A CLUSTER ANALYSIS COMPARISON OF CLASSICAL CHINESE GARDENS WITH MODERN CHINESE GARDENS

By

Yiwen Xu

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

Environmental Design - Master of Arts

2015

ABSTRACT

A CLUSTER ANALYSIS COMPARISON OF CLASSICAL CHINESE GARDENS WITH MODERN CHINESE GARDENS

By

Yiwen Xu

Garden designers and scholars are interested in the differences and similarities between traditional design and modern designs. This investigation examines the similarities and differences of classical Chinese gardens and modern Chinese gardens. The comparison is accomplished by ordinating the design elements and basic principles for each garden. Three classical Chinese gardens in Suzhou, China and five modern gardens in Xiamen, China were selected to study. A mathematical method called Cluster Analysis was applied in this research. Seventy-five variables were selected from literature review and site photos. According to the result of Principal Component Analysis, the eigenvalues represent seven meaningful dimensions can be used for analysis. This research focused on studying the first two principal components for the garden comparison. The results indicate that the first principal component can be a way to identify the difference between classical Chinese gardens and modern Chinese gardens. The second principal component indicates the modern gardens can be grouped into two different categories.

Keywords: Landscape Architecture, Environmental Design, Historic Gardens, Contemporary Gardens, Horticulture, Historic Preservation.

ACKNOWLEDGEMENTS

First, I would like to thank my major advisor Dr. Jon Burley, FASLA, Professor, Michigan State University School of Planning, Design and Construction, for his patient guidance and invaluable assistance through all stages of my work.

I am grateful to my other two committee members, Dr. Patricia Machemer and Dr. April Allen, professors in Michigan State University School of Planning, Design and Construction, for all the advices, support and encouragement.

I would also like to thank Dr. Chunqing Liu, Vice Dean of the College of Landscape Architecture and Art, Jiangxi Agricultural University, China, for her assist with my data collection of the Chinese gardens.

Lastly, I have to thank my parents for all their support.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION AND LITERATURE REVIEW

1.1 Introduction

Classical Chinese gardens have a long history, and many people believe that they are representations of Chinese artistic characteristics and cultural value. As Maggie Keswick (2003) said, “Chinese history is littered with the corpse of gardens.” The unique style and elements of classical Chinese gardens like the nature-like landscape, the use of poetry and paintings, and the rich and varied spaces, attracting many people from all over the world. Even though the classical Chinese gardens are so special and long-standing arts, they have been mysteries for a long time because there is no much study about them until last decades. Publications about classical Chinese gardens written by scholars like Maggie Keswick and Chencong Zhou have helped people to understand more about these gardens. However, there is still little people who really academically study these gardens. The classical Chinese gardens design inspires every design school in China, but they just simply repeat them. Thus, my research will use a truly academic way to study these gardens, and assist people in understanding the breath and depth of Chinese gardens.

1.2 Literature Review of Classical Chinese Gardens

1.2.1 Design Theories and Principles in Classical Gardens

1.2.1.1 Naturalness

In ancient times, the gardens were formal and geometrical not only in Egypt, Babylon and western countries, but also in China. However, China is the first well know country to pursue a "natural" approach to landscape design (Sun, 1994). The gardens in China and the West developed in a diametrically opposite way from that time except the Greek's natural landscape approaches. The gardens in China have been seeking natural site beauty, and most of the Western gardens were in pursuit of a less natural and ordered sense of beauty (Zhou, 2005). Ji Cheng, a famous garden designer of the Ming dynasty, defined the essence of Chinese garden building as "Though man-made, the garden looks like it is springing from nature." His definition demonstrates that garden building is a creative process based on the high degree of extraction and artistic generalization of nature (Liu, 2012).

In Chinese gardening, nature is not the object to be tamed and altered, but the model to be imitated and learned from (Huang, 2008). However, this does not mean that objects of nature have to be presented in their original form. The goal is to depict essence of nature and present nature in a lyrical and artistically succinct manner; that is, naturalness enhanced by artificial effect (Tsu, 1988). Thus, the classical Chinese gardens are known for varied topography including artificial hills reached by sometimes straight and sometimes zigzag path. Some path

cross level land, some others pass through gullies and still some others traverse bridges. One may have to climb up unprocessed rocks to reach the top of a hill. The lake is scattered with islands on which stands a small temple only accessible by boat or bridge (Liu, 2012). Intended activities in the Chinese garden include strolling through the garden, enjoying true nature complete with blue sky, green trees, clean water, and seasonal changes, listening to the song of birds, bathing in the sun, or enjoying shade in the forest (Liu, Burley, and Partin, 2014).

According to ancient Chinese tradition, the human character could be partly judged by the quality of its response to nature. A person who truly loved mountains and water than worldly interests was accepted as a person of deep spiritual cultivation (Tsu, 1988). The philosophical and metaphysical context which implicate the Chinese garden is characterized by two main doctrines: Confucianism and Daoism (Rinaldi, 2011). Confucianism advocates "天人合一", the harmony between man and nature. It refreshed the theory with the idea of human beings' subjective activity. Two aspects characterize this theory: one is the outside environment in the world, that is, Nature; and the other one is the behavioral agent, that is, the human being. During the lives of human beings, nature influences their life-styles and ways of living. At the same time, human behavior involves reacting to nature, which then causes nature to change as well. Hence, the truth of the world is harmony between human beings and nature, and human beings are a part of nature (Liu and Qiu, 2012; Sun, 2010). Taoism was introduced to people in nearly the same period as Confucianism. Taoism regards a theory of 无为 as "noninterference" or "non-action".

It does not mean doing nothing. It means not changing the world's essence by altering it unnaturally. This concept of noninterference expresses the notion that human beings should respect the rules of nature and do nothing that goes against nature (Sun, 2010). Also, it advocates shaking off all fetters in order to fuse human spirit and nature, with the aim to free oneself. The Taoist philosophical school of Laozi and Zhuangzi played an important role in shaping this unique concept of garden by providing the ideas of individual freedom from social restriction and being "true to one's self" (Munakata, 1988). This is why there were so many scholars in China want to build gardens to find sustenance in mountains and waters, follow the call back to nature, return to place of origin, and the wish to leave old habits behind (Engel, 1986).

Figure 1：Nature in the form of rocks, water and trees in the Humble Administrator's Garden. (Copyright ©2014 Kun Zhang all right reserved used by permission).

1.2.1.2 The Spatial Framework

The most important artistic character of China's garden is the sense of space. As the space

of gardens is limited, the designer will use all methods to increase the landscape's feeling of depth, to create the gardens' space rich and variable, in order to turn the limited space into infinite dreamland and increase visitors' interest to the gardens (Liu, 2012).

One of noticeable characteristics of Chinese gardens is that they are divided into units of large and small sizes to create spatial changes. In most cases each divided unit is surrounded by walls and buildings, showing its boundaries very clearly (Munakata, 1988). Each garden contains a certain number of units, each endowed with a specific characterization. All units have a varying number of scenic views, each of which in turn concerns a portion of the unit's area and is made up of a defined viewing zone of the *jing,* the view enjoyed (Rinaldi, 2011). Some units are large and tend to be relatively natural with hills and water; they tend to convey the elegant and relaxed mood one expects of a "paradise" setting. Some units are very small conveying an austere and serene mood with designs essentially symbolic and abstract, using just a few rocks and some bamboo or shrubs, and provide visitors with the spiritual experience of mystical space (Munakata, 1988). Also, the contrast of these divided spaces especially from intense to open gives people various spatial experiences, while making them feel like the garden is larger than its actual size (Ma, 2014).

Even the space is divided into several landscape units, there is always an opportunity to perceive a segment of the hidden view, resulting in "divided not separated" (Tsu, 1988). If a big space is not divided, there will be no alterations of depth, but completely divided it will not

comprise a landscape (Suzhou Institute of Landscape Architecture Design Company, 2010). In many instances the upper parts of trees or buildings projecting from behind the separating walls remind the visitor of the existence of the neighboring division. More important, walls separating two divisions are often perforated with openings, which give the visitor some glimpses of the neighboring world, or at least a feeling of its existence behind the wall (Munakata, 1988). Partial revelation of a space encourages the viewer to imagine a space that is larger than its actual size, giving a deep, gradational and unlimited spatial illusion (Tsu, 1988). The covered walkways are another example, they are not only used to connect single buildings, but are also used to divide spaces without block garden views, penetrating the landscape and object of a walkway's two sides and adding spatial depth (Suzhou Institute of Landscape Architecture Design Company, 2010). Scenic sections can also be subdivided, for diversity of spatial presentation, by lightly changing the levels of landform or by using low partitions of plants and rocks. In this case, there is no risk of blocking the view (Tsu, 1988).

Figure 2: Space divided by artificial mountains and walls with moon gate in Humble Administrator's Garden. (Copyright ©2014 Kun Zhang all right reserved used by permission).

Figure 3: Covered Walkway divides the space without blocking garden views; in the Master of the Nets Garden. (Copyright ©2015 Yiwen Xu all right reserved used by permission).

1.2.1.3 Visual Effect Techniques

People come in contact with landscapes and objects through their senses; this is particularly true of the visual sense, which has the characteristics of tactile sensation and the feeling of motion; thus wholeness of landscape and objects is expressed mainly through visual sensation (Suzhou Institute of Landscape Architecture Design Company, 2010). The composition of garden objects, and line of vision, are often making use the following visual effect principals in classical Chinese garden design.

Borrowed Scenery: This type of landscapes make use of good organization of vantage point and line if vision, and let the exterior landscape and object appear in the line of vision in order to expand the feeling of a limited space (Suzhou Institute of Landscape Architecture Design Company, 2010). The borrowed scenery can be distant hills, temples and pavilions outside garden into the visual scope of the gardens' total composition (Liu, Burley, and Partin, 2014). Elevated vantage points are sometimes arranged in the form of a two- story tower, a pavilion, or a terrace built on an artificial hill commanding distance views of surrounding countryside with sparkling flooded rice fields in patched patterns or overlooking a lower neighboring attraction (Tsu, 1988). Besides that, the landscapes of distant hills and tall buildings outside the garden walls can also serve as the "borrowed landscape" and becomes a part of the garden's total composition (Engel, 1986) As a result, the garden, thus linked with the landscape beyond, seems become boundless no matter what the garden's original size (Rinaldi, 2011; Tsu, 1988). The

borrowed scenery also can be the reflection of water, the shadow of trees, the sound of wind, the fragrance of flowers, and the change of seasons that greatly broaden the imagery of the space, making one feel as if they are within infinite space and perfect harmony, forming and integral whole (Liu, Burley, and Partin, 2014). In practice, the technique of borrowed scenery intermingles constructed garden views with the natural landscape. As a result, the garden space is seemingly multiplied (Tsu, 1988).

Figure 4: The Dual-Delight Pavilion in Humble Administrator's garden is located to "borrow" water scene from the main scenic section, and the pavilion itself also can serve as a spectacular end vista for the main scenic section. (Copyright ©2013 Yiwen Xu all right reserved used by permission).

Figure 5: Beisi Ta, North Pagoda, located to the north of the garden, is “borrowed” as part of the magnificent scenic view of the Humble Administrator’s Garden. (Copyright ©2013 Yiwen Xu all right reserved used by permission).

Framed Scenery: The landscape and objects can be made stand out when they are set in a frame or screen. Framed sceneries use the simple and relatively dark frame to comprise the foreground of the composition, causing a person’s eyesight to focus on the main feature and thus giving a strong artistic influence (Suzhou Institute of Landscape Architecture Design Company, 2010). Examples of architectural frames are doors and windows, or the openings of covered walkways marked by the vertical supports of the roof, but framing can also be achieved by natural elements, like branches of trees or groups of rocks placed in the foreground ((Rinaldi, 2011).

Figure 6: The wall openings framed by blackened terracotta create a “picture” of the plants or rockery. Lingering Garden, Suzhou. (Copyright ©2015 Yiwen Xu all right reserved used by permission).

Opposite Scenery: In traditional design, the logic of “to see” and “to be seen” is especially stressed. It is also a reflection of *Yin-Yang* in Daoism (Ma, 2014). The key visual points of a classical Chinese garden often contain landscapes and objects organized in a deliberate way. Both observation points and the objects viewed must be interesting and enjoyable in themselves. In effect, they become interdependent, comprising intricate cross vistas, so that they form various opposite sceneries (Engel, 1986). But these are different from the symmetrical landscapes of western courtyards, and follow a meandering plane, with new sceneries for each step, revealing themselves one by one. These opposite sceneries attract people’s attention by means of spatial

change caused by the forward direction of roads and walkways, the entrance, and curves, as well as the front views that can be observed through frames of doors and windows (Suzhou Institute of Landscape Architecture Design Company, 2010).

Figure 7: The scene of mountain and the Snow-Like Fragrant Prunus Mume Pavilion being viewed from the Distant Fragrance Hall on the south side of the central pond in Humble Administrator Garden. The pavilion itself also serves as an elevated viewing point for enjoying the scene of the Distant Fragrance Hall. (Copyright ©2012 Kun Zhang all right reserved used by permission).

Contrast: Contrasts are practiced in all aspects of garden design, including the play between tall and low, vertical and horizontal, denseness and sparseness, openness and walling-in of space, the refined craftsmanship of exquisite architectural details and natural trees and rocks, and between the bright and the dark, and so on (Tsu, 1988; Engel, 1986). The approach of "being restrained for the purpose of showcasing the more beautiful" is often adopted in the landscape of Chinese

gardens in order to achieve the result of “small looking big”. By using the method of contrast, small, dark, narrow and zigzag space is laid out before entering the main areas. In this way your eyesight is retrained. Then all of a sudden, you will be surprised to feel yourself in a bright, large open space when you walk in the main area (Liu and Qiu, 2012). Being built as naturalistic environments, Chinese gardens have as their fundamental scenic contrasts hills and water opposed to architecture; that is, a contrast of naturalistic features and artifacts. Also, water is used to contrast to rockery or architecture, like light versus heaviness, void space versus solid mass, and also as moving and romantic versus still and staid. With the mirroring effect of water surface, harmony among these contrasting elements is unfailing (Tsu, 1988).

Figure 8: The mysterious tunnel gives an “endless” look and suggests more space hidden out of sight. Lingering Garden, Suzhou. (Copyright ©2015 Yiwen Xu all right reserved used by permission).

Figure 9: The narrow and dark access to the main open space was created to form an interesting contrast in Lingering Garden. (Copyright ©2015 Yiwen Xu all right reserved used by permission).

1.2.1.4 Deep Implication with Painting and Poetry

A unique characteristic of the Chinese garden is its close association with the art and literary realms, and the integration of poetry, painting, and garden is the culmination of Chinese garden art (Tsu, 1988).

In Chinese history, many painters were also landscape gardeners, as wild nature and scenic landscape are always the theme in Chinese landscape painting, they remold the original natural mountains and streams through the use of artistic and composition principles of landscape painting (Sun, 1994). Many antiques landscape paintings attained eminence by depicting garden scenes. Successful scenes were constructed with famous paintings as models (Tsu, 1988). Also, the theme or tone of a scholar's garden design relies heavily on the borrowed artistic experience of poetry (Dillingham, 1991). When travelling a garden, the poems can be found easily. Sometimes good poetry can increase the garden's aesthetic interest (Pang, 2012). Every garden has tablets or plaques bearing inscriptions of titles or verses composed during certain historical periods by eminent people of letters. The inscriptions use poetic wording and beautiful calligraphy to lend artistic enjoyment as well as literary satisfaction (Tsu, 1988). For example, in the western part of the Humble Administrator's Garden in Suzhou, there stands a waterside pavilion. In the still of night, cool breezes blow gently and on moonlit nights the sky is reflected in water, displaying a serene atmosphere. Quoting from Su Shi's verse "with whom to sit, bright moon, cool breeze and me," the garden owner named the pavilion "with whom to sit," accurately capturing the artistic realm of this scenic spot and also signifying the exclusive character of the garden's owner (Lou, 2011).

When the designer or owner builds a garden, he will put spiritual significance into the scene of the garden, hoping that visitors will be sympathetic and emotionally touched by these

scenes, which are what ancient people called “emotional realm” or the “artistic realm” (Lou, 2011). It is very common in Chinese garden design that every hill, every pond, every pond, every plant or every tree has a profound implication and is thought provoking (Liu and Qiu, 2012). A garden that is full of poetic charm and imaginary space, simple but elegant, pure and fresh, is considered to be the very best (Lou, 2011). If one cannot understand the spiritual significance affiliated to the landscape scene, then one cannot achieve a sympathetic touch and an emotional resonance (Liu, Burley, and Partin, 2014).

Figure 10: “With Whom to Sit” Pavilion in the Humble Administrator’s Garden. (Copyright ©2014 Kun Zhang all right reserved used by permission).

1.2.2 Design Features and Their Applications in Classical Gardens

According to Yang and Volkman's paper, there are five key elements in Chinese gardens – water, rock, pavement, architecture and planting, and they use them as their research variables. They found that site features of any significant size could be categorized into one of these elements (Yang and Volkman, 2010). Within the general structure of the Chinese garden, each element had its own distinctive characteristics and relative importance within the hierarchic scale, which put architecture first, followed by water and rocks, then plant material (Johnston, 1991).

1.2.2.1 Architectural Elements

Architecture predominates over plant life in the Chinese garden scene. This main emphasis differs greatly from that from that of western gardens (Tsu, 1988). There are many kinds of structures in the classical Chinese gardens, including halls, towers, pavilions and walkways, all of which categories are subdivided according to peculiarities of which categories are subdivided according to peculiarities of function and design (Feng and Fan, 2007). The functions include scenic touring, recreation, traffic, and decoration (Pang, 2012). Architecture not only provides spots for people to see the views, but the architecture itself is also a view to be seen (Ma, 2014). Objects and furniture are also part of the garden. This includes walls, wall openings, passages, portal designs, embellished window openings and walkways (Feng and Fan, 2007).

Halls (ting tang): The main hall is he largest building in the Chinese gardens to receive and entertain guests (Feng and Fan, 2007). As Ji Cheng (1963) said in *Yuan Ye*, "In founding a garden,

the disposition of the main hall is essential; it is to be south oriented and located in a position to command the dominating garden scene" (Translated by Tsu, 1988). It usually connected by covered walkways to subsidiary buildings, and its surrounding outdoor space may, in part, be walled off on one or two sides to form large landscape courtyards (Engel, 1986). For example, the Distant Fragrance Hall in the Humble Administrator's Garden is a place intended for major activities and gatherings. The best views of predominating garden scenes are provided there, and subordinate garden scenes are arranged around the central watercourse or perched on a dominating hill within sight of the Distant Fragrance Hall (Tsu, 1988).

Figure 11: The Distant Fragrance Hall in the Humble Administrator's Garden. (Copyright ©2013 Yiwen Xu all right reserved used by permission).

Viewing towers (lou ge): Tall, sizable buildings are usually avoided in private gardens. The viewing towers are normally limited to two or three stories with windows in order to maintain a proportional relation with the surrounding space and garden features. The use of multistory buildings was to block out unpleasant sights adjoining the site or to provide elevated viewing points with a wider sight range for enjoying the scene of garden (Tsu, 1988; Engel, 1986).

Figure 12: The Mountain-In-View Tower in the Humble Administrator's Garden. (Copyright ©2014 Kun Zhang all right reserved used by permission).

Pavilions (ting): The Pavilion is the basic and ubiquitous structure in Chinese garden, relatively small in size and varied in form. The word *ting*, which originated phonetically from a Chinese word meaning "stop", clearly indicates its function as rest stop (Tsu, 1988). Because of its

intimate size, there is more flexibility in siting of the pavilion in garden locations too precarious and difficult for larger structures (Engel, 1986). A pavilion by the water is suitable for appreciating aquatic scenery. One on a mountain is good for appreciating wide vistas. Arranged according to their various shapes and sizes, pavilion come in numerous forms, including square, oblong, hexagonal, octagonal, round, plum-blossom shaped, clover shaped and fan shaped (Feng and Fan, 2007).

Figure 13: Moon Comes with Breeze Pavilion by the central pond in the Master of the Nets Garden. Copyright ©2015 Yiwen Xu all right reserved used by permission).

Walls: Urban gardens depended upon walls to conceal their beauty and ensure seclusion. Walls were seldom straight, either on plan or elevation. They were organic elements within the garden, following the up and down of the ground in large landscape enclosures and curving or stepping in and out in smaller urban gardens. There are different type walls and each type has different functions, such as white washed walls, decorative brick walls, openwork brick walls, and unworked stonewalls (Johnston, 1991). The white washed walls also serve as canvas, upon which rocks, plants and their shadows, change from morning to night, as well as spring to winter (Ma, 2014). One of the most spectacular wall types is the "cloud wall", which has a sine curve at the top. When the blue-black, curved, tiled roofing of an undulating cloud wall is decorated with a pattern resembling the scales of the legendary dragon, the immortal creature seemingly rests upon the winding garden. Besides the symbolism of the dragon is believed to be a guardian who protect the buildings, meandering walls also evoke the sense of a continuum of life – without beginning or end (Tsu, 1988; Engel, 1986). Door and window openings on the walls make perfect scenes as well (Ma, 2014). Window openings with patterned grilles on the walls are elaborately handcrafted with tiles or bricks and the patterns vary greatly, from shape of a single flower to complex geometric patterns. These lattice windows are placed side by side; together they enhance the energy of the gardens inside the walls, while giving the wall the special quality of openness. Apart from that, the variously shaped holes in the lattice windows also echo the mysterious holes and caves of the eroded rocks (Munakata, 1988). The door openings on the walls are often a circular shape, popularly called a *Moon Gate*. Thus, the garden gate contrast

with the door of the dwelling as a circular or irregular shape versus a rectangle, as open versus close. The moon gate also makes it necessary for the visitors to step into the garden over the curved bottom of the circle, thus he has to walk straight through the center and each visitor enters singly, and the act of entrance is this given special emphasis (Keswick, Jencks and Hardie, 2003).

Figure 14: The whitewashed wall with lattice windows. Humble Administrator's Garden, Suzhou. (Copyright ©2014 Kun Zhang all right reserved used by permission).

Figure 15: A cloud wall with a moon gate in the Humble Administrator's Garden. (Copyright ©2014 Kun Zhang all right reserved used by permission).

Covered walkways (Lang): Covered walkways are the most unique of Chinese garden elements, were the main arteries of the garden and within each walled enclosure formed its skeletal structure (Johnston, 1991). They not only make it convenient for visitors to travel though garden by linking various parts of garden, but also unit the different scenic sections by being open and unobstructive, greatly adding to the depth and sequence of the garden views (Feng and Fan, 2007; Tsu, 1988).

The design of the covered walkway can be free-standing, attached to a wall, over water,

or it can take the form of double walkway with a wall built along the center line (Tsu, 1988). The free-standing walkways often provide visitors two different views: one side showing a large and natural landscape with hills and water; the other side a small space, abstract in design, with rocks and small plants. The walkways attached to the wall can conceal from the visitor the outside view except for some glimpses though the window openings, this type of walkway was used to create the effect of a "grotto"; it connects to the hallway of a building or leads directly to cave-gate for a dramatic opening to a new world (Munakata, 1988).

Figure 16: The double walkway built with a whitewashed center wall with lattice windows in the Humble Administrator's Garden. (Copyright ©2014 Kun Zhang all right reserved used by permission).

Figure 17: A free-standing covered walkway in the Humble Administrator's Garden. (Copyright ©2014 Kun Zhang all right reserved used by permission).

1.2.2.2 Rockery and Water

Rockery and water are important elements in Chinese gardens in order to create a nature-like landscape (Pang, 2012; Keswick, Jencks, and Hardie, 2003). The Chinese word for the landscape is *shan shui,* which literally means "mountains and water" (Keswick, Jencks, and Hardie, 2003). This clearly indicates that mountain and water are taken as dominating elements and are the most appreciated subjects in landscape scenes (Tsu, 1988). Garden designers attempt to arrange "mountains" and "waters" within their garden by exaggerating and rescaling them into rockeries and ponds. Influenced by paintings and literature, the shapes of water and rockeries are realistic (Ma, 2014). If the rock is the backbone, then the water is the vein of the garden (Feng and Fan, 2007). Rock is a symbol of virtue, stability, and endurance; water represents lightness and communication. The combining of mountains and water in a garden is an expression if YIN and YANG, the Taoist view of the balancing of opposites, the harmony and duality pervading all things (Engel, 1986).

Rockery is regarded as the essential ingredient to set off and complement water, plants and architecture and enrich the vertical composition of a confined space within the garden (Pang, 2012; Tsu, 1988). Garden designers often use rockeries to create paths, and use its changing direction to emphasize the mountain's winding, rugged, deep and confused characteristics of space (Pang, 2012). The normal design principle is: going down first if you want to go up, going right first if you want to go left; it seems the exit but it is actually an impasse; people feel

uncertain about having no way out, but it is actually a thoroughfare (Li, 2009). There are two types of rockery in Chinese gardens: piled rocks and single rocks as sculptures. Piled rocks are constructed to form artificial mountains (Engel, 1986). Artificial mountains can provide higher elevations needed by garden visitors for a broader view of the garden (Rinaldi, 2011). When the scale of the mountain allows, a pavilion is appreciated as a viewing station and greatly highlights the "mountain view" (Tsu, 1988). Sculptural rocks are individual stones of particular elegance, or simple compositions of such stones that can be placed so as to exalt the formal quality of each single peace, such as the Guanyun Feng in Lingering Garden. They are chosen for their characteristic qualities: conformation, substance, color, texture, presence of fissures and openings, veins (Rinaldi, 2011). Rockery presentations are expected to evoke personal feelings through abstract beauty that inspires the unlimited enjoyment of reminiscence and thus allows for different interpretations, varying with moods or perspectives, as do the changing clouds in the sky. This conception of rockery art, characteristic of the Chinese garden maker, is unique (Tsu, 1988).

Water was as important in creating moods and emotional appeal in the garden as eyes are in the human face (Tsu, 1988). Chinese garden usually features a central pond or lake and several streams. The main buildings are usually placed beside it, and pavilions surround the lake to see it from different points of view (Li, 2015). Water benefits the circulation of the ecosystem and also brings vitality and charm to the garden. Besides, water was a splendid medium for creating

reflection and giving and impressionistic play of light, shade and color, for invoking gentle sounds and for nourishing plants and birds (Huang, 2008). The shores of the pond are often used in conjunction with rockery to create the impression of a cove (Feng and Fan, 2007). The island may simply be decorative piles of rocks, forming and inaccessible garden scene. Bridge or causeways are laid for passages to the island, varying with the size of the watercourse (Tsu, 1988).

Figure 18: The Cloud-Capped Peak (Guanyun Feng) in the Lingering Garden is the most renowned Taihu Rock in China. (Copyright ©2015 Yiwen Xu all right reserved used by permission).

Figure 19: Central Pond with the reflection of trees, architecture and sky in the Humble Administrator's Garden. (Copyright ©2014 Kun Zhang all right reserved used by permission).

1.2.2.3 Vegetation

Plants retain importance as unifying garden elements that blends the artifacts with their surroundings, and they serve as components of a scenic composition or as a foil in garden scenes. Buildings are often named after the plants cultivated around them, such as the Magnolia Hall, the Pines and Breezes Pavilion, and the Willow-Shaded Winding Path in the Humble Administrator Garden (Tsu, 1988). In plant grouping, plant spacing and heights are well arranged to form a screen-like scattered landscape, so that the landscape has a sense of movement, both independently and connectedly, and spatial morphology of different levels. Scenes like "willows planted on embankment and near a bay", "a footpath under peach and plum trees", "prune trees planted around the house" and "bamboos serving as the window" basically reflect plants

landscaping in the traditional Chinese garden design (Li, 2015). Flowers and plants as shrubs are mostly to dot or increase the richness of color in the garden, feature in their colors and gorgeousness (Li, 2014). Trees are planted in small numbers; three to five trees strategically located can represent a grove in the pictorial composition. The tree crown provides a cooling sunshade in summer, and the fascinating shadows cast as patterns on pavements and walls are reminiscent of charming Chinese brush paintings. Lawns are not the basic landscape feature in classical Chinese garden, and usually planted in small areas, because large tracts of land with inexhaustible sight ranges contradicts the Chinese garden design principle of "avoiding total exposure of everything at a glance" (Tsu, 1988).

The plants of a Chinese garden play not only their obvious role as constituent elements, but also, through their traditional symbolic and historic associations, set mood, theme and character of each section of the garden to heighten the poetic and aesthetic quality of the garden scene (Engel, 1986). Since China has long history in cultivating ornamental garden plants, and many poems, words and songs endowed by garden plants and landscape imply matters in human society, the plants are given personified connotation, and allow people to admire the natural and poetic beauty of plants with a combination of plant landscape (Li, 2014). The following is a list of plants and their symbolism according to Feng and Fan (2007).

Magnolias: elegance and purity.

Pine: vigor and longevity.

Bamboo: uprightness.

Plum: courage.

Camellia: brilliance.

Crepe myrtle: naivete.

Sweet osmanthus: nobility.

Peony: richness and prosperity.

Willow: charm and loveliness.

Lotus: purity and honor.

Figure 20: The central pond with the lotus blossoms during summer in the Humble Administrator's Garden. (Copyright ©2014 Kun Zhang all right reserved used by permission).

1.2.2.4 Garden Paths and Pavements

In creating a Chinese garden, the designer aims at laying out a pathway along which the various components of the green space would gradually reveal themselves to the visitor. It is this mechanism of a series of unexpected scenes that is to induce the visitor to investigate the entire garden (Rinaldi, 2011). Two types of paths are constructed. One demands less physical exertion as it follows obvious routes through buildings, corridors, zigzag covered walkways, courtyards and along the water's edge of garden pond. The walking surfaces are easily negotiable, even for the elderly and the infirm. The second type, requiring a more adventuresome spirit and nimble feed, traverses narrow mountain path, coves, gullies and pools (Engel, 1986). One characteristic is common to all paths: they are never linear except for short sections. Following the principles of *fengshui* and the concept of "inspired by nature", the paths can be twisting, zigzaging, or form a series of broken curves (Rinaldi, 2011; Li, 2009). According to Pang (2012), it also shows Chinese people's world view and the value of pursuing natural beauty and the beauty of life. This means that the path is the implied symbol of people's life, and travelling the path includes people's experience of their life. The process which you have been experienced, no matter happy or sad, is more important than the end of the journey.

In the building of the pathways along which the garden was experienced, insignificant or even waste materials were used to form elaborate mosaics of texture and color. The paths were made of broken tiles, pebbles, pieces of brick, crushed stones, fragments of pottery, etc., in an

inexhaustible range of patterns, geometric and naturalistic (Johnston, 1991). The pavement in the Chinese garden has a distinctive rustic touch in harmony with subtleness and elegance (Tsu, 1988).

Figure 21: The mosaic pavement of an animal pattern in the Master of the Nets Garden. (Copyright ©2015 Yiwen Xu all right reserved used by permission).

1.2.2.5 Weather and Four Seasons

When constructing Chinese traditional landscape, attention is always paid to utilizing the elements of weather (Pang, 2012). The views change not only with "every step forward" but also with the seasons, weather, times of day, age of the plantings, and even the beholder's mood. Thus, Chinese gardens are always attractive and fresh to visitors no matter how many times they have seen the same garden (Tsu, 1988). This special charm of garden art is mainly displayed in two

aspects, borrowing scenery from weather and seasonal composition of the landscape (Pang, 2012).

Borrow scenery from weather means to borrow scenery from sun, moon, star, cloud, rain, snow, and such natural elements, and organize an elegant landscape (Pang, 2012). For example, in many gardens, water pavilions are built over the watercourse for enjoy the reflection of moon, clouds and color of sky in water surface during different times of day. Whitewashed walls often serve to capture the shadows of several stalks, some rockery, or a quaint plant in sunlight to enrich garden views (Tsu, 1988).

The seasonal composition of landscape is mainly achieved by utilizing seasonal changes of plants to bring out the diversity of gardens views through their characteristic posture, texture, color, odor, and even the acoustic effects they generate (Tsu, 1988; Morris, 1983). Individual botanical species associated with different seasons are magnolias, peonies, peach and cherry trees in spring; summer is announced by the blooming of wisteria, roses of multiple varieties and the lotus; fall comes in with the flowing of chrysanthemums, maple leaves turning red and ginkgoes turning gold; winter's grey is interrupted by early-blooming species like camellias, rhododendrons, calycanthus and above all flowering plums (Rinaldi, 2011).

1.3 Literature Review of Modern Chinese Gardens

1.3.1 The Impact of Western Design Theory

Since the end of 20th century, the design theory of west modern landscape had been introduced into China, many international famous landscape designers and groups came to China, they enriched the theories and practices of China landscape (Jia, 2012). Due to the differences in natural conditions, historical origins, social environments, cultural backgrounds and religious factors, the gardens in China and the West developed in a diametrically opposite way from the very beginning (Zhou, 2005). Chinese traditional landscapes created an ideal natural recreational living space by imitating nature, but Western landscape designers often satisfied people's living needs from natural space by arranging natural elements more formally (Pang, 2012). The geometrical gardens of the west present a strong artificially created order in opposition to nature, human power expressed by organizing nature under the control of human will, although there are also may exceptions to this generation like the Greeks' landscape (Tsu, 1988). The Tale 1 shows the comparison of principle characteristics of Chinese and the formal European-inspired approach in landscape designs (Yang and Volkman, 2010). In the layout of a formal Western garden, geometrical style emphasized on the axial symmetry of geometrical patterns--even flowers and plants are regularly trimmed into geometrical symmetry. The style laid emphasis on artificial beauty or geometrical beauty, rather than natural beauty (Zhou, 2005). According to Turner (2011), mathematics was seen as fundamental to perception and representation in the

West. Geometry was the branch of mathematic with the most obvious relevance to garden design, so circles, squares proportions and mathematical patterns were in used in Western gardens. Perspective was used to integrate buildings with gardens, and axes became their dominant feature. Water in Western formal gardens also restricted geometrically shaped pools, canals, or fountains, and theses force the water to do things against its own nature. The Villa Lante in Italy is an excellent example shows the bilateral symmetry layout. The villa was opened out from the thick woodland on the hill. Along the central axis, the house on the hillside was divided into two parts in order to let the central vista of the garden run through without interruption, and to provide a framed, distant view. Thus, in most of the Western formal gardens, the sight line is oriented on the center or on the axis of a space (Liu, 1989). Nevertheless, as a kind of social ideology, the arts of garden making, like other kinds of arts, are deeply influenced by social and cultural background (Zhou, 2005).

Table 1: Comparison of principle characteristics of Chinese and European-inspired approach in landscape designs

	Chinese style	European-inspired style
Composition	Asymmetrical	Bilateral symmetry
View	Framed by structures in the garden	Lines of sight; views open at ground level
Planting	In naturalistic groupings	In rectilinear arrangements; expansive lawn; geometric
Rock	Used as sculpture and to define water edge	Rarely used, except in carved form
Building	Integrated with garden	Dominate the view; often focal point on axis
Water	Naturalistic shape	Rectilinear shape
Pavement	Often circuitous	Often linear

Due to the influence of Western landscape design, function for the public is gradually being seen to be more and more important in the design of landscape in China. The English landscape garden emphasized landscape's practical applicability and popularity, which had a wide range of service targets, and even was more open and public. Its function serviced for the public, which was close to nowadays landscape (Pang, 2012). On the contrary, Chinese traditional landscape always had the tendency of refusing utilitarianism because of the influence of Chinese traditional Confucianism's "heavy righteousness, light benefit" idea (Zhou, 1999). According to Guo (2001), the Chinese aesthetic theory was always lack of the reasonable understanding of the connection between pleasure and benefit in general. So the function of Chinese traditional landscape was always the place for few literati to self-communion and spiritual satisfaction, and the material function never became the main function in Chinese traditional landscape (Pang, 2012). Nowadays, the designers in China gradually pay more attention on the innovations of function in landscape design. According to Wang (1995), the landscape must have functional value to satisfy people's material and mental needs.

However, the globalization has led to a homogenization in public space design, the dominance of Western traditions of landscape architecture applied in non-Western settings has been questioned (Yang and Volkman, 2010). Especially during the Great Proletarian Culture Revolution period (1966-1976), everything related to old China was regarded as symbolic of backwardness in society including traditional landscape design. Western architecture and

landscape design flooded rapidly into China, leaving earthshaking changes all over the country. Chinese landscape design has inevitably been impacted by Western design ideas (Sun, 2010). Nowadays, contemporary Chinese landscape architects continue to struggle to define an indigenous design tradition, often ending up by following Western models uncritically (Yang and Volkman, 2010). This kind of modern landscape design neglects the regional and cultural difference, only pursues the graceful composition of geometry, and uses large numbers of expensive materials, it looks like be pomposity, because of its lack of the building emotional situation, and these landscapes can not cause the resonance of experiencer (Jia, 2012). Thus, landscape architecture projects are having less and less connection to the history and tradition of Chinese culture (Ma, 2014). Chinese landscape design should be retained as a part of Chinese culture, especially since Chinese landscape design has taught valuable lessons about adapting to local conditions (Zhu, 2005).

Figure 22: Bilateral symmetrical layout in Villa Lante, Italy. (Copyright © 2003 Jon Bryan Burley, all right reserved used by permission)

Figure 23: Line of Sight on ground, Stourhead, England. (Copyright © 2008 Jon Bryan Burley, all right reserved used by permission).

Figure 24: expansive lawn and geometric plantings in Versailles, France. (Copyright © 2007 Jon Bryan Burley, all right reserved used by permission).

Figure 25: Trevi Fountain, Rome, Italy. (Copyright © 2003 Jon Bryan Burley, all right reserved used by permission).

Figure 26: Focal point on axis, Ville D'Este, Italy. (Copyright © 2003 Jon Bryan Burley, all right reserved used by permission).

Figure 27: Rectilinear shape in Generelife, Granda, Spain. (Copyright © 2005 Jon Bryan Burley, all right reserved used by permission).

Figure 28: The straight path and row upon row of plants in modern Chinese landscape design. Dongsha Lake Park, Suzhou. (Copyright ©2014 Kun Zhang all right reserved used by permission).

1.3.2 Reinterpreting Tradition in Modern Chinese Garden Design

As the globalization result in a same style of landscape design and the loss of cultural identity in China, many scholars started to investigate how to apply the design elements and principle of classical Chinese garden in modern garden design (Ma, 2014; Feng and Xu, 2012; Dillingham 1991; Yang and Volkman, 2010; Huang, 2008). Borrowing ideas for modern landscaping designs from Chinese traditional landscaping thinking is not only the requirement of the time and the nation, but also the crystal of encountering and conflicts between modern life and Chinese traditional culture (Feng and Xu, 2012). Only when we introduce traditional garden design theory into modern gardens, we can build landscape with distinctive characteristics and

permanent activity (Jia, 2012).

However, applying classical Chinese garden design elements and principles in modern gardens does not imply that the modern garden design should directly replicate classical Chinese gardens, but to make variation on and adjust traditions in order to best fit into the contemporary context (Ma, 2014; Dillingham, 1991). According to Rinaldi (2011), if the neo-historical garden seems destined for further development, due also to the wider knowledge of the gardens of ancient times that archeology has uncovered, and intriguing development, parallel to but distinct from this revival of historicist taste, is the revisitation of tradition in contemporary way. Some compositional elements and principles of Chinese garden design are now reconsidered as bearers of modernity, and are applied and readapted as such to contemporary landscape design. But some elements in classical Chinese garden are believed cannot fit the modern society. For example, traditional gardens are designed for the privilege few with a very slow and leisurely pace of life. A public garden or park design using the elements – zigzag paths and bridges, an artificial meandering creek or small pond – will not easily accommodate large numbers of people and the activities inherent in large groups. The intended serenity and interest of traditional garden is lost or spoiled (Dillingham, 1991). Classical gardens are products during the feudalism, represents many characteristics of that outdated system. Such landscape design does not meet the requirements of today's public (Ma, 2014).

Thus, those traditional gardens are just the design source of modern landscape (Jia, 2012). Landscaping designers need to research Chinese classical garden culture and features of local resource environment deeply, draw design nutrition from classical gardens, master the inspiring meanings of traditional landscaping thinking and blend them with environmental atmosphere of modern life—this is the true development direction of Chinese modern landscaping designs (Feng and Xu, 2012).

Figure 29: The zigzag whitewashed walls bring people similar experience of visual transition and spatial atmosphere as the classical Chinese gardens. Bamboo Garden, Xiamen. (Copyright © 2007 Chunfeng Lee all right reserved used by permission).

1.3.3 Toward Sustainable Open Spaces

As the world population continues to grow and as global urbanization continues to unfold,

problems on landscaping are becoming more serious, and our ecosystems and landscapes will be increasingly domesticated and designed. Developing and maintaining sustainable landscapes have become one of the most challenging and imperative tasks for scientists and stakeholders of all sorts (Feng and Xu, 2012). According to Yu (2006), statistics shows that in the past 50 years in China, 50 percent of the nation's wetlands have disappeared, and 40 percent of the surviving wetlands have been polluted. The underground water level drops every day. In Beijing for example, the overuse of underground water is 110 percent, and each year the water level drops by one meter. The widespread degradation of ecosystems has generated recent efforts in the country to recreate the natural landscape in areas sharply affected by human activities (Rinaldi, 2011). The greatest needs for the 21st century are for society to become attuned to the ecological constraints of the environment while simultaneously providing more livable communities for humankind (Linehan and Gross 1998).

Sustainable environmental design is not alien from Chinese tradition, because the founding premises of the Chinese garden are the same as those principles inspiring the current conception of a sustainable environment (Rinaldi, 2011). The Chinese traditional landscape thoughts, like " unity of man with nature" philosophy, " peach blossom spring" ideal, and Feng-shui theory, call for people to respect and protect nature and indicate the direction for people to dealing with the relationship with the nature (Chen and Wu, 2009, Huang, 2008). For example, the core of the " unity of man with nature" philosophy is to present that man is integral part of nature (Rinaldi,

2011). Thus, the garden emphasizes people' s intimation and integration into the nature. Constructing according to the existing landform, making scenes by adapting the natural landscape are the keys in its design. Though the ancient Chinese had no idea about ecosystem, they just believe man and nature should live in harmony, and the garden design should learn from and be in harmony with the nature (Rinaldi, 2011; Huang, 2008). Nowadays, with the deterioration of environment, the Chinese traditional garden design thoughts can provide useful guidelines for this integration as well as for the development of a sustainable landscape architecture, and landscape architecture in China is taking can be considered as part of the evolution of an ancient tradition (Rinaldi, 2011; Chen and Wu, 2009).

Although the traditional Western garden design has stronger emphasis on "taming" the natural world, conservational and environmentalist started to pay much more attention on promoting a harmonious relationship between society and nature since 1900s (Chen and Wu, 2009). The American environmentalist Aldo Leopold (1949) described the natural environment around his home in the book *A Sand County Almanac*. This book started to remind people the importance of nature and stimulate people's interest in ecology. The ecology movement has changed people's perception of their relationship with nature. With the experience of visiting natural parks, hiking, eating, and living with nature, people feel that they have rediscovered them selves, understand nature and their role in it better, and realize that they are part o f the natural environment - not separate from it (Gu, 1994). Also, the great works of Mumford, McHarg, and

Olmsted formulate and articulate socially and ecologically relevant arguments to the problems associated with an aberrant development paradigm (Linehan and Gross 1998). In recent decades, new ecological concepts from western countries, such as green infrastructure and sustainable design, have gradually been accepted by more and more Chinese scholars. Advanced ecological strategies and design concepts that are needed more than ever before are encouraged and applied to every single project (Ma, 2014).

The emergence of sustainability science in the early 2000s—has made it possible for the paradigm shift that allowed sustainability to be better integrated in landscape research and practice (Musacchio 2009). According to Linehan and Gross (1998), for although natural processes largely determine the ecological condition of our landscapes, social processes will continue to determine the directionality these processes take. To close the gap between society and the environment, the modern landscape designers must be aware of, account for, incorporate, and challenge the problems and opportunities that cultural adoptability, economic viability, social equitability, and political relevancy have on the ecological condition of our landscapes. With the development of science and technology, we should use new vocabularies, technologies, rhetoric, and self-referring academic knowledge to address and correct the aberrations our development paradigm has on the ecological, economic, cultural, and political dimensions of our landscapes.

Figure 30: New ecological strategies such as wetlands, rain gardens, and aeration ponds, are applied to improve the stormwater management. Wusong River Park, Kunshan, (Copyright © 2014 Kun Zhang all right reserved used by permission).

1.4 Conclusion

Some researchers advocate that contemporary Chinese landscape design must balance the relationship between the traditional Chinese-style and the contemporary Chinese-style design environments (Sun, 2010). Comparing the classical and modern Chinese garden is an effective way for designers to understand the suctions and patterns of these gardens and help designers to discover the ways to integrate traditional Chinese design elements into modern designs. Most classical and modern Chinese garden design comparative studies were undertaken through heuristic method by scholars' personally stating of design theories and principles, which tended

to be more subjective. Little quantitative research has been undertaken, however, that uses mathematic method to compare gardens. Thus, this research will exam the difference between classical and modern Chinese garden by using a mathematic method named Cluster Analysis which is an exploratory data analysis tool for solving classification problems. Its objective is to sort different members into groups, or clusters, so that the degree of association is strong between gardens of the same cluster and weak between gardens of different clusters. Then, assess which elements make them different and which elements they have in common.

CHAPTER 2: METHODOLOGY

2.1 Purpose of Study

The objective of this study is to find out the similarity and difference in design elements between classical Chinese gardens and modern Chinese gardens. The result of this research can help researchers and designers understand the Chinese garden design better, and provide a kind of guidance for them to see if traditional design elements could still effectively serve a modern design inspiration. Also, this research can be a way to test if the mathematic method Cluster Analysis can be applied to compare gardens.

Thus, the followings are the 4 research question issues that I want to address through this study:

1. What are the major measurable variables in classical Chinese garden?

2. What are the major measurable variables in modern Chinese garden?

3. How similar or different the elements are in classical and modern Chinese gardens?

4. Discuss the value of metric approaches.

2.2 Study Sites

In this research, three classical Chinese gardens in Suzhou and five modern gardens in Xiamen were chosen to compare.

2.2.1 Classical Gardens

The traditional Chinese are generally classified into two major types: the private gardens of the south and the imperial gardens of the north. Imperial gardens of the north tend toward staidness and resplendence consistent with a sense of palatial grandeur (Tsu, 1988). Typical examples are the Summer-Retreating Mountain Villa in Chengde, Hebei Province, and Summer Palace in Beijing. Gardens of south are mostly located in the cities of Jiangsu province and Zhejiang province, including Suzhou, Yangzhou, Wuxi, Nanjing, and Hangzhou. Unlike the imperial gardens, the private gardens are urban residences where the gardens and living quarters are quiet retreats within the city (Henderson, 2013). These gardens are relatively small in size compared to imperial gardens, and are famous for their open-space disposition and variety of tropical plants.

Suzhou, a city located in the middle part of China's Yangtze River Delta, has been famous for its classical gardens for many centuries. During the Ming and Qing periods the city was a gathering place for the nation's leading poets and painters, which may account for the number of outstandingly beautiful gardens which brought fame. There is a saying that "South-east gardens are the best in the world, and Suzhou gardens are the best in the south-east." More than a hundred such gardens were recorded in the city's history. There was, of course, a wide range in size of both house and garden, and although Suzhou has under gone much change since the thirteenth century, there is still sufficient of the old fabric remaining for the planning authorities

to wish to preserve and rehabilitate a part of the old city and to recreate the feeling that existed in former times. The most representative gardens in Suzhou include the Humble Administrator's Garden, the Master of the Nets, the Lingering Garden, the Lion Grove, the Surging-Wave Pavilion, the Couple's Garden, the Garden of Cultivation, the Garden of Harmony, and the Mountain Villa of Embracing Beauty. Therefore, in my study, I will focus on the Suzhou gardens for the classical part. The three classical gardens I chose for this study are the Humble Administrator's Garden, the Master of the Nets, and the Lingering Garden. All the three gardens have been registered on the World Heritage List by UNESCO since 1997.

The Humble Administrator's Garden is one of the four finest classical gardens in Suzhou. It was built in the Zhengde Period (1506 – 1521) of the Ming Dynasty by Wang Xianchen. The garden's name refers to its verdant vegetables, which made it a suitable residence for a minor administrator after he retired from government service (Feng and Fan, 2007).

Since its creation, the garden has undergone many vicissitudes and its owners continually changed. Now, the garden includes three parts: eastern part, middle part and western part, covers an area of 5.6 hectares totally (Suzhou Institute of Landscape Architecture Design Company, 2010). The middle part is the most distinguished part of the garden, contains four areas: the Loquat Court, the winding corridors in the northwest corner, the area of the flying bridge in the southwest corner, and the central pond surrounded by numerous pavilions, terraces, halls and studios. The western part contains the sceneries of the Stay and Listen Pavilion, the "with whom

to sit" Pavilion, the Flowering Green Pavilion, the Thirty-Six Pairs of Mandarin Ducks Hall, and the Hall of Eighteen Camellias. The eastern part has few buildings, but its prominent features are its lush forest, natural environment, and open and distant scenery (Liu and Qiu, 2012).

Also, the garden is based on water, and the three parts of the Humble Administrator's garden are connected mainly by water, and each has its own aquatic attractions. The eastern part has a stream that winds between banks planted with peach and willow trees. The middle part has a large lotus pond resembling a natural lake. The majority of the structures in the garden are by water, such as buildings, pavilions, terraces, halls and studios.

Figure 31: The overall plan of the eastern and middle part of the Humble Administrator's Garden. (Copyright ©2010 Suzhou Institute of Landscape Architecture Design Company all right reserved used by permission).

Figure 32：The flying bridge in the middle part of the Humble Administrator's Garden. (Copyright ©2014 Kun Zhang all right reserved used by permission).

Figure 33: The With Whom to Sit Pavilion and Thirty-Six Pairs of Mandarin Ducks Hall in the Eastern part of the Humble Administrator's Garden. (Copyright ©2014 Kun Zhang all right reserved used by permission).

The Master of the Nets, which is located in the Kuojietou Street in the south of Suzhou, was first built in 1140 of the Southern Song Dynasty by Shi Zhengzhi. It is a typical private classical garden that that combines garden spaces and living spaces. The garden area is not big, approximately 0.47 hectares (Suzhou Institute of Landscape Architecture Design Company, 2010). It is an outstanding of "mini-garden" style.

The eastern part of the garden features loft structures, its middle part plants and flowers, and its western part courts and halls (Feng and Fan, 2007). The main area of the garden is centerd on water, and the whole layout is very compact. The relationship between the halls and pavilions in the garden to the square-shaped pond is noted for their variety of being " on, against, near, overlooking, and secluded from" the pond itself (Henderson, 2013). South of the pond includes the small Hill and Osmanthus Fragrance Pavilion, the Washing my Ribbon Pavilion, and the cloudy Ridge. North of the pond includes the Watching Pines and Appreciating Painting Studio, the Prunus Mume Pavilion. We find the Duck Shooting Corridor to the east, and the Moon Comes with Breeze Pavilion to the west (Suzhou Institute of Landscape Architecture Design Company, 2010). The use of proper scale of structures and contrast method, like the handling of closed and open space, make the small garden looks big. The Ming Garden built in the Metropolitan Museum of Art in New York is modeled on the courtyard named "Dianchun" in the northwestern corner of the Master of the Nets Garden. As a result the garden is famous all over the world.

Figure 34: The overall plan of the Master of the Nets Garden. (Copyright ©2010 Suzhou Institute of Landscape Architecture Design Company all right reserved used by permission).

Figure 35: The central pond and its surrounding architectures in the middle part of the Master of the Nets Garden. (Copyright ©2015 Yiwen Xu all right reserved used by permission).

Figure 36: A Courtyard in the eastern part of the Master of the Nets Garden. (Copyright ©2015 Yiwen Xu all right reserved used by permission).

The Lingering Garden, which covers an area of about 2 hectares is located outside the Chang Gate of Suzhou and was first built in 1593 of the Ming Dynasty by Xu Taishi (Suzhou Institute of Landscape Architecture Design Company, 2010).

The garden comprises of four majors parts: eastern part, middle part, western part and northern part. The middle part is the garden's quintessential area with pond, mountains, buildings, pavilions and covered walkways, constitutes the principal scenic spot of the Lingering Garden. The relationship of between the rockery and pond is especially fine here; this part is consistent with *fengshui*, preference for mountains to the north and west with waters flowing to the southeast, with preferred view of the rockery being from the terrace of the Mountain Villa on the south side of the pond (Henderson, 2013). The northern part had a view of natural mountain village, using a bamboo picked fence enclosing a small garden of miniature trees with many famous species. The western part is characteristic of its beautiful hills and ponds. The eastern part is distinguished by its spectacular buildings and courtyards. (Liu and Qiu, 2012). Among these buildings, the Five Peak Celestial Hall for the rare species wood from which it is constructed, is the largest hall in Suzhou garden (Henderson, 2013). Also, the Guanyun Peak, the highest rockery built with Taihu rocks in Suzhou, is the most famous scenic spot located in a courtyard of eastern part of Lingering Garden.

Figure 37: The overall plan of the Lingering Garden. (Copyright ©2010 Suzhou Institute of Landscape Architecture Design Company all right reserved used by permission).

Figure 38: The central pond and the Small Fairy Isle in the middle part of the Lingering Garden. (Copyright ©2014 Yiwen Xu all right reserved used by permission).

Figure 39: The courtyard on the south side of the Five Peak Celestial Hall in the Lingering Garden. (Copyright ©2014 Yiwen Xu all right reserved used by permission).

2.2.2. Modern Gardens

For the modern part, the gardens designed for 2007 Garden EXPO in Xiamen, China were selected in this research. Many well-known Chinese landscape architects were invited to participate in garden design for this Garden EXPO. These modern gardens combine both classical and modern garden design elements. The five modern gardens that were chosen for this study are: Bamboo Garden, Net. Wet. Garden, Learning Garden, Sugar Cane Garden and Landscape New Wave Garden.

The Bamboo Garden was designed by Wang Xiangrong, a professor from Beijing Forestry University. The design focuses on using zigzag walls and wall holes through the site to create a variety of spaces and provide continues scenery change. It brings people similar experience of visual transition and spatial atmosphere as the classical Chinese gardens. It reflects the designer's unique understanding of classical Chinese gardens, as well as his seeking for modern aesthetics (Wang and Lin, 2007). The design focuses on three meticulous aspects of interpretations on isomorphism of space, synonym of elements and similarity of treatments between the Bamboo Garden and classical Chinese gardens through graphic contrast. The contemporary translation of garden elements including corridors, pavilions and walls in shaping the moving, static and continuous space and the continuous use of scenery from obstacle, opposite, borrowed scenery through site design (Zhang and Ren, 2013).

Figure 40: The site photo of the Bamboo Garden. (Copyright ©2014 Jon Burley all right reserved used by permission).

Figure 41: The site photo of the Bamboo Garden. (Copyright ©2007 Chunfeng Lee all right reserved used by permission).

The Net. Wet. Garden was designed by Zhu Jianning, a professor from Nanjing Forestry University. The design focused on three elements: “fishing net”, “wetland”, and “home”. The vast spread of reed is the most distinctive characteristic of the garden. The designer uses three nets layer to increase the space’s richness and variation: “water net”, “path net”, and “fishing net”. The first layer “water net” is the irregular fishing pond contains soil, water and plants, which represents the nature. The second layer “path net” is the elevated bamboo paved pathway, inspired from the fishing boats of the local fisherman. The interweaving “fishing nets” composes the third layer of the space hold up by boat masts, providing a net shadow for the site (Zhu, 2007). The fishing net, fishing pond, wetlands, reeds, boats and wood poles, they all try to bring people back to the nature and a carefree life in their memories.

Figure 42: The site photo of the Net. Wet. Garden. (Copyright ©2007 Chunfeng Lee all right reserved used by permission).

The Learning Garden was designed by Wang Hao, also a professor from Nanjing Forestry University. The concept of this design is to learn from nature and obtain inspiration from nature, and the design tries to merge with architecture, painting, sculpture, and other related elements. It borrows the internal space layout of Lingering Garden, Suzhou, adopts simple and abstract geometric forms in planar composition and lays stress on combination of classical garden details with western modern composition techniques in integrating points, lines and faces in its three-dimensional composition (Wang, Qiu, and Li, 2007).

Figure 43: The site photo of the Learning Garden. (Copyright ©2014 Jon Burley all right reserved used by permission).

Figure 44: The site photo of the Learning Garden. (Copyright ©2014 Jon Burley all right reserved used by permission).

The Sugar Cane Garden was designed by Yu Kongjian, the president and principle designer of Turenscape. This garden is a sinking garden with spiral slope path to create a more closed space. As the sugar can is a main crop in Xiamen, they are planted on the strips of planting sections surrounding the hole in parallel. Local grass is planted on the top of surrounding walls to increase the enclosure of the space (Wang and Lin, 2008). With the sounds from people, birds, dogs and cattle, it creates a laid-back rural life experience for people when they visit the garden.

Figure 45: The site photo of the Sugar Cane Garden. (Copyright ©2014 Jon Burley all right reserved used by permission).

The Landscape New Wave Garden was designed by Zhang Junhua, a professor from Chiba University in Japan. The design concept is "visible nature and invisible nature." The designer applies many traditional meaningful culture elements, such as the symbolism pavement patterns, glass carvings of the eight sceneries in four Chinese characters, and the enframed paintings in this garden design, which is similar to the deep implication design principle in classical Chinese garden designs. Different types of ground covers are used to represent continents, which also

helps to increase the diversity of plants for the site (Zhang, 2007).

Figure 46: The site photo of the Landscape New Wave Garden. (Copyright ©2014 Jon Burley all right reserved used by permission).

2.3 Data Collection

All the traditional and modern Chinese gardens' elements were chosen from literature review and site photos. There are 75 variables totally. The data selection noted the gardens' attributes of different types of architectures, water, rocks, pavement, plants, locations, design principles and other related garden design elements. The following is a list of all the variables.

1. The Great Halls (ting tang)

2. Covered Stone Boat (fang)

3. Viewing Towers (lou ge)

4. Studies (shufang)

5. Covered Walkways (lang)

6. Pavilions (ting xie)

7. Viewing terrace

8. Black tile pavement

9. Brick paving

10. Cracked Ice Stone paving

11. Pebbles area

12. Mosaic pave with special pattern

13. Whitewashed walls

14. Grey Stone Walls

15. Openwork brick walls

16. Curved top walls

17. Zigzag wall

18. Meandering walls

19. Bamboo paved pathway

20. Boardwalk

21. Curved Pathway

22. Straight Pathway

23. Zigzag Bridge

24. Semi-circular bridge

25. Straight Bridge

26. Wall holes with symbolized shape

27. Lattice window

28. Moon Gate

29. Wood carvings

30. Glass carvings

31. Brick carvings

32. Reflecting Pond

33. Stream

34. Fish pond

35. Wetland

36. Island

37. Artificial mountains

38. Sculptural rocks

39. Pond bank rocks

40. Taihu rocks

41. Trees

42. Shrubs

43. Ground covers

44. Turf area

45. Pine

46. Bamboo

47. Plum

48. Magnolias

49. Camellia

50. Crepe myrtles

51. Sweet osmanthus

52. Peony

53. Willow

54. Lotus

55. Reed

56. Sugar cane

57. Moon

58. Clouds

59. Rain

60. Wind

61. Shadow

62. Originally private

63. Public

64. Located in suburban

65. Located in urban

66. Design concept

67. Poem and painting concept

68. Naturalness

69. Varied spaces with visual devices

70. Borrowed scenery

71. Enframed scenery

72. Opposite scenery

73. Contrast

74. Deep implication

75. Abstract geometrical composition

2.4 Analysis Techniques

Cluster analysis is used to determine clusters of similar objects, to find out which objects in a set are similar or dissimilar (Romesburg, 1984). Group similar objects into categories, so that the objects can be understood more easily and the data can be analyzed more efficiently.

To begin the cluster analysis, a statistical analysis software system called SAS was used to generate the principal components analysis (PCA) of all the elements. A principal component analysis is a technique that linearly transforms an original set of variables into a substantiall smaller set of uncorrelated variables that represents most of the information in the original data set (Dunteman, 1989). The output of PCA typically begins with presentation of eigenvalues for all the dimensions in the data set. Eigenvalues correspond to each of the principal components and represent a partitioning of the total variation in the sample. The sum of all the eigenvalues should equal to the number of variables. Eigenvalues greater than 1.0 originating from standardized variables are considered to represent meaningful dimensions, which can be used for further study. Also, the proportion of the sum for any combination of eigenvalues indicates the amount of variance explained by those eigenvalues, meaning that if the eigenvalue proportion of the first principal component is 50 percent and the eigenvalue proportion of the second principal is 40 then the first two principal components together account for 90 percent of the standardized variance.

After determining the useful principal components according to eigenvalues, the table of eigenvectors should be used to obtain the eigenvector coefficients for all the variables. Eigenvectors correspond to each of the eigenvalues and are used to form linear combinations of the variables. Eigenvector coefficients in the table of eigenvectors indicate the correlation of all the variables in each principal component. Each eigenvector coefficient represents the strength of association the variable has with the eigenvalue. If the elements' coefficients are close, the

elements should be more similar; if the coefficients vary widely on the dimension, the elements should be very different.

Once all the meaningful eigenvector coefficients, means and standard deviation were obtained from the SAS software program, standardize the data first to give all variables with the same weight during analysis. It will then transform it to have zero mean and unit variance, for example, using the equation below (Equation1):

Standard score of a variable = $\frac{X - \bar{X}}{SD}$

Where:

X = Each Value of Variable

$\bar{X}$= Mean of the Variable

SD = Standard Deviation of the Variable

Then the score of each observation in every meaningful principal component can be calculated by using the standardized data. The equation is given below (Equation2):

Garden score = $\left[\left(\frac{X_1 - \bar{X}_1}{SD_1}\right) k_1\right] + \left[\left(\frac{X_2 - \bar{X}_2}{SD_2}\right) k_2\right] + \left[\left(\frac{X_3 - \bar{X}_3}{SD_3}\right) k_3\right] + \ldots\ldots$

$+ \left[\left(\frac{X_{74} - \bar{X}_{74}}{SD_{74}}\right) k_{74}\right] + \left[\left(\frac{X_{75} - \bar{X}_{75}}{SD_{75}}\right) k_{75}\right]$

Where:

X_n = Each Value of Variable

$\bar{X}_n$ = Mean of the Variable

SD_n = Standard Deviation of the Variable

k_n = Each Principal Component Coefficient

After applying the equation to get the score of each garden in each principal component, compare the gardens by placing the scores on a scatter graph. Put the scores of one principal component on the horizontal axis and put the scores of another principal component on the vertical axis. The pattern of their intersecting points can graphically show relationship patterns. If there are gardens that can be grouped as a cluster together, it means these gardens are "closer" to each other than they are to the gardens in another cluster or group. Therefore, these garden clusters can be used to identify the similarities and differences of the gardens.

CHAPTER 3: RESULTS

Firstly, the 75 garden elements (variables) and their existence in each of the 8 gardens are displayed in Table 2. If the garden contains the element, then it can get one point for this element, otherwise, it gets zero.

Table 2: List of garden design elements included in the eight selected gardens.

	Classical Garden			Modern Garden				
	Humble Administrator's	**Master of the Nets Garden**	**Lingering Garden**	**Bamboo Garden**	**Net. Wet. Garden**	**Learning Garden**	**Sugar Cane Garden**	**Landscape New Wave**
The Great Halls (ting tang)	1	1	1	0	0	0	0	0
Covered Stone Boat (fang)	1	0	0	0	0	0	0	0
Viewing Towers (lou ge)	1	1	1	0	0	0	0	0
Studies (shufang)	1	1	1	0	0	0	0	0
Covered Walkways (lang)	1	1	1	0	0	0	0	0
Pavilions (ting xie)	1	1	1	0	0	0	0	0
Viewing terrace	1	0	0	1	0	1	0	0
Black tile pavement	1	1	1	0	0	0	1	0
Brick paving	1	1	1	0	0	0	0	0
Cracked Ice Stone paving	1	1	1	0	0	1	0	0
Pebbles area	0	0	0	1	0	1	1	0
Mosaic pave with special pattern	1	1	1	0	0	1	0	1
Whitewashed walls	1	1	1	1	0	1	0	0
Grey Stone Walls	1	0	0	1	0	0	1	0
Openwork brick walls	1	1	1	1	1	1	0	1
Curved top walls	1	0	1	0	0	0	0	0
Zigzag wall	1	1	1	1	0	0	0	0
Meandering walls	1	0	1	0	0	0	0	0
Bamboo paved pathway	0	0	0	0	1	0	0	0
Boardwalk	0	0	0	0	1	0	0	0
Curved Pathway	1	1	1	1	1	0	1	0
Straight Pathway	1	1	1	1	0	1	0	1
Zigzag Bridge	1	1	1	1	0	0	0	0
Semi-circular bridge	1	1	0	0	0	0	0	0
Straight Bridge	1	1	1	1	0	1	0	0

Table 2 (cont'd).

Wall holes with symbolized shape	1	1	1	1	0	0	0	0
Lattice window	1	1	1	0	0	0	0	0
Moon Gate	1	1	1	0	0	0	0	0
Wood carvings	1	1	1	0	0	0	0	0
Glass carvings	0	0	0	0	0	1	0	1
Brick carvings	1	1	1	0	0	0	0	0
Reflecting Pond	1	1	1	1	0	1	1	1
Stream	1	1	0	0	0	0	0	0
Fish pond	1	1	1	0	1	0	0	0
Wetland	0	0	0	1	1	0	0	0
Island	1	0	1	1	0	0	0	0
Artificial mountains	1	1	1	0	0	0	0	0
Sculptural rocks	1	1	1	1	1	1	0	1
Pond bank rocks	1	1	1	0	0	0	0	0
Taihu rocks	1	1	1	0	0	0	0	0
Trees	1	1	1	1	0	1	0	1
Shrubs	1	1	1	0	0	1	0	1
Ground covers	1	1	1	0	0	0	1	1
Turf area	1	0	0	1	0	0	0	1
Pine	1	1	1	0	0	1	0	0
Bamboo	1	1	1	1	0	1	0	1
Plum	1	1	1	0	0	0	0	0
Magnolias	1	1	1	0	0	0	0	0
Camellia	1	1	1	0	0	0	0	0
Crepe myrtles	1	1	1	0	0	0	0	0
Sweet osmanthus	1	1	1	0	0	1	0	0
Peony	1	1	1	0	0	0	0	0
Willow	1	1	1	0	0	0	0	0
Lotus	1	1	1	0	0	1	0	1
Reed	0	0	0	1	1	0	0	0
Sugar cane	0	0	0	0	0	0	1	0
Moon	1	1	0	0	0	0	0	0
Clouds	0	1	1	0	0	0	0	0
Rain	1	0	1	0	0	0	0	0
Wind	1	1	1	0	0	0	0	0
Shadow	1	0	0	0	1	1	0	0
Originally private	1	1	1	0	0	0	0	0
Public	0	0	0	1	1	1	1	1
Located in suburban	0	0	0	1	1	1	1	1
Located in urban	1	1	1	0	0	0	0	0
Design concept	1	1	1	1	1	1	1	1
Poem and painting concept	1	1	1	0	0	1	0	1

Table 2 (cont'd).

Naturalness	1	1	1	0	1	0	1	1
Varied spaces with visual devices	1	1	1	1	1	1	1	1
Borrowed scenery	1	1	1	0	1	0	0	0
Enframed scenery	1	1	1	1	1	1	0	1
Opposite scenery	1	1	1	1	0	1	0	1
Contrast	1	1	1	1	1	1	1	1
Deep implication	1	1	1	1	1	1	1	1
Abstract geometrical composition	0	0	0	1	1	1	1	1

Table 3 illustrates the eigenvalues for the garden elements variables from the SAS software program. The first seven principal component eigenvalue are greater than 1.0, so they are qualified for further study. All other principal components' eigenvalues are 0 and thus are not considered. The eigenvalue associated with the first principal component axis contains 57.66 percent of the variance in the data set and is primary candidate for the further analysis. The second principal component is the secondary candidate, which contains 13.53 percent of the variance. The first two eigenvalues comprise over 71 percent of the variance in the garden elements variables. The principal components from 3 to 7 contain smaller percent but greater than one, they may also merit further study.

Table 3 shows the eigenvectors for the first seven principal components. All the seven principal components contain all the three types of eigenvector coefficients: positive coefficients, negative coefficients and zero coefficients.

Table 3: Principal Component Analysis eigenvalues of the covariance matrix from the SAS Software Program

	Eigenvalue	Difference	Proportion	Cumulative
PRIN1	41.5124321	31.774282	0.5766	0.5766
PRIN2	9.7381501	2.2806378	0.1353	0.7118
PRIN3	7.4575123	1.8862912	0.1036	0.8154
PRIN4	5.5712211	2.4732904	0.0774	0.8928
PRIN5	3.0979307	0.289999	0.043	0.9358
PRIN6	2.8079317	0.9931095	0.039	0.9748
PRIN7	1.8148221	1.8148221	0.0252	1
		……		

On each dimension of the first five principal component, it can be suggested that the dependent variables may be divided into a positive group meaningfully associated with the axis, a negative group meaningfully associated with the axis, and a zero group that associated with both positive and negative groups on the axis.

For the principal component 6, there are two distinctive elements (shadow and covered stone boat), due to they have their coefficients greater than 0.4. Also, principal component 7 contains two distinctive elements (semi-circular bridge and stream) that have their coefficients greater than 0.4.

Table 4: Principal Component Analysis coefficient for each variable from the SAS software program.

Variables	PRIN1	PRIN2	PRIN3	PRIN4	PRIN5	PRIN6	PRIN7
The Great Halls (ting tang)	0.15340	-0.04629	-0.00767	0.00449	-0.01236	-0.01935	0.00640
Covered Stone Boat (fang)	0.07907	-0.02251	0.00642	0.0801	0.11313	0.46317	0.17780

Table 4 (cont'd).

Viewing Towers (lou ge)	0.15340	-0.04629	-0.00767	0.00449	-0.01236	-0.01935	0.00640
Studies (shufang)	0.15340	-0.04629	-0.00767	0.00449	-0.01236	-0.01935	0.00640
Covered Walkways (lang)	0.15340	-0.04629	-0.00767	0.00449	-0.01236	-0.01935	0.00640
Pavilions (ting xie)	0.15340	-0.04629	-0.00767	0.00449	-0.01236	-0.01935	0.00640
Viewing terrace	-0.05538	0.22759	0.07578	0.15873	-0.24377	0.01710	0.00686
Black tile pavement	0.11001	-0.13051	-0.20418	0.04821	-0.05007	-0.00561	0.00411
Brick paving	0.15340	-0.04629	-0.00767	0.00449	-0.01236	-0.01935	0.00640
Cracked Ice Stone paving	0.12702	0.08301	-0.00817	-0.09156	-0.25114	0.08518	-0.00721
Pebbles area	-0.08933	0.11507	-0.13541	0.18728	-0.25739	0.02886	0.00398
Mosaic pave with special pattern	0.10656	0.15456	-0.02400	-0.22284	0.05055	0.04907	-0.01267
Whitewashed walls	0.10387	0.15726	0.06010	0.14647	-0.23041	-0.00405	0.01254
Grey Stone Walls	-0.01309	-0.03234	-0.13026	0.34107	0.06690	0.23793	0.13930
Openwork brick walls	0.05825	0.12953	0.29745	-0.06631	0.0576	-0.01985	0.00315
Curved top walls	0.11750	-0.03439	0.00166	0.05832	0.06240	0.24860	-0.34071
Zigzag wall	0.12208	0.02443	0.05893	0.23774	0.01607	-0.10785	0.02556
Meandering walls	0.11750	-0.03439	0.00166	0.05832	0.06240	0.24860	-0.34071
Bamboo paved pathway	-0.05775	-0.20143	0.23225	-0.09295	-0.05880	0.04303	-0.00756
Boardwalk	-0.05775	-0.20143	0.23225	-0.09295	-0.05880	0.04303	-0.00756
Curved Pathway	0.06933	-0.04868	0.22804	0.06011	0.32016	-0.13516	0.01790
Straight Pathway	0.08859	0.25278	0.04980	0.02034	0.08890	-0.04803	0.00819
Zigzag Bridge	0.12208	0.02443	0.05893	0.23774	0.01607	-0.10785	0.02556
Semi-circular bridge	0.11440	-0.03456	-0.00533	0.00789	0.01017	0.08351	0.48368
Straight Bridge	0.10387	0.15726	0.06010	0.14647	-0.23041	-0.00405	0.01254
Wall holes with symbolized shape	0.12208	0.02443	0.05893	0.23774	0.01607	-0.10785	0.02556
Lattice window	0.15340	-0.04629	-0.00767	0.00449	-0.01236	-0.01935	0.00640
Moon Gate	0.15340	-0.04629	-0.00767	0.00449	-0.01236	-0.01935	0.00640

Table 4 (cont'd).

Wood carvings	0.15340	-0.04629	-0.00767	0.00449	-0.01236	-0.01935	0.00640
Glass carvings	-0.05237	0.22457	-0.01825	-0.25417	0.07034	0.07650	-0.02132
Brick carvings	0.15340	-0.04629	-0.00767	0.00449	-0.01236	-0.01935	0.00640
Reflecting Pond	0.05775	0.20143	-0.23225	0.09295	0.05880	-0.04303	0.00756
Stream	0.11440	-0.03456	-0.00533	0.00789	0.01017	0.08351	0.48368
Fish pond	0.11033	-0.17806	0.14618	-0.05713	-0.05087	0.00972	0.00119
Wetland	-0.07465	-0.07387	0.25402	0.19850	-0.01252	-0.07002	0.01658
Island	0.07778	0.04076	0.07003	0.29320	0.08478	0.13032	-0.28475
Artificial mountains	0.15340	-0.04629	-0.00767	0.00449	-0.01236	-0.01935	0.00640
Sculptural rocks	0.05825	0.12953	0.29745	-0.06631	0.0576	-0.01985	0.00315
Pond bank rocks	0.15340	-0.04629	-0.00767	0.00449	-0.01236	-0.01935	0.00640
Taihu rocks	0.15340	-0.04629	-0.00767	0.00449	-0.01236	-0.01935	0.00640
Trees	0.08859	0.25278	0.04980	0.02034	0.08890	-0.04803	0.00819
Shrubs	0.10656	0.15456	-0.02400	-0.22284	0.05055	0.04907	-0.01267
Ground covers	0.08899	-0.06596	-0.22644	-0.07848	0.25821	-0.04470	-0.00097
Turf area	0.00207	0.12497	0.05737	0.16749	0.41618	0.18547	0.13624
Pine	0.12702	0.08301	-0.00817	-0.09156	-0.25114	0.08518	-0.00721
Bamboo	0.08859	0.25278	0.04980	0.02034	0.08890	-0.04803	0.00819
Plum	0.15340	-0.04629	-0.00767	0.00449	-0.01236	-0.01935	0.00640
Magnolias	0.15340	-0.04629	-0.00767	0.00449	-0.01236	-0.01935	0.00640
Camellia	0.15340	-0.04629	-0.00767	0.00449	-0.01236	-0.01935	0.00640
Crepe myrtles	0.15340	-0.04629	-0.00767	0.00449	-0.01236	-0.01935	0.00640
Sweet osmanthus	0.12702	0.08301	-0.00817	-0.09156	-0.25114	0.08518	-0.00721
Peony	0.15340	-0.04629	-0.00767	0.00449	-0.01236	-0.01935	0.00640
Willow	0.15340	-0.04629	-0.00767	0.00449	-0.01236	-0.01935	0.00640
Lotus	0.10656	0.15456	-0.02400	-0.22284	0.05055	0.04907	-0.01267
Reed	-0.07465	-0.07387	0.25402	0.19850	-0.01252	-0.07002	0.01658
Sugar Cane	-0.05825	-0.12953	-0.29745	0.06631	-0.0576	0.01985	-0.00315
Moon	0.15340	-0.04629	-0.00767	0.00449	-0.01236	-0.01935	0.00640
Clouds	0.11112	-0.03456	-0.01348	-0.05615	-0.10023	-0.37539	-0.12863
Rain	0.11750	-0.03439	0.00166	0.05832	0.06240	0.24860	-0.34071
Wind	0.15340	-0.04629	-0.00767	0.00449	-0.01236	-0.01935	0.00640
Shadow	-0.00765	-0.02094	0.16227	-0.10784	-0.20990	0.45314	0.10243

Table 4 (cont'd).

Shadow	-0.00765	-0.02094	0.16227	-0.10784	-0.20990	0.45314	0.10243
Originally Private	0.15340	-0.04629	-0.00767	0.00449	-0.01236	-0.01935	0.00640
Public	-0.15340	0.04629	0.00767	-0.00449	0.01236	0.01935	-0.00640
Located in suburban	-0.15340	0.04629	0.00767	-0.00449	0.01236	0.01935	-0.00640
Located in urban	0.15340	-0.04629	-0.00767	0.00449	-0.01236	-0.01935	0.00640
Design concept	0	0	0	0	0	0	0
Poem and painting concept	0.10656	0.15456	-0.02400	-0.22284	0.05055	0.04907	-0.01267
Naturalness	0.05538	-0.22759	-0.07578	-0.15873	0.24377	-0.01710	-0.00686
Varied spaces with visual devices	0.05775	0.20143	-0.23225	0.09295	0.05880	-0.04303	0.00756
Borrowed scenery	0.11033	-0.17806	0.14618	-0.05713	-0.05087	0.00972	0.00119
Enframed scenery	0.05825	0.12953	0.29745	-0.06631	0.0576	-0.01985	0.00315
Opposite scenery	0.08859	0.25278	0.04980	0.02034	0.08890	-0.04803	0.00819
Contrast	0	0	0	0	0	0	0
Deep implication	0	0	0	0	0	0	0
Abstract geometrical composition	-0.15340	0.04629	0.00767	-0.00449	0.01236	0.01935	-0.00640

Table 5: The means Procedure from the SAS software program.

Variables	Mean	Std Dev
The Great Halls (ting tang)	0.375	0.5175492
Covered Stone Boat (fang)	0.125	0.3535534
Viewing Towers (lou ge)	0.375	0.5175492
Studies (shufang)	0.375	0.5175492
Covered Walkways (lang)	0.375	0.5175492
Pavilions (ting xie)	0.375	0.5175492
Viewing terrace	0.25	0.46291
Black tile pavement	0.5	0.5345225
Brick paving	0.375	0.5175492
Cracked Ice Stone paving	0.5	0.5345225
Pebbles area	0.375	0.5175492

Table 5 (cont'd).

Mosaic pave with special pattern	0.625	0.5175492
Whitewashed walls	0.625	0.5175492
Grey Stone Walls	0.375	0.5175492
Openwork brick walls	0.875	0.3535534
Curved top walls	0.25	0.46291
Zigzag wall	0.5	0.5345225
Meandering walls	0.25	0.46291
Bamboo paved pathway	0.125	0.3535534
Boardwalk	0.125	0.3535534
Curved Pathway	0.75	0.46291
Straight Pathway	0.75	0.46291
Zigzag Bridge	0.5	0.5345225
Semi-circular bridge	0.25	0.46291
Straight Bridge	0.625	0.5175492
Wall holes with symbolized shape	0.5	0.5345225
Lattice window	0.375	0.5175492
Moon Gate	0.375	0.5175492
Wood carvings	0.375	0.5175492
Glass carvings	0.25	0.46291
Brick carvings	0.375	0.5175492
Reflecting Pond	0.875	0.3535534
Stream	0.25	0.46291
Fish pond	0.5	0.5345225
Wetland	0.25	0.46291
Island	0.375	0.5175492
Artificial mountains	0.375	0.5175492
Sculptural rocks	0.875	0.3535534
Pond bank rocks	0.375	0.5175492
Taihu rocks	0.375	0.5175492
Trees	0.75	0.46291
Shrubs	0.625	0.5175492
Ground covers	0.625	0.5175492
Turf area	0.375	0.5175492
Pine	0.5	0.5345225

Table 5 (cont'd).

Bamboo	0.75	0.46291
Plum	0.375	0.5175492
Magnolias	0.375	0.5175492
Camellia	0.375	0.5175492
Crepe myrtles	0.375	0.5175492
Sweet osmanthus	0.5	0.5345225
Peony	0.375	0.5175492
Willow	0.375	0.5175492
Lotus	0.625	0.5175492
Reed	0.25	0.46291
Sugar Cane	0.125	0.3535534
Moon	0.375	0.5175492
Clouds	0.25	0.46291
Rain	0.25	0.46291
Wind	0.375	0.5175492
Shadow	0.375	0.5175492
Originally Private	0.375	0.5175492
Public	0.625	0.5175492
Located in suburban	0.625	0.5175492
Located in urban	0.375	0.5175492
Design concept	1	0
Poem and painting concept	0.625	0.5175492
Naturalness	0.75	0.46291
Varied spaces with visual devices	0.875	0.3535534
Borrowed scenery	0.5	0.5345225
Enframed scenery	0.875	0.3535534
Opposite scenery	0.75	0.46291
Contrast	1	0
Deep implication	1	0
Abstract geometrical composition	0.625	0.5175492

Table 5 illustrates the mean and standard deviation of all observed variables from the SAS software program. After collecting all the data from the SAS software program, the garden scores can be calculated by plugging the variable values, means, standard deviations and principal component coefficients into the equation. For example, the following is the calculation process for the Humble Administrator's Garden in principal component 1:

$$\text{Garden score} = \left[\left(\frac{1-0.375}{0.517}\right) \times 0.153\right] + \left[\left(\frac{1-0.125}{0.353}\right) \times 0.079\right] + \left[\left(\frac{1-0.375}{0.517}\right) \times 0.153\right]$$

$$+ \ldots\ldots + \left[\left(\frac{0-0.625}{0.517}\right) \times (-0.153)\right] = 8.124$$

Table 6 gives the calculation results of all the garden scores in first seven principal components.

Table 6: Garden scores in first seven principal components.

	Humble Administrator's	**Master of the Nets Garden**	**Lingering Garden**	**Bamboo Garden**	**Net. Wet. Garden**	**Learning Garden**	**Sugar Cane Garden**	**Landscape New Wave**
PRIN1	8.124	7.265	7.386	-4.109	-5.770	-3.342	-3.342	-3.853
PRIN2	-0.543	-0.548	-0.453	2.524	-4.285	4.658	-3.227	2.533
PRIN3	0.119	-0.248	-0.064	1.852	3.630	-0.021	-4.997	-0.913
PRIN4	1.105	-0.962	-0.060	4.865	-1.019	-2.000	1.044	-2.719
PRIN5	0.867	-0.765	-0.217	0.325	-0.285	-2.772	0.250	2.787
PRIN6	3.219	-2.459	-0.919	-0.936	0.177	1.092	-0.154	-0.104
PRIN7	0.799	2.046	-2.815	0.131	-0.013	-0.091	0.025	-0.073

The scatter graph can be used to visually identify clusters. Figure 7 reveals the relationship of all the eight classical and modern gardens, based on the garden scores in the first two principal components. The horizontal axis shows the scores of the first principal component, and the

vertical axis shows the scores of the second principal component. Since the plot of the scores on the first two principal components for the gardens can reveal a clear pattern of clusters already, this research will focus on studying the first two principal components for the garden comparison.

The distribution of the garden scores on figure 7 suggests that there are three clusters of gardens. On the horizontal axis, the gardens are divided into two groups, one positive group and one negative group. The gardens in the positive group are: Humble Administrator's Garden, Master of the Nets Garden, and Lingering Garden, which are all classical Chinese gardens. The five gardens in the negative group are: Bamboo Garden, Net. Wet. Garden, Learning Garden, Sugar Cane Garden and Landscape New Wave Garden, which are all modern Chinese gardens. Therefore, the principal component 1 is the dimension can be used to identify the difference between classical and modern Chinese gardens. As well, the vertical axis separates the five modern garden gardens into two groups: one positive group and one negative group. The positive group contains Bamboo Garden, Learning Garden, and Landscape New Wave Garden. The negative group contains Net. Wet. Garden and Sugar Cane Garden. For the classical gardens, there are no further classifications, thus the second principal component can be considered as the dimension to identify the types of modern gardens only.

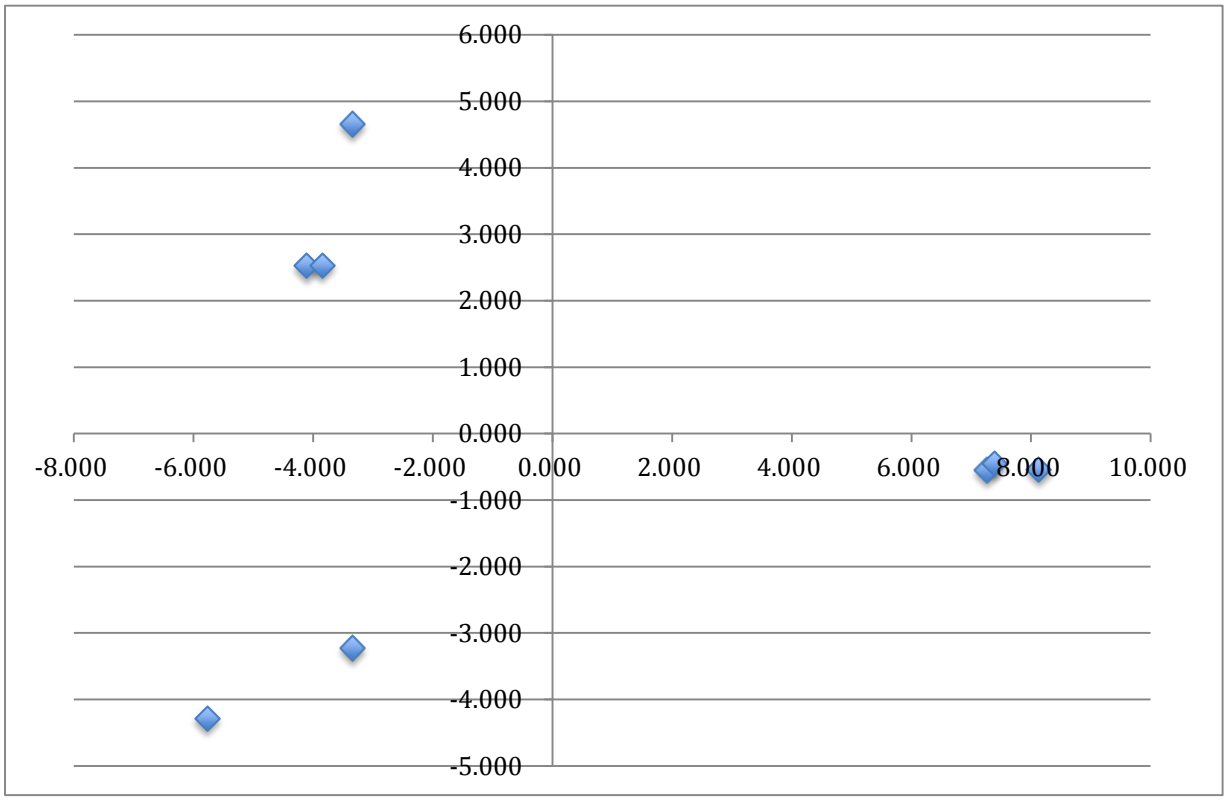

Figure 47: A scatter graph of the relationship of all the eight gardens, based on the garden scores in principal component 1 and 2.

Table 7 and table 8 present the list of positive, negative and zero garden elements in principal component 1 and principal component 2 respectively. According to the analysis from the scatter graph (figure 47), in table 7, the positive elements belong to the classical garden elements group, and the negative elements belong to the modern garden elements group. The elements with zero value indicate that they are the elements that all the eight classical and modern gardens contain in their designs. Similarly, in table 8, the positive elements can be categorized as the elements belong to one type of modern garden, and the negative element can be categorized as the elements belong to another type of modern garden.

Table 7: List of positive, negative and zero elements in principal component 1.

Positive	Negative	Zero
The Great Halls	Viewing terrace	Design concept
Covered Stone Boat (fang)	Pebbles area	Contrast
Viewing Towers (lou ge)	Grey Stone Walls	Deep implication
Studies (shufang)	Bamboo paved pathway	
Covered Walkways (lang)	Boardwalk	
Pavilions (ting xie)	Glass carvings	
Black tile pavement	Wetland	
Brick paving	Reed	
Cracked Ice Stone paving	Sugar Cane	
Mosaic pave with special pattern	Shadow	
Whitewashed walls	Public	
Openwork brick walls	Located in suburban	
Curved top walls	Abstract geometrical composition	
Zigzag wall		
Meandering walls		
Curved Pathway		
Straight Pathway		
Zigzag Bridge		
Semi-circular bridge		
Straight Bridge		
Wall holes with symbolized shape		
Lattice window		
Moon Gate		
Wood carvings		
Brick carvings		
Reflecting Pond		
Stream		
Fish pond		
Island		
Artificial mountains		
Sculptural rocks		
Pond bank rocks		
Taihu rocks		
Trees		
Shrubs		
Ground covers		
Turf area		

Table 7 (cont'd).

Pine		
Bamboo		
Plum		
Magnolias		
Camellia		
Crepe myrtles		
Sweet osmanthus		
Peony		
Willow		
Lotus		
Moon		
Clouds		
Rain		
Wind		
Originally Private		
Located in urban		
Poem and painting concept		
Naturalness		
Varied spaces with visual devices		
Borrowed scenery		
Enframed scenery		
Opposite scenery		

Table 8: List of positive, negative and zero elements in principal component 2.

Positive	Negative	Zero
Viewing terrace	The Great Halls (ting tang)	Design concept
Cracked Ice Stone paving	Covered Stone Boat (fang)	Contrast
Pebbles area	Viewing Towers (lou ge)	Deep implication
Mosaic pave with special pattern	Studies (shufang)	
Whitewashed walls	Covered Walkways (lang)	
Openwork brick walls	Pavilions (ting xie)	
Zigzag wall	Black tile pavement	
Straight Pathway	Brick paving	
Zigzag Bridge	Grey Stone Walls	
Straight Bridge	Curved top walls	
Wall holes with symbolized shape	Meandering walls	
Glass carvings	Bamboo paved pathway	

Table 8 (cont'd).

Reflecting Pond	Boardwalk	
Island	Curved Pathway	
Sculptural rocks	Semi-circular bridge	
Trees	Lattice window	
Shrubs	Moon Gate	
Turf area	Wood carvings	
Pine	Brick carvings	
Bamboo	Stream	
Sweet osmanthus	Fish pond	
Lotus	Wetland	
Public	Artificial mountains	
Located in suburban	Pond bank rocks	
Poem and painting concept	Taihu rocks	
Varied spaces with visual devices	Ground covers	
Enframed scenery	Plum	
Opposite scenery	Magnolias	
Abstract geometrical composition	Camellia	
	Crepe myrtles	
	Peony	
	Willow	
	Reed	
	Sugar Cane	
	Moon	
	Clouds	
	Rain	
	Wind	
	Shadow	
	Originally Private	
	Located in urban	
	Naturalness	
	Borrowed scenery	

CHAPTER 4: DISCUSSION

4.1 Cluster Analysis Method in Garden Comparison

As mentioned in study purpose, most classical and modern Chinese garden design compare studies were undertaken by researcher's own thoughts and understandings of design theories and principles. Little research used mathematic method to compare gardens. This study applied a mathematic method called Cluster Analysis to compare classical and modern Chinese gardens. After collecting data, inputting data in SAS software program, and calculating garden scores, the final graph shows that the gardens can be grouped in three clusters clearly according to their elements variables. The classical and modern Chinese gardens can be identified obviously based on the first principal component, and the modern gardens are divided into two categories based on the second principal component. Thus, the result of this research shows that the Cluster Analysis could be a method to compare gardens, and the quantitative study of garden comparison can have many applications and opportunities in the future.

4.2 Comparison of Gardens and Garden Elements

The most obvious difference between classical and modern Chinese gardens according to the result graph is all the three classical gardens scores are very close but the five modern gardens' scores are relatively much more dispersed. As always, the classical Chinese garden designs were greatly influenced by Chinese landscape paintings and the three main schools of philosophies: Taoism, Confucianism and Buddhism. Although different classical gardens have different design

concepts, their design elements and design principals are still very similar. Thus, there is not much variance among classical Chinese gardens. However, because of the global sharing, the modern garden designs were influenced by a variety of cultures and landscape designs all over the world. These modern gardens also contain the design principles and design elements from other cultures, such as the abstract geometrical composition, a basic design principal in western garden designs. Also, the rapid development of new technology can provide the opportunity for the designers to use more types of new materials and elements to produce the effects they want. Therefore, the modern gardens are not so similar compared to the classical Chinese gardens.

The next marked difference between classical and modern Chinese gardens is the architecture structures. In classical Chinese gardens, architectures are significant elements in their designs. There are many types of architecture in classical gardens, including halls, towers, pavilions and walkways, all of which types are subdivided according to their function and design, and they are all completely integrated with the garden. However, there is no any actual architecture in modern gardens. Modern gardens are more abstract. They use more simple structures like walls to divide space instead of architectures. For example, the bamboo garden focuses on using zigzag walls and wall holes through the site to create a variety of spaces and provide continues scenery change. Also, modern gardens create more open space as resting points like viewing terrace instead of viewing towers and pavilions for people enjoy scenic view. This might be because the classical Chinese gardens were originally designed for private

residence and were played and lived in by few people, but modern gardens were designed for the public so they need more open space for much more amount of visitors.

The use of plants is another major difference between classical and modern Chinese gardens. The plants in classical Chinese garden focus on providing mental, emotional pleasures and presenting beautiful and rich visual effects for people. Most of plants used classical gardens were given personified connotations. For example, magnolia represents elegance and purity, pine represents vigor and longevity, bamboo represents uprightness, plum represents courage, lotus represents purity, and so on. In addition, the variety of plants with rich and varied color changes can create distinctively seasonal landscape attractions in order to give people rich aesthetic experiences. However, the plants in modern gardens are more monotonous, they do not have various types of plants like the classical Chinese gardens. The modern gardens focus more on improving ecology and sustainability for the site by using right plants. According to table 6, the native plants in Xiamen like sugar cane and reed are used as major plants in modern gardens, and wetland is also applied in modern gardens to colleting, storing and purifying stormwater. In addition, grass lawn is not much used in classical gardens, but modern gardens use it much more to achieve the effect of openness and simplicity due to the influence the Western landscape design.

Also, all the classical gardens in this research are originally private residential gardens located in urban areas, and all the modern gardens are public gardens located in suburban areas.

The private gardens were designed for the privilege few, like gentleman scholars, the rich and ranked class of feudal society, and the common people were not able to visit these gardens. Thus, the garden's service objects are extremely limited. However, the modern gardens were designed for the public, and have to meet the functional requirements of the public. The design elements such as meandering and narrow pathways, zigzag bridges, and artificial meandering streams will not easily accommodate large numbers of people and activities inherent in large groups. They need more open space and more convenient pathway for people to go through. Moreover, since this research used two different types of gardens, the further study can choose same type of garden to compare to identify the difference, for example, compare traditional private gardens with modern private gardens, or compare traditional public gardens with modern public gardens.

In addition, the final result suggests the five modern gardens can be subdivided into two groups. One group contains Bamboo Garden, Learning Garden, and Landscape New Wave Garden. The other group contains Net. Wet. Garden and Sugar Cane Garden. By analyzing the positive and negative elements in principal component 2, I could not find a very clear character that can summarize these two different groups. Both groups contain variety kinds of elements, such as natural features, hardscape features, structural features, and scenic features. By further analyzing, I suppose there could be one difference between these two groups, which is one group has more hardscape, and the other one is more naturalistic style. Since the positive group contains the

structural elements with straight lines and geometrical forms, such as zigzag wall, straight pathway, zigzag bridge, and straight bridge, the gardens in this group provide people a more artificial environment. The two modern gardens in negative group seem more naturalistic style. Although this group also contain the artifact features like walls, paved pathways, and bridges, but the shape, form or texture are more naturalistic compared to the positive group. For example, this group contains walls like curved top walls and meandering walls, which are endowed with curvilinear configuration derived from nature. The pavements are made by the more naturalistic materials, such as boardwalk and bamboo paved pathway. Besides that, the negative group includes more variety of plants and natural elements, such as moon, clouds, rain, wind, and shadow.

In addition, we can see there are two gardens are very close on the upper left part of the scatter graph. These two gardens are Learning Garden and Landscape New Wave Garden. They are very close in principal component 1 because both gardens are modern public gardens, so they contain similar design principles and have same garden location. In principal component 2, both gardens contain many elements in positive group which is the more artificial group, such as openwork brick walls, straight pathway, reflecting pond, sculpture rocks, and abstract geometrical composition. However, the Bamboo Garden has more positive elements than the Landscape New Wave Garden, such as pebbles area, whitewashed walls, zigzag wall, zigzag bridge, straight bridge, and so on. And the Bamboo Garden also contains some elements in negative group which is the naturalistic group, such as wetland, reed, curved pathway, and grey

stone walls. Although the Landscape New Wave Garden contains fewer elements, most of the elements are in positive group. Thus, the scores of the two gardens are very close on the graph.

4.3 Future Implication

The research provides a guide for designers and researchers a way to explore the classical and modern Chinese gardens and to apply the findings into their design. The result of this research shows there are three types of gardens, and each contains a list of design elements that make this type of gardens different from others. This list can be a kind of guideline for designers to determine what type of gardens they want to create. For example, if designers want to create a classical style Chinese garden, they can follow the classical garden list in the first principal component and apply the elements to their garden design.

Classical Chinese gardens have a long history, and many people believe that they are representations of Chinese artistic characteristics and cultural value. Fully understanding the design elements and principles in classical Chinese gardens is the premise for the good Chinese garden designers who want to create gardens with Chinese artistic characteristics. Researchers and designers can use the elements in the group of classical Chinese gardens to discover the ways to integrate the culture of the past into the modern designs in this age of globalization, and try to see if the traditional design elements could still effectively serve a modern design inspiration instead of using simple imitation and reproduction.

4.4 Limitations and Suggestion for Future Research

Firstly, the five modern gardens are divided into two categories in this research, but there is no any clear character that can summarize these two different groups. This may be because the access to information on the five selected modern gardens is limited. The literature review and site photos for the data collection are not enough. Because there is only one published book gives some brief introductions of these gardens, it is not possible to include all the design ideas in the book. A lot of information are missing, especially those element that are hard to be found easily like wind, moon, sounds, and other related elements. In addition, due to the bad maintenance of the selected modern gardens, many garden elements had been destroyed or even closed when this research was taken. It is really hard to get enough information about the modern gardens from the site visiting and site photos. Thus, the further study can focus on studying the modern gardens. More data collection methods should be applied for the study. For example, make interviews with those modern gardens designers to check if there is any important element that they did not mention in the published books and need to be added on the list of variables. Also, except these five gardens in Xiamen, involve more modern garden observations in the further research to figure out the difference between these two groups.

Secondly, in this research, the result shows the modern gardens are more dispersed, and the three classical gardens are very close. The small number of classical gardens selected for this research may be the reason. Due to the time limit there are only three classical gardens were

selected for the research. However, there are many other attracting classical gardens in Suzhou, built during the time period from the Northern Song to the late Qing dynasties, can also be used for future research, such as the Surging Waves Pavilion, the Lion Grove Garden, the Garden of Cultivation, the Couple's Retreat Garden, and the Mountain Villa with Embracing Beauty. In addition, this research only took the scholars' private classical gardens in Suzhou as observations. The future research may expand the research to other classical gardens except the gardens of Suzhou. For example, the imperial gardens are another important type of classical Chinese garden, such as the Summer Palace in Beijing, and the Summer Resort in Chengde. The further study can select more classical gardens to test if the classical Chinese gardens are still very close or they will spread out more.

Thirdly, the selection of garden elements used in this research was based on my own understandings and opinions according to the published literature review. This circumstance may have resulted in the data selection is biased on my own opinions. There may be some elements that I think is important, but others do not think so. Thus, the variables collection needs to be improved. The further study should involve more people's opinions, such as garden design professionals. Also, some variables in my research can be subdivided into more variables. For example, I used the design principle of "contrast" as one variable, but it also can be divided into "real and false", "assembling and spreading", "connecting and separating", "open and close", "unevenness and neatness", and so on. The further study can seek more detailed garden variables, and create a

kind of criteria of garden elements for garden study. In addition, most of the variables in my research are invisible elements, such as architectures, water features, rocks, and plantings, and some non-invisible elements should also be considered, such as sound, smell, usability, and familiarity. Thus, Agreement on the extent and types of garden elements needs to be established in further research.

Finally, according to the result of this research, equations can be developed to identify if a garden is classical or modern Chinese garden. Future researchers can select more classical gardens and modern gardens to test the equation. Check if the selected modern or classical garden contain the elements on the list, then substitute the data in the equation. Consequently, check if the garden score from the equation can present the right type of the garden. If the equation can work successfully, then it can be a standard equation to identify Chinese garden types.

BIBLIOGRAPHY

BIBLIOGRAPHY

Burley, J. B. and Kopinski. E. (2014). Villa Lante: Italy's greatest renaissance garden. *The Michigan Landscape*, 57(2:March/April): 27-30.

Burley, J. B., Yue, Z., Wei, S. (2012). Non-Euclidian methods to replicate urban and garden patterns in R.P. of China. *International Journal of Energy*, Vol. 6, pp. 106-114.

Casault, J. and Burley, J.B. (2010). Restored Versailles: A French Garden with a message. *The Michigan Landscape*, November/December: 37-42.

Chen, C.Z. (1984) *On Chinese garden.* Shanghai, PRC: Tongji University Press.

Chen, X. and Wu, J. (2009). Sustainable landscape architecture: implications of the Chinese philosophy of ''unity of man with nature'' and beyond. *Landscape Ecology*, 24(8), pp. 1015-1026.

Dillingham, C. (1991). Stepping out of the scholar's garden: Landscape architecture for modern China. *Habitat International*, 15(3), pp. 67-72.

Dunteman, G. H. (1989). *Principal components analysis*. Newbury Park: Sage Publications.

Engel, D. H. (1986). *Creating a Chinese garden*. London: Croom Helm.

Everitt, B. S., Landau, S., Leese, M. and Stahl, D. (2011) An Introduction to Classification and Clustering, in Cluster Analysis, 5th Edition, John Wiley & Sons, Ltd, Chichester, UK.

Feng, C., & Fan, Y. (2007). *The classical gardens of Suzhou: Suzhou gu dian yuan lin*. Beijing: New World Press.

Feng, S. and Xu, K. (2012). The elaboration of five "perspectives": Application to traditional landscape idea in modern landscape design. *Applied Mechanics and Materials*, pp. 226-228.

Gu, Y. (1994). *A cross-cultural study of Chinese and Western landscape design principles* (Master's thesis, University of Guelph). Retrieved from SLU University Library.

Guo, H. (2001). *The comparison research of Chinese and English landscape garden art*. Huanan: University of Science and Engineering.

Henderson, R. (2013). *The gardens of Suzhou*. Philadelphia: University of Pennsylvania Press.

Huang, J. (2008). Modern design application of Chinese traditional gardening theory of "man living harmony with nature." *9th International Conference on Computer-Aided Industrial Design and Conceptual Design*, pp. 1345-1348.

Ji, C. (1988). *The craft of gardens* (A. Hardie, Trans.). New Haven: Yale University Press.

Jia, L. and Zhao, D. (2012). A reference research on the local traditional garden art for the regional landscape. *Applied Mechanics and Materials*, pp. 174-177.

Johnston, R. S. (1991). *Scholar gardens of China: A study and analysis of the spatial design of the Chinese private garden*. Cambridge, England: Cambridge University Press.

Keswick, M., Jencks, C., & Hardie, A. (2003). *The Chinese garden: History, art, and architecture*. Cambridge, Mass: Harvard University Press.

Leopold A. (1949). *A sand county almanac*. New York: Oxford University Press.

Li, M. (2009). *30 Talks on the Chinese Classical Gardens.* Beijing: China Architecture & Building Press.

Li, Z. (2014). Application of plants in Chinese garden landscape. *Canadian Social Science*, 10(5), pp. 143-145.

Li, Z. (2015). Application of traditional Chinese gardening elements in modern garden design. *Cross-Cultural Communication*, 11(1), pp. 108-111.

Linehan J. R. and Gross M. (1998). Back to the future, back to basics: the social ecology of landscapes and the future of landscape planning. *Landsc Urban Plan,* 42:207–223.

Liu, C., Burley, J. B., and Partin, S. (2014). A metaphor for design: Fishing and seclusion – the Master of Nets Garden. *The Michigan Landscape*. November | December, pp. 32-42.

Liu, F. (1989). A study of Western formal geometric gardens and Eastern informal natural gardens. (Master's thesis, University of Manitoba).

Liu, T., & Qiu, M. (2012). *Classical gardens in China*. New York: Better Link Press.

Lou, Q. (2011). *Chinese gardens*. Cambridge: Cambridge University Press.

Ma, S. (2014). *The continuation of traditional garden design principles into contemporary landscape architecture in China* (Master's thesis, University of Southern California). Retrieved from USC Digital Library.

McHarg, I. L. (1992). *Design with nature*. New York: J. Wiley.

Morris, E. T. (1983). *The gardens of china: History, art, and meanings.* New York: Scribner.

Munakata, K. (1988). Mysterious heavens and Chinese classical gardens. *Anthropology and Aesthetics*, (15), pp. 61-88.

Murck, A., Fong, W., and Metropolitan Museum of Art. (1980). *A Chinese Garden Court: The Astor Court at the Metropolitan Museum of Art*. New York: The Museum.

Musacchio, L. R. (2009). The scientific basis for the design of landscape sustainability: A conceptual framework for translational landscape research and practice of designed landscapes and the six Es of landscape sustainability. *Landscape Ecology*, 24(8), 993-1013.

Naveh, Z. (1991). Some remarks on recent developments in landscape ecology as a transdisciplinary ecological and geographical science. *Landscape Ecology*, 5(2), 65-73.

Pang, J. (2012). *Ideas and tradition behind Chinese and Western landscape design: similarities and differences* (Master's thesis, Swedish University of Agricultural Sciences). Retrieved from SLU University Library.

Peng, Y.G. (1986). Analysis of the Traditional Chinese Garden,) Beijing, PRC: China Architecture and Building Press.

Ren, L. (2013). *Traditional Chinese visual design elements: Their applicability in contemporary Chinese design*. (Master's thesis, Arizona State University). Retrieved from ProQuest.

Rinaldi, B. M. (2011). *The Chinese Garden: Garden Types for Contemporary Landscape Architecture.* Basel: Birkhäuser Press.

Romesburg, H. C. (1984). *Cluster analysis for researchers*. Belmont, Calif: Lifetime Learning Publications.

Sun, X. (1994). The city should be rich in the pleasure of wild nature – a traditional aesthetic concept of China for urban planning. *Ekistics.* 61.364-365, pp. 22-28.

Sun, Y. (2010). *Principles for contemporary Chinese landscape design practice* (Master's thesis, Beijing Forestry University).

Suzhou Institute of Landscape Architecture Design Company. (2010). *Suzhou Gardens*. China Architecture & Building Press.

Tsu, F. Y. (1988). *Landscape design in Chinese gardens*. New York: McGraw-Hill Book Co.

Turner, T. (2011). *European gardens: History, philosophy and design*. Abingdon, Oxon: Routledge.

Wang, A. (1995). *System thinking and Modern design*. Beijing: China Architecture & Building Press.

Wang, G., and Lin C. (2008). *A Creative Journey of Landscape Architects*. Beijing: China Urban Press.

Wang, H., Qiu, B., Li, X. (2007). Learning Garden. *Chinese Landscape Architecture*, 23(9).

Wang, X. and Lin, Q. (2007). Bamboo Garden, the Poetry of Space and the Space of Poetry. *Chinese Landscape Architecture*, 23(9), pp. 26-29.

Yang, B., & Volkman, N. J. (2010). From traditional to contemporary: Revelations in Chinese garden and public space design.*Urban Design International, 15*(4), 208-220.

Yang, H.X. (1982) The Classical Gardens of China: History and Design Techniques, Translated by H.M.Wang. New York: Van Nostrand Reinhold.

Yu, K. (2006). The art of survival: Positioning contemporary landscape architecture in China. *Architecture Journal*, 10, pp. 39-43.

Zhang, D., and Ren, L. (2013). Interpretation of Chinese Classical Garden in modern concept from the Bamboo Garden. *Chinese Landscape Architecture*, Vol.29 No.6, pp. 59-64.

Zhongxin, L. (2014). Application of plants in Chinese garden landscape. *Canadian Social Science,* 10(5), 143-145.

Zhou, W. (1999). *Chinese classical landscape history*. Beijing: Qing-Hua University Publishing.

Zhou, W. (2005). A comparative study on Chinese and Western classical garden arts. *Canadian Social Science*, 1(3), pp. 83-90.

Zhu, J. (1992). Chinese Landscape Gardening. Beijing, PRC: Foreign Languages Press.

Zhu, J. (2005). The modern meaning of Chinese traditional gardens. *Journal of Guangdong Landscape architecture*, 28(2), pp. 6-13.

Zhu, J. (2007). On the Garden of Net and Wetness. *Chinese Landscape Architecture*, 23(9).