A CLUSTER ANALYSIS COMPARISON OF SELECTED TRADITIONAL JAPANESE GARDENS, CLASSICAL CHINESE GARDENS AND MODERN CHINESE GARDENS

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ABSTRACT

A CLUSTER ANALYSIS COMPARISON OF SELECTED TRADITIONAL JAPANESE GARDENS, CLASSICAL CHINESE GARDENS AND MODERN CHINESE GARDENS

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Cluster analysis is a useful mathematical method that has been used to examine the differences or similarities between gardens (Xu Y. , 2015). This investigation aims to test the differences and similarities between traditional Japanese gardens in Kyoto, the classical Chinese gardens in Suzhou, and the modern Chinese gardens in Xiamen, by comparing the design elements and design principles of the gardens. A hundred and thirty-four variables are selected based upon a literature review and the author's personal experience in Kyoto, where the first seventy-five variables are adopted from earlier garden research by Yiwen Xu (Xu Y. , 2015). After collecting the variables and applying the Principal Component Analysis by the software SAS, a group of corresponding eigenvalues are generated. According to the Principal Component Analysis, the first two principal components covered 63.81 percent of the sample variance. The first and second principal component together divided the gardens into three groups: the first principal component indicated similarities between the traditional Japanese gardens and classical Chinese gardens; the second principal component indicated similarities between traditional Japanese gardens and modern Chinese gardens. Therefore, the final result is a group of three two-dimensional scatter graphs, where each point represents a garden's character on two coordinate axes, and the dimensions are generated from the meaningful eigenvalues.

Keywords: Landscape Architecture, Environmental Design, Historic Gardens, Contemporary Gardens, Garden Design, Aesthetic Principles, Cultural Context, Oriental Gardens.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION AND LITERATURE REVIEW

1.1 Introduction

The first impression that many people may have of traditional Japanese gardens is a space which has few flowers, and a sitting area comprised of only sand and rocks, which aims to represent a peaceful and harmonious landscape in the spirit of Zen Buddhism. The arrangement of the rocks in traditional Japanese gardens has attracted many people to understand the principles of visual balances in a continued and a limited space (Weiss, 2010). The context and aesthetic principles of Japanese culture have influenced the evolution of the garden style that resulted in these garden landscapes, which can only be fully understood through deep thinking. Spending time walking and sitting in these gardens is often the best way to understand the spiritual concepts and the conventional rules that have spanned the evolution of Japanese gardens. Although traditional Japanese gardens and classical Chinese share many similar characteristics, few scholars have used a scientific method to illustrate the similarities and differences between them. In order to comprehensively examine the similarities and differences of traditional Japanese gardens, classical Chinese gardens, and modern Chinese gardens, a statistical method called Principal Component Analysis will be used. Therefore, this study can assist in developing a broader understanding of oriental garden designs.

1.2 Literature Review of Classical Chinese Gardens and Modern Chinese Gardens

The classical Chinese gardens can be mainly classified as residential style in southern China and imperial style in northern China (Xu Y. , 2015). Compared to the imperial gardens in Northern China, classical Chinese gardens in Suzhou are typically characterized by a relatively small size of land occupancy (Xu Y. , 2015).

During the Ming and Qing dynasty, Suzhou, a city in southern China, were renowned because they were home to the leading poets and painters of the ancient era (Xu Y. , 2015).

The cultural ambience of Suzhou citizens fostered the practice of classical residential gardens in southern China (Xu Y. , 2015). Many classical Chinese gardens were destroyed during wars and revolutions; however, some private residential gardens were well preserved in Suzhou, and UNESCO evaluated these spaces as representative of world cultural heritage (Liu, Burley, & Partin, 2014).

In the ancient era, the philosophies inherit in Daoism, Confucianism, Buddhism emphasized “seclusion-like thinking” which formed the lifestyles of educated Chinese men. This type of thinking was also widely employed in practices of reading, playing music, painting, and gardening (Liu, Burley, & Partin, 2014). Chinese culture is also famous for a fondness for rocks, stones, and mountains, where rocks and mountains were considered aesthetic pleasures and reminders of the flexible visual experience in daily life (Parkes, 2005). Mountains are considered sacred and the most spectacular representatives of earthly power; this type of energy is re-created in garden spaces by building artificial miniature mountains constructed of strangely shaped rocks (Parkes, 2005). In classical Chinese gardens, a water feature is a significant design element, but great skill is needed to reproduce the metaphor of natural water and mountains in gardens (Liu, Burley, & Partin, 2014).

Names of Chinese gardens are commonly derived from romantic ideas with implied, short, hinting or profound messages. For example, names of classical gardens include Master of Nets garden, Lingering garden, and Humble Administrator’s garden, which were all generated from philosophical concepts (Liu, Burley, & Partin, 2014). During the T’ang dynasty (618-906), a scholar-poet and prime minister, Li Deyu, built a famous rock garden near Luoyang, where he collected and arranged strangely shaped rocks from all over the country. The most incredible rocks in his garden came from Lake Tai (Tai Hu), which were later known as Taihu Rock. Li carved the word “youdao” (possessing the way) on the rocks to dignify them. From that point on, inscriptions on rocks became common practice in China (Shih, 1962).

The classical Chinese gardens are very similar in terms of the design elements and principles, while modern Chinese gardens are varied in terms of design elements and principles because of global exchange and the development of new materials and technology (Xu Y. , 2015). For example, architectural structures are highly valued in the design of classical Chinese gardens, but they are absent in modern Chinese gardens (Xu Y. , 2015).

In 2007, many modern gardens were built for the Garden EXPO held in Xiamen, China. Designed by many outstanding Chinese landscape designers, these gardens were an attempt to combine classical Chinese and modern garden design elements in the modern era, which probably represent the contemporary aesthetics and considerations of garden design in China (Xu Y. , 2015). Xu analyzed three private residential gardens in Suzhou, southern China, registered as World Heritage by UNESCO (Xu Y. , 2015). Further information about classical Chinese gardens and modern Chinese garden is included in Xu's study (Xu Y. , 2015).

1.3 Literature Review of Traditional Japanese Gardens

1.3.1 A Brief History of Traditional Japanese Gardens

The history and culture of Japan has affected and produced the evolution of Japanese gardens. Japanese design principles that integrate natural landscapes and the changing seasons have also influenced Japanese garden design (Makowska, 2014). Two considerations were involved in the creation of Japanese landscape form: one concern was to protect or isolate the inner structures against other activities, which created normal dwellings. The other concern came from the pursuit of an understanding of natural sequences and processes, which led to the invention of formal architecture and sanctified spaces (Treib & Herman, 2003).

Figure 1: A garden setting on gravel paving area in Tenryu-ji temple. (Copyright ©2017 Dexin Chen all right reserved used by permission).

The Japanese gardens were derived from the sanctified space of the Shinto shrine (Treib & Herman, 1993). The history of Japanese gardens can be traced to the grand shrines at Ise in the fifth century, which represented the traditions of both the Chinese and Japanese at that time (Treib & Herman, 1993). For example, the red gateway (torii), which labels the place as a sacred space, evolved from the raised wooden storehouse of Japan; the geometric order of the layout on the North-South axis was imported from ancient China (Treib & Herman, 1993). The adjacent site around the shrines was covered with gravel (Figure 2), was retained as an element of garden planning, and became the formal entry courts (Treib & Herman, 1993). In the shrines, the formal entry courts remained void; in the palaces, these courts were decorated with trees, rocks, ponds, and other elements that came together as a landscape (Treib & Herman, 1993).

Figure 2: A void, open gravel space adjacent to the revered hall in Yasaka Shrine. (Copyright ©2017 Dexin Chen all right reserved used by permission).

1.3.1.1 Nara period

Before the Heian period, Nara was the capital city of Japan in the seventh century (Treib & Herman, 1993). In the seventh century, the T’ang Dynasty was founded and soon became the government for most of the nation because of its splendid culture and military superpower (Brinkley & Kikuchi, 1915). Amazed by the T’ang Dynasty, Japanese emperor Kotoku imported the Chinese culture including religious, architectural, literary, and dress practices (Brinkley & Kikuchi, 1915). Lavish Chinese palaces guided Japanese construction in the Nara period (Treib & Herman, 1993). Buddhism was imported from China sometime during the sixth century, which enriched the Japanese civilization with its worldview (Treib

& Herman, 1993). Furthermore, the philosophical ideas behind religious rituals fostered new art forms in Japan (Treib & Herman, 1993).

Figure 3: Architectural style strongly influenced by T’ang dynasty of China is shown in Byodo-in temple. (Copyright ©2017 Dexin Chen all right reserved used by permission).

For over a thousand years, Japanese civilization used the garden and architectural styles from the T’ang dynasty (Figure 3) (Treib & Herman, 1993). The original gardens from the Nara period are all now gone; however, the remaining paintings and texts from the Nara period recorded the rustic style landscapes and water features with islands and grouped rocks, all of which are reminiscent of the influence of Chinese prototypes (Treib & Herman, 1993). In the Nara period, the Japanese nobility often used boats in the Chinese styled ponds and composed poetry. Recent excavations in Nara provided evidence of the river-style gardens of that period (Treib & Herman, 1993).

1.3.1.2 Heian period

Emperor Kammu moved the capital to Heian-kyo (now Kyoto) in 794, and from then on Kyoto became the capital city for almost a thousand years (Treib & Herman, 1993). The layout followed the Chinese Chang'an city plan (Treib & Herman, 1993). The palace (Figure 4) was placed in the center of the city, and based on this plan, the Gosho (Imperial Palace) was also positioned in the center of the symmetrical city plan of Kyoto (Treib & Herman, 1993). Japanese court life was based on people's imagining of court life in China (Treib & Herman, 1993). *The Tale of Genji (Genji Monogatari)* was a book written in the early tenth century, which described how Chinese Style boating lakes were common in the courts during that time (Treib & Herman, 1993). Nobility also adopted tray landscaping (Bonseki) as an artistic activity during the Heian period (Treib & Herman, 1993).

Figure 4: Architectural style strongly influenced by T'ang dynasty as shown in Kyoto Imperial Palace. (Copyright ©2017 Dexin Chen all right reserved used by permission).

Under comparatively peaceful political conditions, nobility had abundant time to amuse themselves by fashioning their gardens in the Heian period (Treib & Herman, 1993). The Shinden style (Palatial style) of gardening design became the mainstream in the Heian period, and evolved into the Shoin-zukuri style in the Kamakura period (Burley & Machemer, 2016). In the eleventh century, a book called *Sakuteiki* recorded the rules and layout principles of Japanese gardens (Treib & Herman, 1993). According to *Sakuteiki* (Takei

& Keane, 2008), or *Records of Garden Making*, water should flow from the Blue Dragon to the White Tiger, where Blue Dragon symbolizes the east and White Tiger symbolizes the west in the geomancy concepts of the Four Guardian Gods. Using the Four Guardian Gods is a reflection of Japanese culture, which imported the geomancy rules originating from central China (Takei & Keane, 2008). Due to the reduced connection with China, Japanese civilization became more local, and garden styles transformed as a result (Treib & Herman, 1993). For example, the river-style garden from the Nara period became more naturalized by using native plant materials and imitating domestic country streams, rather than the Chinese prototypes (Treib & Herman, 1993).

In the Heian period, Buddhist temples were often built with accompanying gardens (Makowska, 2014). At first, gardens were outdoor spaces for religious ceremonies and concerts. Gardens were framed by and subordinate to the rectangular Buddhist monastery complexes built on a North-South axis. However, the status of gardens and temples was reversed, where temples became subordinate in status to the gardens (Makowska, 2014).

1.3.1.3 Kamakura period and Muromachi period

In the Kamakura period, the samurai (the military class) rose in influence (Treib & Herman, 1993). Their leader, Shogun, became the regent of Japan (Treib & Herman, 1993). In the twelfth century, the Ch'an sect of Chinese Buddhism was introduced in Japan. The samurai favored this form of Chinese Buddhism, which later became known as Zen Buddhism (Treib & Herman, 1993). As a result, the aesthetic of garden design in the Kamakura period was most affected by the spirit of samurai and Zen Buddhism, and an austere and symbolic style replaced the prevailing courtly style derived from the Heian period (Treib & Herman, 1993). For example, the military class did not patronize the boating ponds for activities; in fact, Zen philosophy influenced thought and symbolized gardens for meditation became popular (Treib & Herman, 1993). In addition, the Shinden and Shoin-zukuri style founded the basis of the Samurai (the military class) residential gardening style, which became the predecessor of the classical Japanese residential style (Burley & Machmer, 2016). Zen culture reached its peak in the Muromachi period. Among the various artistic forms derived from the ritual of Zen, the tea ceremony (chanoyu) had the greatest influence on garden design, which fostered the growth in tea gardens (roji) (Treib & Herman, 1993). The Chinese Sung (Song) dynasty had the greatest impact on Japanese arts during the fourteenth century (Treib & Herman, 1993).

Figure 5: Aerial view of Shogun's residence, Nijo Castle. (Copyright ©2017 Dexin Chen all right reserved used by permission).

1.3.1.4 Momoyama period

After the Muromachi period, Toyotomi Hideyoshi controlled the country. The name of the Momoyama period was named after Hideyoshi's residential castle, which was located in the Fushimi Momoyama district (Treib & Herman, 1993).

The aesthetic of refined poverty and simplicity was abandoned. In contrast to the previous period, the primary characteristics of gardens in the Momoyama period were "opulence" and "ornamentation" (Treib & Herman, 1993). Plant materials and rocks were highly cherished as priceless objects; garden workers would sometimes commit suicide or leave the district if the major plant or rock under their care was damaged (Treib & Herman, 1993). Lesser lords devoted valued stones and plants (Treib & Herman, 1993). Thus, Hideyoshi had a great collection of garden materials, and he ordered the gardener, Kentei, to modify the Sambo-in near his castle with the materials (Treib & Herman, 1993). Although the gardener spent almost twenty years trying to arrange the great amount of garden materials, the garden never achieved a harmonious transition between the various elements because there were too many (Treib & Herman, 1993). The Sambo-in best represents the gardens predominant during this period (Treib & Herman, 1993).

1.3.1.5 Edo period & Meiji period

The three imperial architectural styles of the Edo period, the Katsura Villa, the Sento Gosho, and the Shugaku-in Villa best represent the aesthetic principles of this period (Treib & Herman, 1993). The popularity of the Stroll garden style rose, and the mainstream garden styles in this era were elegant and sophisticated (Treib & Herman, 1993). It was also popular to use the display concepts of approaching on the diagonal, hide and reveal, and borrowed scenery in garden design (Treib & Herman, 1993). Because of the end of Japanese isolation during the Meiji period, Japanese traditional culture was heavily impacted by western culture

(Treib & Herman, 1993). As a result, interest in traditional Japanese gardens decreased during this period (Treib & Herman, 1993).

Figure 6: Dry landscape named *Honryutei* in Enkou-ji, imitating a dragon flying among the clouds. (Copyright ©2017 Dexin Chen all right reserved used by permission).

1.3.2 Cultural Context and Aesthetic principles

1.3.2.1 Geography

Japan is an archipelago and this isolated physical location has a strong influence on Japanese culture. For example, the isolated physical location has contributed to unique Japanese internal views, which is expressed in their landscape design and planning (Burley & Machmer, 2016). The native Japanese religion, Shintoism, evolved from animistic beliefs. Shintoism was derived from people's respect for the spirits of Japanese ancestry and specific places (Treib & Herman, 1993). One main concept of Shintoism is that if a place was considered sacred, it should be marked and separated from human residential areas (Treib &

Herman, 1993). A Shinto shrine is a sacred place set for the specific spirit (Treib & Herman, 1993). Compared to Chinese sacred places, Japanese sacred places tend to be implied, rather than enclosed under Shintoism's influence (Treib & Herman, 1993). Noclear boundaries exist between the Shinto Shrine and other spaces; instead a few gates (Torii), fences, straw ropes, and other signs are commonly placed inside Shinto shrines and a wall is constructed that can only be sensed, rather than viewed (Treib & Herman, 1993).

A recent geographical analysis in 2010 researched the 164 renowned Japanese gardens in the Kyoto Basin by using GIS data to find the link between garden locations and the geography of Kyoto (Ogata, Li, & Yamada, 2010). The major finding from this research is that the rock gardens (karesansui type gardens) are located in the alluvial fan; and water gardens (chisen type gardens) are clustered along the piedmont spring zones and the artificial canals of the irrigation system (Biwako sosui) constructed in 1890 (Ogata, Li, & Yamada, 2010). These findings suggest that the hydrological and geological conditions have a large impact in determining the appropriate site for specific types of Japanese gardens (Ogata, Li, & Yamada, 2010).

Figure 7: Naturalness in the pathway to Kasuga-taisha, a Shinto shrine in Nara. (Copyright ©2017 Dexin Chen all right reserved used by permission).

1.3.2.2 Zen Buddhism and Tea

After the practice of drinking tea was imported from China, the Japanese generated the tea ceremony under the influence of Zen Buddhism (Burley & Machmer, 2016). Zen Buddhism was a sect of Buddhism originating from T'ang, China, which is also known as the Ch'an sect of Buddhism (Treib & Herman, 1993). The ritual of Zen and seated meditation (Figure 8) fostered the tea ceremony, and led to the designs of tea gardens and Zen meditative gardens (Treib & Herman, 1993). In fact, the Chinese also developed meditative gardens, but they were not the mainstream gardens in China, as they were in Japan (Burley & Machmer, 2016). In about the 15th century, the Japanese had largely adopted the Chinese culture, including tea ceremonies and Zen Buddhism. The Japanese had also created the concept of Wabi, or Wabi-Sabi, which became a unique Japanese aesthetic culture (Bullen, 2016). Japanese garden design of the Muromachi period were impacted by the influence of a new school of painting which was derived from Zen Buddhist practices (Stefan, Fora, Visoiu, Hernea, & Constantinescu, 2009). As a result, gardens were considered to be akin to the art of landscape paintings and thereby should be viewed statically, the way someone would view a painting (Stefan, Fora, Visoiu, Hernea, & Constantinescu, 2009). Through the study of literature and paintings from ancient Japan, it is apparent that Wabi is an abstract, "nature-based" aesthetic concept reflecting spiritual and ethical ideas of Zen (Bullen, 2016).

Because of the Chinese preference for the sense of the "plain, ordinary or unaffected" and the interaction between Chinese and Japanese culture, the chanoyu (tea masters) developed the design principles of roji in the medieval period (Bullen, 2016). Guided by the aesthetics of Wabi, the system of Chanoyu (Tea ceremony) was developed and the typical place setting for tea activities was called chaya or sukiya (tea house), which was built inside of a roji (tea garden) (Bullen, 2016). The setting of roji integrated Chinese philosophy and literary theory including Confucianism, Daoism (Taoism) and Buddhism, along with Zen principles of simplicity and the exclusion of bright colors. Roji aimed to provide "unaffected naturalness and ordinariness" and the design principles presented wabi aesthetics (Bullen, 2016). In general, Wabi could be used to describe the condition of a sense of loneliness, outside of society and materiality, focused on spiritual freedom, the evanescence of life, imperfection, impermanence, rustic beauty, and the elegant simplicity of natural elements (Juniper, 2003).

Figure 8: Meditation by sitting in front of the Zen garden in Ryogen-in, a sub-temple of Daitoku-ji. (Copyright ©2017 Dexin Chen all right reserved used by permission).

1.3.2.3 Geomancy Rules

Geomancy (Fengshui) also affected the design plans of traditional Japanese gardens. For example, a stream that ran from east into a pond and emptied to the southwest of a garden usually satisfied the principles of geomancy (Treib & Herman, 1993). In the 11th century, a book called the *Sakuteiki* recorded the Taoist, Shinto and Buddhist influences of garden rules and layout principles (Treib & Herman, 1993).

The geomancy rules reflected in traditional Japanese garden designs originated in ancient China (Takei & Keane, 2008). The geomancy rules act as an explanation of the existence and inner workings of all things and a divination to guide man's plans (Takei & Keane, 2008). There are three geomancy theories that guided the garden designs in *Sakuteiki*: Yin Yang (Theory of Mutal Opposites), Wuxing (Theory of Five Phases), and Yi (Theory of changes) (Takei & Keane, 2008). According to *Sakuteiki*, it was believed that the earth is the lord of water. Thus, the stream serves the mountain, and the stones would be the mountain's counsellors; the mountain is complete when it contains stones (Takei & Keane, 2008). In this example, the Five Phase theory is used as the prototype for garden design (Takei & Keane, 2008).

Geomancy has a long history of being widely applied in East Asia as an approach to explain natural phenomena and seek the balance between the human and the natural environment (Kalland, 1996). Geomancy has also been used as guidance for urban planning, housing designs, and grave designs (Kalland, 1996). Although geomancy was often related to superstition, geomantic principles can still be found in many architectural and planning practices (Kalland, 1996). A study of Geomancy and town planning in 1996 found that Japanese villages are typically planned using the geomancy terms, including the flow of vital energy, yin and yang forces, the five basic elements of nature, and the pursuing of the mutual benefit of the human and natural environments (Kalland, 1996).

Other than the geometric order of construction style and Buddhism, the idea of vertical disposition of rock clusters was also imported from China (Treib & Herman, 1993). The Chinese attitude toward landscape was to treat the garden as a three-dimensional painting, and to view the landscape using one's mind instead of physical feelings (Treib & Herman, 1993). Therefore, the main purpose of the design was to provide people with the impression of a landscape (Treib & Herman, 1993).

1.3.2.4 Imitation of Natural Landscapes

According to *Sakuteiki* (Takei & Keane, 2008), which was a garden design book written nearly a thousand years ago, the core of Japanese gardens is the art of setting stones (Takei & Keane, 2008). At that time, when designing a garden, one was expected to aim to create a subtle atmosphere, reflect wild nature, and re-create the essence of the famous landscapes of Japan (Takei & Keane, 2008). It was believed that if people broke the conventional architecture rules, their households would become disordered (Takei & Keane, 2008). For example, according to the rules of *Sakuteiki*, stones taller than ninety centimeters should not be set close to buildings (Takei & Keane, 2008). Aside from using a pond or stream as the major feature of a garden, another method of creating gardens included following the Dry Garden Style, which involved setting stones in a small area without water features in a larger garden (Takei & Keane, 2008). However, this garden style (*kara sanzui*) is somewhat different from the *kare sansui* in Zen temples (Figure 9) and the residences of the warrior class in the later era, where designers imitated landscapes as expressed in ink paintings (Takei & Keane, 2008).

Figure 9: Rock settings and dry landscape in Daitoku-ji temple. (Copyright ©2017 Dexin Chen all right reserved used by permission).

1.3.3 Traditional Japanese garden styles and functions

1.3.3.1 River-style garden (Yarimizu)

Similar to the T'ang prototype, a river-style garden (Figure 10) featured a riverway or stream with rock outcroppings to form a pond (Treib & Herman, 1993). The earliest known written book of Japanese gardens, the *Sakuteiki*, recorded the rules of how to construct a river-style garden: struck stones would make water change directions and dash; it was considered preferable to place stones in a manner so that the feeling gradually changes (Treib & Herman, 1993). The nobility of that period tended to own such gardens (Treib & Herman, 1993).

Figure 10: River style garden in Kyoto Imperial Palace. (Copyright ©2017 Dexin Chen all right reserved used by permission).

1.3.3.2 Shinden style Garden (Palatial Architecture)

Shinden style is a unique garden design style of Japanese palatial architecture which began in the Heian period. Shinden style architecture usually consists of a group of symmetrically arranged rectangular buildings and pavilions, which are connected by the covered corridors with courtyards or atriums, and the structures are placed in a geometric U-shape around a large central court (Burley & Machmer, 2016). The style is very similar to the ancient Chinese and Korean palatial design practices. Another design concept of the Shinden style is using the enclosed buildings to define the landscape (Burley & Machmer, 2016). The outdoor space, or the main court of the architecture, usually includes a stream or large boating pond as the major feature to mimic greater natural landscape forms (Burley & Machmer, 2016). The ponds later became the center of the strolling gardens (Burley & Machmer, 2016).

1.3.3.3 Shoin-Zukuri Style Garden

The Kamakura period started after the Heian period, where the samurai and their leader, shogun, became the new noble elite (Burley & Machmer, 2016). Due to the political change, the culture of simplicity and devotion to duty was promoted, while personal pleasure was discouraged (Burley & Machmer, 2016). As a result, the architectural style turned to small scale designs. The gardens and the buildings from the Kamakura period share these common characteristics: small, quiet, and asymmetrical (Burley & Machmer, 2016).

Shoin-Zukuri style is a smaller asymmetrical residential design style that evolved from the large, symmetrical Shinden style (Burley & Machmer, 2016). Shoin-Zukuri style is considered an important innovation of Japanese architectural design because it uses the enclosed landscape to define the buildings and make the buildings themselves features. This stands in contrast to the Shinden style (Burley & Machmer, 2016).

In the Shoin-Zukuri style, the main garden is usually secluded and the ponds are smaller than in the Shinden style; ponds tend to include reflection ponds or fish ponds; Shoji-screens are placed to blend the indoor and outdoor spaces; and dwelling walls are designed as picture windows (Burley & Machmer, 2016). Although it was a new design feature for the Japanese ton use screens, the Chinese started to use screens during the Zhou dynasty (Burley & Machmer, 2016). The Dojinsai Tea Room within Ginkaku-ji in Kyoto is an example of Shoin-Zukuri style (Burley & Machmer, 2016).

1.3.3.4 Zen Garden

By the 12th century, during the Kamakura period, the Ch'an sect of Chinese Buddhism, which is also known as Zen Buddhism, was introduced in Japan and became a part of Japanese cultural practices (Burley & Machmer, 2016). At that time, the military class (samurai) favored and accepted because of the devotion to simplicity and duty inherent in Zen beliefs (Treib & Herman, 1993). The principle of Zen focused on the philosophy in daily life, which pursues austerity, eternity, and simplicity (Treib & Herman, 1993). Zen and its related aesthetics had a great influence on the Japanese arts including gardens, where gardens became places merely to be viewed (Treib & Herman, 1993). The gardens influenced by Zen were set for a series of perspectives, and the viewpoints were tightly controlled (Treib & Herman, 1993). One of the first gardens that presented the Zen influences was included in Tenryu-ji, where the pond garden was created in the Heian style, and the vertical arrangement of rock clusters was derived from Chinese aesthetics of the Southern Sung dynasty (Treib & Herman, 1993). Later gardens like Ryoan-ji, continually diminished the number of garden materials until rock and gravel were highlighted as the primary features of the gardens (Treib & Herman, 1993). In addition, Buddhist temples were often located near Shinto Shrines, which implies that Buddhism and Shintoism have a harmonious relationship in Japan (Burley & Machmer, 2016).

In the Muromachi period, the principle of a dry garden was developed for meditative use by providing symbolic space (Treib & Herman, 1993). The dry gardens mimic the natural Japanese landscape by contrasting “flat water” with “undulating mountains,” which are displayed as sand, gravel, pebbles, and rocks (Burley & Machmer, 2016). The dry gardens provide a symbolic sense of archipelago through pure abstract views at a small scale (Burley & Machmer, 2016). In the Edo period, the capital city was moved from Kyoto to Edo (now Tokyo), where the natural landscape was very different (Burley & Machmer, 2016). The rocks of the dry gardens were replaced by nicely trimmed shrubs because of the lack of rock formations in Edo (Burley & Machmer, 2016). Most of the Zen gardens (Figure 11) provided a sense of enclosure through walls, and the sense of enclosure also came from the function of the gardens during a civilly tumultuous period in Kyoto, where walls defined spaces for tranquility (Treib & Herman, 1993).

Figure 11: Moss featuring Zen garden with sitting area named *Ryugintei* in Ryogen-in, a sub-temple of Daitoku-ji. (Copyright ©2017 Dexin Chen all right reserved used by permission).

Zen garden design includes a seating area that guides and limits people to sit down, view the area, and meditate, such as the roofed veranda in the Ryoan-ji garden (Treib & Herman, 1993). By viewing the miniature landscape, people can stay and engage in self-reflection in the dry gardens and enjoy the space of simplicity and tranquility (Burley & Machmer, 2016). In general, the experience is provided by both the scenery and the mind (Treib & Herman, 1993). The temple corridors serve as both walkways and sitting areas, and in this way, the perspective of view is changed and determined through the action of sitting, standing, or walking (Weiss, 2010). These gardens are small; thus, people are able to easily realize the large visual differences between viewpoints because the view changes as one moves (Weiss, 2010).

1.3.3.5 Tea Garden (Roji)

Importing tea from China to Japan possibly dates back to the fifth century (Treib & Herman, 1993). The Japanese modified it with their own traditions and developed another unique Japanese cultural practice, the tea ceremony (Treib & Herman, 1993). Chinese cultural philosophy and Chinese artifacts, including Chinese paintings, were imported to Japan and fostered the aesthetics of the tea ceremony (Bullen, 2016).

About 800 years ago, the Japanese Buddhist monks drank tea to stay concentrated through meditation and this act fostered the tea ceremony in Japan (Burley & Machmer, 2016). In the sixteenth century, tea masters modified the ritual of the tea ceremony according to their preferences (Treib & Herman, 1993). The Chanoyu masters regularly practiced the tea ceremony, which was typically held in a teahouse (Chaya, sukiya) within a roji (tea garden) (Bullen, 2016). Through a series of acts of tea making that follows sophisticated rules, the tea ceremony allows people to share emotions and focus their minds (Sakuae & Reid, 2012). Recent findings reflect that such a specific place for occupational engagement encourages a pause in usual routines, engages learning skills, and fosters connection between people (Sakuae & Reid, 2012). With the increasing popularity of tea drinking, tea tasting parties were held for introducing various tea species and tastes while testing the sophistication of the guests (Treib & Herman, 1993).

A tea garden (Figure 12) is a specific place for tea a ceremony, where people can empty their mind for simplicity while making tea (Sakuae & Reid, 2012). The size of roji varies greatly, but the setting of roji was standardized in the Edo period, where a fence blocked roji from the outside world (Bullen, 2016). The composition of roji implies "inward-focused and sealed environments" (Bullen, 2016). Roji includes:

> "…a small waiting house (machiai), an 'outer garden' (soto niwa) containing an outside waiting arbour (koshikake machiai), a fence with a 'middle-gate'

(chūmon), and an ‘inner garden’ (uchi niwa), which contains a water-basin and teahouse, a pathway leads from machiai, through the chūmon to the entrance of the teahouse” (Bullen, 2016).

Figure 12: A tea house in a bamboo fenced *roji* located in Shisen-do. (Copyright ©2017 Dexin Chen all right reserved used by permission).

At first, the tea house was developed as a proper setting for a tea ceremony, and a dew path that surrounds the tea house was called the tea garden (roji) (Treib & Herman, 1993). The tea garden functioned as a path that led people to the tea house, rather than serving as an embellished garden for people to admire (Treib & Herman, 1993). In addition, the aesthetic of Wabi-Sabi had a great impact on the tea garden and tea house design, which pursued the art of the simple life with insufficient materials (Bullen, 2016). Tea gardens were used to differentiate the space for the tea ceremony from other gardens in the garden complex

(Burley & Machmer, 2016). In a way, the dew path itself provided a transition of the psyche (Treib & Herman, 1993).

1.4 Design Rules and Major Features in Traditional Japanese Gardens

1.4.1 Borrowed scenery (Shakkei)

The concept of borrowed scenery (Figure 13) was first used in the Tenryu-ji garden (Treib & Herman, 1993). To fit the design site into the surrounding landscape without destroying the rural natural environment, the idea of the Tenryu-ji garden borrowed from distant landscape elements and incorporated them into the design of the site (Treib & Herman, 1993). When a garden is created in the foreground of a building, using plants, walls or hedges to block the undesirable views in the middle ground ensures a smooth transition from foreground to background. For example, the two mountains, Arashiyama and Kameyama, which are behind Tenryu-ji in Kyoto, are seen as part of the garden (Treib & Herman, 1993). In this case, the borrowed mountains integrate with the designated pond, rocks and plants harmoniously (Treib & Herman, 1993). In the early Edo period, the borrowed scenery design was skillfully used in garden designs, including Shoden-ji, Entsu-ji and the upper garden of Shugaku-in (Treib & Herman, 1993).

Figure 13: The mountain is borrowed as background in this view as *Borrowed Scenery* in Tenryu-ji temple. (Copyright ©2017 Dexin Chen all right reserved used by permission).

1.4.2 Hide and Reveal

The concept of hide and reveal existed in the garden of Sento Gosho of the Edo period (Treib & Herman, 1993). In Sento Gosho, the direction of the pathway first turned left to grant a view of a tree, and then turned right to grant a view of a group of rocks on the pond. Following the view of the pond, the path then approached stepping stones which encourages people look down. Finally, a building emerged in the front (Treib & Herman, 1993). In addition, due to the different views of the four seasons, some designated views could only be seen during a specific season, and the entire design intent could only be revealed over time (Treib & Herman, 1993).

Figure 14: The whole view is blocked by a wall, but a part of it is exposed. Photo taken in Kyoto Imperial Palace. (Copyright ©2017 Dexin Chen all right reserved used by permission).

1.4.3 Rock positions

The most attractive element of the dry landscapes, or rocks, are “randomly” positioned under a kind of traditional gardening rule, which aims at exhibiting the abstract concept of traditional Japanese culture and simplicity (Van Tonder, Lyons, & Ejima, 2002). It is the unconscious perception that leads to the mystical appeal of the garden (Van Tonder, Lyons, & Ejima, 2002). One famous example is the Ryoan-ji rock garden (Figure 15), where the fifteen rocks were placed in a sophisticated composition (Treib & Herman, 1993). The myth of rock arrangement is that one rock is always hidden when viewing the rock garden from any point of the seating area (veranda) (Treib & Herman, 1993).

Although entering is prohibited in most of the Zen gardens, walking and sitting are integrated into the garden design (Weiss, 2010). In Ryoan-ji, mobility became part of the myth of the rock arrangement in the Zen garden, because only fourteen out of fifteen rocks in total are visible from any perspective (Weiss, 2010). The incessant motions of people influence the meditation process (Weiss, 2010).

Figure 15: Zen garden in Ryoan-ji temple. (Copyright ©2017 Dexin Chen all right reserved used by permission).

According to *Sakuteiki* (Takei & Keane, 2008), large stones should typically be set adjacent to a water fall, on the tip of an island or at the rear of a hill (Takei & Keane, 2008). Solitary stones (hanere ishi) should be set on a stone shore, at the foot of a hill or at the tip of an island (Takei & Keane, 2008). Furthermore, solitary stones can also be set in water with a foundation. First, one should set several large stones in a triangular shape under the water surface. Then, one should set the solitary stone in the center of the triangle, and finally place foundational stones around the solitary stone (Takei & Keane, 2008). Most of the stones in the garden are set horizontally. (Takei & Keane, 2008).

1.4.4 Water Features (*Sakuteiki*)

According to *Sakuteiki* (Takei & Keane, 2008), a water level should be established before construction (Takei & Keane, 2008). In the design plan, the surface of the pond should be set twelve to fifteen centimeters below the bottom edge of the veranda of the fish pavilion, so that the exposure percentage of a given stone can be controlled through the water level (Takei & Keane, 2008). Moreover, the soil base under the stones must be strengthened with foundation stones. In this way, the stones are able to last for a long time and even if the pond is drained, the stones will look like they were well set (Takei & Keane, 2008). This technique is found in Tenryu-ji: when the pond is drained during reparation, the foundation stones are revealed (Takei & Keane, 2008). When designing islands in a pond, if set stones along the edge of the island are built, the stones will fail after the water is added (Takei & Keane, 2008). One should set stones around the desired edge of the island, and gradually identify the shape of island (Takei & Keane, 2008). There are many styles of islands including Mountain Isle, Meadow Isle, Forest Isle, Rocky Shore Isle, Cloud Type, Mist Type, Cove Beach Type, Slender Stream, Tide Land, and Pine Bark (Takei & Keane, 2008).

Figure 16: An island with its reflection in the pond. Photo taken in Kyoto Imperial Palace. (Copyright ©2017 Dexin Chen all right reserved used by permission).

When a waterfall is established, one should choose a Waterfall stone which allows water to fall over and is rough, while harmoniously fitting the Bracketing stones (Takei & Keane, 2008). If the major viewpoint is from the right side, set a pretty stone of appropriate height above the left Bracketing stone (Takei & Keane, 2008). On the opposite side, set the stone above the right bracketing stone to achieve the best visual result (Takei & Keane, 2008). The low waterfalls that expose the source of the water stream lack depth and become unimportant (Takei & Keane, 2008). Waterfalls look best if they appear unexpectedly from narrow splits between half-hidden stones in shades (Takei & Keane, 2008).

During the T'ang dynasty of China, the Chinese always built wellsprings in residences to bring in coolness in the hot weather (Takei & Keane, 2008). The wellsprings often appeared in the form of the mystic mountain, Hōrai, or flowed out of the mouth of animal sculptures (Takei & Keane, 2008). A Buddhist story in ancient India revealed that the Earth Goddess, Kenrō Jishin, was ordered to build a wellspring in the monastery garden, Gion Shōja, which is called the Sweet Spring (Takei & Keane, 2008). In Japanese gardens, it is better to set a roof above the wellspring, a pipe inside the wellspring to push the water flow, and a small, slatted deck to let water pass through (Takei & Keane, 2008). An artificial wellspring can be used to fill a well when a large water tank is constructed beside the well (Takei & Keane, 2008).

Figure 17: Stone hand wash basin in Tenryu-ji. (Copyright ©2017 Dexin Chen all right reserved used by permission).

The Chinese classics books, Four Books/Five Classics and the Four Guardian Gods theory underlie the decision to have the water flow in different directions (Takei & Keane, 2008). According to the books, water should flow from East to South, and then West (Takei & Keane, 2008). The stones in the garden stream should not follow a uniform pattern or be gathered in a crowd; they must be stuck deeply into the riverbed (Takei & Keane, 2008). These stones can be divided into five types: Bottom Stones, Water-Splitting Stones, Foundation Stones, Crosswise stones, and Spillway Stones (Takei & Keane, 2008).

1.4.5 Clipped Bushes

In the Edo period, bushes were clipped to maintain a certain shape as a design feature (Treib & Herman, 1993). Gardeners would selectively pluck the blossoms of the bushes to balance the color that changed the space (Treib & Herman, 1993). For example, the traditional dry garden in Konchi-in was composed of a large clipped shrub on a raked gravel plane, which was thought to be a transitional form of “dry and planted garden traditions” (Treib & Herman, 1993). In contrast to using topiary as living statues in western traditions, another example of using clipped plant material as a design feature is found Daichi-ji, where the hedge was clipped to represent a dragon or wave and became the major feature of the garden (Treib & Herman, 1993).

1.5 Conclusion

Over time, the traditional Japanese gardening construction and design system became a cultural product since its development in ancient Japan (Burley & Machmer, 2016). The traditional Japanese gardens constructed during modern times essentially repeated the ideas embellished in the traditional design styles (Burley & Machmer, 2016).

In 1853, Japan opened ports to the west for trade and decided to promote its cultural dissemination by exporting cultural products, such as the Japanese gardening culture (Goto, Ristovska, & Fujii, The Japanese garden at Sonnenberg: the first traditional private Japanese garden in North America, 2014). The *Nihon Fakeiron* (Japanese Landscape) written by Shiga Shigetaka, demonstrated the traditional Japanese elements that had become an inseparable part of the Japanese people and geography (Gavin, 2000). Shiga highly valued the potential of promoting the Japanese landscape to raise national awareness and Japan’s position in the world order (Gavin, 2000). In fact, Japanese-style gardens have grown tenfold outside of Japan compared to the number of Chinese-style gardens constructed outside China since the 1860s (Gregory Kenneth Missingham Faculty of Architecture, 2007). The primary reason for the large growth in Japanese gardens compared to Chinese gardens may be that access to Japanese gardens and the ability to learn traditional garden designs in Japan was easier than entering the Chinese gardens in China or learning Chinese gardening designs (Gregory Kenneth Missingham Faculty of Architecture, 2007). Some Chinese gardens were private gardens that were not open to the public; in contrast, many Japanese gardens were located in places for public worship, such as at Buddhist temples and Shinto shrines (Gregory Kenneth Missingham Faculty of Architecture, 2007). Also, a series of educational aids, including monasteries and university programs were provided in Japan for foreigners interested in Japanese gardens; but many Chinese craft traditions vanished with the fall of the imperial system (Gregory Kenneth Missingham Faculty of Architecture, 2007). The spread of traditional Japanese gardens was aided in many aspects, while the construction style of Chinese gardens was outside of the knowledge of many western countries.

In conclusion, the key principle of traditional Japanese gardens is the spatial relationship between structure and landscape, where the aesthetic and spaces are implied instead of stated (Treib & Herman, 1993). The abstract view consisted of the mutual relationship, not the physical component (Treib & Herman, 1993). It should be understood that a traditional Japanese garden required a great deal of maintenance, otherwise the views that provided a sense of naturalness would rapidly disappear (Treib & Herman, 1993). After perceiving and adopting many aspects of the ancient Chinese cultural rules for gardening, including geomancy rules, aesthetics, and architectural styles, Japanese gardens developed their own characteristics (Treib & Herman, 1993). In the Edo period, the design principles and construction rules of the traditional Japanese garden were almost fully finalized (Treib & Herman, 1993). Although the traditional Japanese gardens also followed a constructed design style, each garden tended to be unique (Treib & Herman, 1993). The traditional gardens and ancient city planning reflected the culture and history of Japan (Treib & Herman, 1993). Kyoto was the capital city in the foundational periods of the Japanese garden style (Treib &

Herman, 1993). Thus, an analysis of the ancient architectures in Kyoto is necessary to provide a complete overview of traditional Japanese gardens.

In 2003, a study was conducted to evaluate people's impressions of classical Chinese and traditional Japanese gardens using a series of surveys and scientific methods (Zhao, Matsumoto, Liu, Yuan, & Kawata, 2003). The study from 2003 (Zhao, Matsumoto, Liu, Yuan, & Kawata, 2003) was based on a literal understanding of gardens, and the author did not look into the garden design process and design elements. Therefore, the current study aims to understand the design elements and principles using a statistical method to compare Chinese gardens and Japanese gardens.

CHAPTER 2: METHODOLOGY

2.1 Purpose of Study

This research utilizes Principal Component Analysis to gain a better understanding of the mutual relationship between oriental gardens, and to compare traditional Japanese gardens, classical Chinese gardens, and modern Chinese gardens. The primary goal of this research is to seek the similarities or differences between the selected gardens and develop theories as to what makes these gardens similar or different from the distinguishable garden elements. Moreover, the distinguishable garden elements are considered the primary indications of authenticity in traditional Japanese garden designs. Through integration of the results from the principal component analysis and literature review, the aesthetic evolutions of oriental garden designs can be suggested. Previous research using cluster analysis, generated through principal component analysis, includes Yiwen Xu’s study of Chinese gardens (Xu Y. , 2015) and Haoxuan Xu’s study of burial sites (Xu H. , 2017).

There primary goals of this research include:

1. Analyze the mutual relationship between traditional Japanese gardens and classical Chinese gardens;
2. Analyze the mutual relationship between traditional Japanese gardens and modern Chinese gardens;
3. Discuss the major design elements that divide or bring together the selected gardens.

2.2 Study Sites

2.2.1 Classical Chinese Gardens in Suzhou and Modern Chinese Gardens

In this study, the three classical Chinese gardens in Suzhou and five modern Chinese gardens in Xiamen as described in Xu’s study are selected as study objects (Xu Y. , 2015). The three Chinese gardens are the Humble Administrator’s Garden, Master of Nets Garden, and Lingering Garden. The five modern Chinese gardens are the Bamboo Garden, Net. Wet.

Garden, Learning Garden, Sugar Cane Garden, and Landscape New Wave Garden. Detailed information about each of these Chinese gardens is illustrated in Xu's study (Xu Y. , 2015).

2.2.2 Traditional Japanese Gardens in Kyoto

The Chinese had the greatest influence during the Nara period. After the Nara period, the Heian period began and the emperor Kammu moved the capital city from Nara to Kyoto. Kyoto was developed based on the symmetrical plan of the capital city of the T'ang dynasty, Chang'an, and it became the capital city of Japan for almost a thousand years. Comparing the maps of Chang'an and Kyoto, it is easy to find their common characteristics: streets are planned in an order of importance; the streets defined the rectangular blocks in a rectangular site plan; architecture was oriented North-South following geomancy principles; the imperial palace was located in the North of a broad central avenue that divided the city into Eastern and Western districts. The design concept emphasized the idea of imperial control, hierarchy, and regent power (Treib & Herman, 1993).

Kyoto is renowned for its traditional Japanese gardens. In this research, eight traditional Japanese gardens and two Shinto Shrines in Kyoto, Japan, are selected as the objects of study.

2.2.2.1 Shisen-do

In the Edo period, Ishikawa Jozan escaped to Kyoto because of his opposition to military rule and built Shisen-do in 1636. During the forty years he lived in Shisen-do, Ishikawa studied tea, arts, philosophy, and garden design (Treib & Herman, 1993). At first Shisen-do was designed to be a private villa, later it became a Zen temple (Mehta & Tada, 2012).

Portraits of thirty-six Chinese and Japanese poets were displayed on the wall of the main building. The design of Shisen-do was called "literary man's style". The main viewing veranda, the raked sand area, the nicely trimmed bushes, and the natural vegetation in the background comprise the major aspects of Shisen-do (Treib & Herman, 1993).

Shisen-do is also famous for its unique water device, *Shishiodoshi*, which is made of bamboo and generates sounds when motivated by the water stream to hit the rock (Mehta & Tada, 2012). The original function of this device was to scare deer and other animals away from the crops (Fowler, 2015). Shishi-odoshi can be considered an artificial technique to produce a "soundmark" or a "rhythmic counterpoint" to a background sound from constant falling water; it is believed that the "percussiveness and regularity" may give typical characters to the garden and remind people of the history of agriculture (Fowler, 2015).

Figure 18: Meditation in Shisen-do while viewing the dry landscape. (Copyright ©2017 Dexin Chen all right reserved used by permission).

Figure 19: Shishiodoshi in Shisen-do. (Copyright ©2017 Dexin Chen all right reserved used by permission).

2.2.2.2 Byodo-in

In the Heian period, Fujiwara Yorimichi, a member of the imperial court, built a palace in the former villa of Fujiwara Michinaga, which was turned into a Buddhist temple in 1052. Of all the buildings, only the Phoenix Hall survived because it best represented the architectural style of the Heian period. Functionally, the Phoenix Hall is used as a chapel of Amida Buddha. The main hall and the arcades on both sides were believed to be symbolic of a phoenix landing or taking off. The entire setting of the garden was based on the imagination of Amida’s western palace (Treib & Herman, 1993).

Figure 20: The phoenix hall of Byodo-in temple. (Copyright ©2017 Dexin Chen all right reserved used by permission).

2.2.2.3 Kiyomizu-dera

In 780, Sakanoweno-Tamu-ramaro founded Kiyomizu-dera. Currently, the temple present today is are construction that Tokugawa Iyemitsu built in 1633. The main hall was built on a deep ravine with the support many columns, which referred to the Shinden style (Shūkyōkyoku, 1920). The Kiyomizu complex is a great example of Japanese spatial planning called “sophisticated order”. In this complex, the rigid, geometrical setting style of architecture was abandoned, while the unexpected appearance of the buildings arose from the merging with nature and created a splendid spatial composition (Treib & Herman, 1993).

Figure 21: Pagoda and wisteria pergola in Kiyomizu-dera. (Copyright ©2017 Dexin Chen all right reserved used by permission).

Figure 22: The stairs before getting to the gateway of Kiyomizu-dera, creating a sense of entering a sacred place. (Copyright ©2017 Dexin Chen all right reserved used by permission).

2.2.2.4 Daikaku-ji

In the early Heian period, emperor Saga Rikyu-in built the imperial villa in Kyoto, and Daikaku-ji originated from the imperial villa of Emperor Saga. Daitoku-ji is famous for the oldest artificial garden pond in Japan, Osawa-no-ike Pond, which has perimeter of about eight-hundred meters. Emperor Saga constructed the lake to imitate Lake Dongting in China.

Figure 23: A view towards Osawa-no-ike pond. (Copyright ©2017 Dexin Chen all right reserved used by permission).

Figure 24: The lifted covered walkway in Daikaku-ji. (Copyright ©2017 Dexin Chen all right reserved used by permission).

2.2.2.5 Tenryu-ji

Shogun Ashikaga Takauji built Tenryu-ji in about 1339 (Kamakura period). A famous garden designer and priest named Muso Kokushi designed the garden. Muso believed in the value of meditating while viewing gardens. The garden style was both Heian pond style and Chinese (Sung dynasty) style, which produced a sophisticated landscape (Treib & Herman, 1993).

The unique design feature of the Tenryu-ji garden is a cluster of seven rocks in the pond and “borrowed scenery”. The group of seven rocks is raised in the water, and it provides strong vertical textures that contrast h with the horizontal pond surface. The composition of the seven rocks are highly valued. The reflection of the rocks in the pond lengthens the vertical shape of the rocks; thus, the impression of the rock composition is enhanced (Treib & Herman, 1993).

Figure 25: The main hall facing to the pond of Tenryu-ji. (Copyright ©2017 Dexin Chen all right reserved used by permission).

Figure 26: The raked sand design is merged into the view as foreground; the rock groupings suggest the pond edge as midground; the mountain behind is borrowed as background. (Copyright ©2017 Dexin Chen all right reserved used by permission).

2.2.2.6 Ryoan-ji

Ryoan-ji rock garden was constructed in about 1500; although the original temple building was ruined by a fire in the 1790's, the rock garden was saved in the blaze (Treib & Herman, 1993). Ryoan-ji is famous for its dry garden and the sense of Zen and enclosure (Treib & Herman, 1993).

The most famous feature of the Ryoan-ji garden is the dry garden (karesansui) (Treib & Herman, 1993). Enclosed by a wall, the dry landscape consists of fifteen rocks placed on a large flat plane of gravel, which reflects Zen Buddhist aesthetic principles of simplicity and the Chinese influence of rock composition (Treib & Herman, 1993). The design is entirely symbolic, where water and the landscape elements are represented only by rocks and raked gravel. In this dry garden, except for the moss that surrounds the rock pieces, none of the plant material is used (Treib & Herman, 1993). Most of the Zen gardens emphasize the sense of enclosure, for example, the surrounding wall in the Ryoan-ji garden works as a visual boundary against the gravel plane (Treib & Herman, 1993).

Figure 27: One of the fifteen rocks in the Zen garden of Ryoan-ji. The rectangular wall brings a sense of enclosure. (Copyright ©2017 Dexin Chen all right reserved used by permission).

Figure 28: A Torii is put in the pond in Ryoan-ji, suggesting the Shinto influence of this Buddhist temple. (Copyright ©2017 Dexin Chen all right reserved used by permission).

2.2.2.7 Kinkaku-ji/Rokuon-ji (The Golden Pavilion)

The culture of the Chinese Sung (Song) dynasty dominated the Japanese arts in the fourteenth century with the promotion of the third Ashikaga shogun, Yoshimitsu (Treib & Herman, 1993). He organized a group of artists, poets and Zen priests who had been to China to help build a palace complex, aimed to imitate the Sung style as well as the Heian Shinden style. After Yoshimizu's death, this palace complex became a Zen temple (Treib & Herman, 1993). Few of the original buildings survived during the long history (Treib & Herman, 1993). The large boating pond, rock groupings and extensive plantings, and the pavilion comprised the main view of today's Kinkaku-ji (Treib & Herman, 1993). The pavilion was designed to exhibit the characters learned from the Chinese Sung style (Treib & Herman, 1993). In 1950, the original unpainted pavilion was destroyed by fire, but an exact copy was constructed soon after the fire (Treib & Herman, 1993). The exterior walls of the pavilion are painted in gold to match its name of the Golden Pavilion (Treib & Herman, 1993).

Figure 29: The golden pavilion and its reflection in Kinkaku-ji temple. (Copyright ©2017 Dexin Chen all right reserved used by permission).

2.2.2.8 Daitoku-ji

Daitoku-ji is one of the largest Zen temple complexes in Kyoto, which contains many prayer halls and twenty-three sub-temples (Treib & Herman, 1993). Daitoku-ji was founded in 1319 by the priest Shuho Myocho (later called Daito Kokushi), but later it was destroyed by fire and war (Treib & Herman, 1993). The priest Ikkyu rebuilt Daitoku-ji in 1474 (Treib & Herman, 1993). Many of the sub-temples were built in the sixteenth century when the military government supported Daitoku-ji (Treib & Herman, 1993). The layout of the entire

Daitoku-ji area exhibits the transformation from formal planning to informal planning, where a North-South axis that derives from the traditional formal religious architectural manner of Japan and China underlies the layout of the major buildings, and a cluster of the small sub-temples encircles the main halls (Treib & Herman, 1993). The central main halls are akin to the symbolic and visual center of the whole area; in contrast, the sub-temples are treated as private centers of religious ritual (Treib & Herman, 1993). The sub-temples express unique characters and Zen Buddhism in the garden design, because the garden is believed to be the most significant part of meditation in Zen practices (Treib & Herman, 1993).

Figure 30: The dry landscape design in Zuihō-in, a sub-temple of Daitoku-ji. (Copyright ©2017 Dexin Chen all right reserved used by permission).

Figure 31: Stepping stones and solitary stones on raked sand design in Zuihō-in, a sub-temple of Daikaku-ji. (Copyright ©2017 Dexin Chen all right reserved used by permission).

2.2.3 Shrines in Kyoto

2.2.3.1 Yasaka Shrine/Yasaka Jinsha

In the ninth century, Fujiwara Mototsune turned his residence into the main shrine, and the architecture was restored in an imperial palace style (Shūkyōkyoku, 1920). In 1654, the Yasaka shrine was reconstructed in old Shinden style according to the old prototype (Shūkyōkyoku, 1920). The main shrine, the small subordinated shrines, the two-storied gate (which was built in the Kamakura period), and the stone Torii (which was one of the largest stone Torii in Japan), were the main features in this area (Shūkyōkyoku, 1920).

Figure 32: The main gate with viewing terrace in the Yasaka shrine. Chinese characters are used in the informative plaques. (Copyright ©2017 Dexin Chen all right reserved used by permission).

2.2.3.2 Fushimi-Inari Taisha

The main hall of Fushimi-Inari Taisha was restored in 1499 in the nagare-zukuri style with an extra-long eave (Cali & Dougill, 2013). The red-painted woodwork and the white stucco walls are typical characteristics of Inari shrines (Cali & Dougill, 2013). The five-thousand red Torii together compose a symbolic tunnel of a walking trail, which begins from the main hall and climbs up to the Inari Mountain (Cali & Dougill, 2013). The pathway of the red Torii strongly contrasts with the green background of the natural environment, which provides a breathtaking scene (Cali & Dougill, 2013). Thousands of fox statues and stone altars that are inscribed with the names of the gods or animistic beliefs are placed all over the site, reflecting the traditional practices of Inari (Cali & Dougill, 2013).

Figure 33: Thousands of Torii cover the outdoor pathway in Fushimi-Inari Taisha. (Copyright ©2017 Dexin Chen all right reserved used by permission).

2.3 Data Collection

This research will compare the eight Japanese gardens and two shrines in Kyoto, Japan which are selected by the author, Dexin Chen, to the Chinese gardens that were selected by Yiwen Xu in a previous study (Xu Y. , 2015). The first seventy-four design elements are adopted from Xu's list in '*A Cluster Analysis Comparison of Classical Chinese Gardens with Modern Chinese Gardens'*, the other sixty design elements are selected based on the literature review and the author's personal experience in Kyoto (Xu Y. , 2015). Thus, a list of one hundred and thirty-four design elements in total is generated, as described below (Table 1).

Table 1: List of design elements and principles included in the eighteen selected sites.

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

Table 1 (cont'd)

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
76. Miniature of natural landscapes
77. Boating pond
78. Stepping stones
79. Yellow painted wall
80. Unpainted structures or elements
81. Fall color of plant material
82. Metal components in wooden structures
83. Courtyard/atrium

Table 1 (cont'd)

84. Wooden / bamboo fences and railings
85. Bench
86. Pagoda
87. Adjacent to burial site
88. Stairs
89. Geomancy rules/Fengshui
90. Stone lanterns
91. Wooden lanterns
92. Trellis/pergola
93. Obviously exposed drainage ditch/gutter
94. Signage stone
95. Elevation change
96. Plaque
97. Lifted base of building
98. Building partially painted in red
99. Strings implied enchantment boundary
100. Raked sand design
101. Stone hand wash basin
102. Well
103. Bell
104. Shishiodoshi
105. Grouping stones
106. Ophiopogon japonicas
107. Hydrangea
108. Japanese maple
109. Moss
110. Azalea
111. Trimmed plant material
112. Weeping form plant material
113. Multiple layers of entry sequence
114. Multiple layers of edges
115. Control view point
116. Foreground, Midground and Background (visual technique)
117. Large scale
118. Small scale
119. Located on the foot of mountain
120. Location adjacent to Shinto shrine
121. Curved roof
122. Chinese characters
123. Wabi-sabi
124. Religious property
125. Tea
126. Sense of sacred place
127. Animistic believes
128. Buddhism
129. Shinto

Table 1 (cont'd)

130.	Confucianism
131.	Imperial background
132.	Simplicity
133.	Tranquility
134.	Harmony

2.4 Analysis Techniques

A cluster analysis is applied in this analysis focused on a garden comparison in order to identify the similarities or differences by grouping similar items into categories. Following the same steps used in Xu's study, a statistical analysis software program called SAS (version: 9.4 TS Level 1M2, X64_8PRO platform, English, Copyright© 2002-2012 by SAS Institute Inc., Cary, NC, USA.) is used to build principal component analysis (PCA) as the first step of the cluster analysis (Xu Y. , 2015). By standardizing the original variables, the weight of the variance can be calculated by PCA to help generate the final scores of each studied site (Xu Y. , 2015).

In a research of suitability overlay in Southern Michigan, the authors Jon Bryan Burley and Terry Brown applied principal component analysis to study the suitability maps of fifteen suitability overlays. The original data was eventually reduced into seven dimensions that covered 65% of the original data structure and still presented the major characteristics of the fifteen suitability overlays (Burley & Brown, Constructing Interpretable Environments from Multidimensional Data: GIS Suitability Overlays and Principal Component Analysis, 1995). Through Burley's study, principal component analysis reduced the complexity of combining suitability maps (Burley & Brown, Constructing Interpretable Environments from Multidimensional Data: GIS Suitability Overlays and Principal Component Analysis, 1995).

Principal component analysis can simplify the original set of variables into smaller "sets of the uncorrelated variables" that correspond to the distinguishable characteristics and combine the correlated variables as one variance because they are expressing the same characteristics. Therefore, the output of PCA would represent most of the meaningful variance of the sample data and make the cluster analysis more efficient by reducing the insignificant dimensions (Xu Y. , 2015).

After inputting the data into SAS (version: 9.4 TS Level 1M2, X64_8PRO platform, English, Copyright© 2002-2012 by SAS Institute Inc., Cary, NC, USA.), a set of eigenvalues, corresponding to the proportion of eigenvalues, means, standard deviations and eigenvectors, which correspond to the variables, is created for PCA. Means and standard deviations can be used to compute the standard scores of the corresponding variables. Each eigenvalue represents a dimension of the sample data; the eigenvalue that is greater than 1.0 would be defined as the representation of a meaningful dimension and used as a distinguishable principal component in the cluster analysis. The proportion of each eigenvalue among the whole data set represents its level of significance in the variance of sample data (Xu Y. , 2015). Usually, cumulative eigenvalues that cover more than sixty to eighty percent of sample data are preferred for further study. In this study, the principal component that corresponds to the highest eigenvalue is defined as the first principal component, the second principal component that corresponds to the highest eigenvalue is defined as the second principal component, and so on.

When the meaningful principal components are separated from the original set of principal components, it is typical to use the corresponding eigenvalues to generate the eigenvector coefficients. In the output of SAS (version: 9.4 TS Level 1M2, X64_8PRO platform, English, Copyright© 2002-2012 by SAS Institute Inc., Cary, NC, USA.), eigenvalues can be used to build “linear combinations” of variables, and eigenvector coefficients can be used to reveal the degree of mutual relationships between the variables and principal components. The variables are defined as more similar in terms of items when the numbers of corresponding eigenvalue coefficients are closer (Xu Y. , 2015).

In this research, cluster analysis is conducted using the equations adopted from Xu's study of Chinese garden comparison (Xu Y. , 2015). The first step includes standardizing the variables using the equation shown below (Equation 1) (Xu Y. , 2015):

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

Where:

X = Each Value of Variable

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

SD = Standard Deviation of the Variable

In this equation, mean is the average number of the whole sample data set; standard deviation is the number indicated the sample data that tend to be close to the mean, so that it can quantify the variance of sample data. The second step involves computing the score of each site with standardized variable scores and principal component coefficients corresponding to the variables using the equation shown below (Equation 2) (Xu Y. , 2015):

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

$$+ \left[\left(\frac{X_{133} - \bar{X}_{133}}{SD_{133}} k_{133}\right)\right] + \left[\left(\frac{X_{134} - \bar{X}_{134}}{SD_{134}} k_{134}\right)\right]$$

Where:

$\mathrm{X_n}$ = Each Value of Variable

$\bar{\mathrm{X}}_{\mathrm{n}}$ = Mean of the Variable

$\mathrm{SD_n}$ = Standard Deviation of the Variable

k_n = Each Principal Component Coefficient

Finally, the last step includes computing the site score of each selected site on a scatter graph in Excel (Microsoft® Excel for Mac, version: 15.32), where each site score of one corresponding set of the principal components is located by one axis. For example, in a two-dimensional scatter graph, site scores of one principal component set should be located by the horizontal axis, while site scores of another principal component set should be located by the vertical axis. In this way, site scores of two principal components can be reviewed directly through their location on the scatter graph. When the points of the corresponding site scores are clustered together on this scatter graph, according to the definition of the principal components, these corresponding sites are defined as more similar than other sites. Eigenvector coefficients can be used to explain the visually detected linear combinations of variables in the scatter graphs; the highest and lowest eigenvalue coefficients are considered most responsible to the coordinates of the site scores. Then, the next steps involves addressing the corresponding variables of the highest and lowest eigenvalue coefficients, so that the explanation of the data variance can be suggested using these distinctive variables. Thus, a conclusion of the site comparison can be generated using the cluster analysis to address their similarities or differences in the design elements and principles (Xu Y. , 2015).

CHAPTER 3: RESULTS

In this study, the design elements and principles are shown in Table 1 as one hundred and thirty-four variables. Numbers are recorded in Table 2 and Table 3 to describe the site conditions by the previous investigation of the eighteen selected sites, including three classical Chinese gardens, five modern Chinese gardens, eight traditional Japanese gardens and two shrines. In this case, “one” represents “present”, “zero” represents “absent”. In this study, four out of the one-hundred and thirty-four variables (design concept, contrast, deep implication, and simplicity) are defined as insignificant variables because they all scored “one” as “present” in all eighteen selected sites. In other words, this finding means that there is no variance from these variables, and are therefore not considered in PCA.

Table 2: List of design elements and principles in the three classical Chinese gardens and five modern Chinese gardens.

	Classical Chinese Gardens			**Modern Chinese Gardens**				
Design elements	**Humble Administrator's Garden**	**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	0	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

Table 2 (cont'd)

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
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 /scholars' stone	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

Table 2 (cont'd)

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
Naturalness	1	1	1	0	1	0	1	1
Varied spaces with visual devices	1	1	1	1	0	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
Miniature of natural landscapes	1	1	1	0	0	0	0	0

Table 2 (cont'd)

Boating pond	1	0	1	0	0	0	0	0
Stepping stones	0	0	0	0	0	0	0	0
Yellow painted wall	0	0	0	0	0	0	0	0
Unpainted structures or elements	1	1	1	0	0	0	0	0
Fall color of plant material	1	1	1	0	0	0	0	0
Metal components in wooden structures	0	0	0	0	0	0	0	0
Courtyard/atrium	1	1	1	0	0	0	0	0
Wooden /bamboo fence/railings	1	0	0	1	0	1	0	1
Bench	0	0	0	1	0	1	0	1
Pagoda	0	0	0	0	0	0	0	0
Adjacent to burial site	0	0	0	0	0	0	0	0
Stairs	0	0	0	1	0	0	1	1
Geomancy rules/Fengshui	1	1	1	0	0	0	1	0
Stone lanterns	0	0	0	0	0	0	0	0
Wooden lanterns	0	0	0	0	0	0	0	0
Trellis/pergola	1	1	1	0	0	0	0	0
Obviously exposed drainage ditch/gutter	0	0	0	0	0	0	0	0
Signage stone	0	0	0	0	0	0	0	0
Elevation change	1	1	1	0	0	0	0	0
Plaque	1	1	1	0	0	0	0	0
Lifted base of building	1	1	1	0	0	0	0	0
Building partially painted in red	1	1	1	0	0	0	0	0
Strings implied enchantment boundary	0	0	0	0	0	0	0	0
Raked sand design	0	0	0	0	0	0	0	0
Stone hand wash basin	0	0	0	0	0	0	0	0

Table 2 (cont'd)

Well	1	1	1	0	0	0	0	0
Bell	0	0	0	0	0	0	0	0
Shishiodoshi	0	0	0	0	0	0	0	0
Grouping stones	1	1	1	0	0	0	0	0
Ophiopogon japonicus	1	1	1	0	0	0	0	0
Hydrangea	0	0	0	0	0	0	0	0
Japanese Maple	1	1	1	0	0	0	0	0
Moss	0	0	0	0	0	0	0	0
Azalea	1	1	1	0	0	1	0	1
Trimmed plant material	1	1	1	1	0	1	0	1
Weeping form plant material	1	1	1	0	0	0	0	0
Multiple layers of entry sequence	1	1	1	0	0	0	0	0
Multiple layers of edges	1	1	1	0	0	0	0	0
Control view point	1	1	1	1	0	0	0	1
Foreground, Midground, and Background	1	1	1	0	0	0	0	0
Large scale	0	0	0	0	0	0	0	0
Small scale	1	1	1	1	1	1	1	1
Located on the foot of mountain	0	0	0	0	0	0	0	0
Location adjacent to Shinto Shrine	0	0	0	0	0	0	0	0
Curved roof	1	1	1	0	0	0	0	0
Chinese characters	1	1	1	0	0	0	0	0
Wabi-sabi	0	0	0	0	0	0	0	0
Religious property	0	0	0	0	0	0	0	0
Tea	1	1	1	0	0	0	0	0
Sense of sacred place	1	1	1	0	0	0	0	0
Animistic believes	1	1	1	0	0	0	0	0
Buddhism	1	0	1	0	0	0	0	0
Shinto	0	0	0	0	0	0	0	0
Confucianism	1	1	1	0	0	0	0	0

Table 2 (cont'd)

Imperial background	0	0	0	0	0	0	0	0
Simplicity	1	1	1	1	1	1	1	1
Tranquility	1	1	1	0	0	0	0	0
Harmony	1	1	1	0	0	0	0	0

Table 3: List of design elements and principles in the eight traditional Japanese gardens and two shrines.

	Traditional Japanese Garden								**Shrines**	
Design elements	**Daitoku-ji**	**Ryoan-ji**	**Kinkaku-ji**	**Tenryu-ji**	**Shisen-do**	**Kiyomizu-dera**	**Daikaku-ji**	**Byodo-in**	**Yasaka Shrine**	**Fushimi-Inari Taisha**
The great halls (ting tang)	1	1	1	1	1	1	1	1	1	1
Covered stone boat (fang)	0	0	0	0	0	0	0	0	0	0
Viewing towers (lou ge)	1	1	1	1	1	1	1	1	1	1
Studies (shufang)	1	1	1	1	1	1	1	1	1	1
Covered walkways (lang)	1	1	1	1	0	1	1	1	1	1
Pavilions (ting xie)	1	1	1	1	0	1	1	1	1	1
Viewing terrace	1	1	1	1	1	1	1	1	1	1
Black tile pavement	0	0	0	0	0	0	0	0	0	0
Brick paving	1	0	0	0	0	0	0	0	0	0
Cracked ice stone paving	1	1	0	1	1	1	0	0	0	0
Pebbles area	1	1	1	1	1	1	1	1	1	1
Mosaic pave with special pattern	0	0	0	0	0	0	0	0	0	0
Whitewashed walls	1	1	1	1	0	1	1	1	1	1
Grey stone walls	1	0	0	0	1	1	0	0	1	1
Openwork brick walls	0	0	0	0	0	0	0	0	0	0
Curved top walls	0	0	0	0	0	0	0	0	0	0
Zigzag wall	0	0	0	0	0	0	0	0	0	0
Meandering walls	0	0	0	0	0	0	0	0	0	0
Bamboo paved pathway	0	0	0	0	0	0	0	0	0	0
Boardwalk	0	0	0	0	0	0	0	0	0	0

Table 3 (cont'd)

Curved Pathway	1	1	1	1	1	1	1	1	0	1
Straight Pathway	1	1	1	1	1	1	1	1	1	1
Zigzag Bridge	0	0	0	0	0	0	0	0	0	0
Semi-circular bridge	1	1	0	0	0	0	1	1	0	0
Straight Bridge	1	1	0	1	1	0	0	1	0	1
Wall holes with symbolized shape	0	0	0	0	0	0	0	0	0	0
Lattice window	1	1	1	1	1	1	1	1	1	1
Moon Gate	0	0	0	0	0	0	0	0	0	0
Wood carvings	1	1	1	1	0	1	1	1	1	1
Glass carvings	0	0	0	0	0	0	0	0	0	0
Brick carvings	0	0	0	0	0	0	0	1	0	0
Reflecting Pond	1	1	1	1	1	1	1	1	0	1
Stream	1	1	1	1	1	1	1	1	1	1
Fish pond	1	1	1	1	1	1	1	1	0	1
Wetland	0	0	0	0	0	0	0	0	0	0
Island	1	1	1	1	1	1	1	1	0	0
Artificial mountains	0	0	0	0	0	0	0	0	0	0
Sculptural rocks	1	1	1	1	1	1	1	1	1	1
Pond bank rocks	1	1	1	1	1	1	1	1	0	0
Taihu rocks /scholars' stone	0	0	0	0	0	0	0	0	0	0
Trees	1	1	1	1	1	1	1	1	1	1
Shrubs	1	1	1	1	1	1	1	1	1	1
Ground covers	1	1	1	1	1	1	1	1	0	1
Turf area	0	0	0	0	0	0	0	1	0	0
Pine	1	1	1	1	1	1	1	1	1	1
Bamboo	1	1	1	1	1	1	1	1	1	1
Plum	1	1	1	1	1	1	1	1	1	1
Magnolias	1	1	1	1	1	1	1	1	1	1
Camellia	1	1	1	1	1	1	1	1	0	1
Crepe myrtles	1	1	1	1	1	1	1	1	1	1
Sweet osmanthus	1	1	1	1	1	1	1	1	1	1
Peony	0	1	0	1	0	0	0	0	0	0
Willow	0	0	0	0	0	0	0	0	0	0
Lotus	0	1	1	0	0	0	1	1	0	0
Reed	0	1	1	1	1	0	1	0	0	0
Sugar cane	0	0	0	0	0	0	0	0	0	0
Moon	0	0	0	0	1	1	1	0	1	1
Clouds	0	1	0	0	1	1	1	0	1	1

Table 3 (cont'd)

Rain	0	1	0	0	1	1	1	1	0	1
Wind	0	0	0	0	1	0	1	0	0	0
Shadow	1	1	1	1	1	1	1	1	1	1
Originally private	1	1	1	1	1	1	1	1	0	0
Public	0	0	0	0	0	0	0	0	1	1
Located in suburban	0	1	1	1	1	1	1	1	0	1
Located in urban	1	0	0	0	0	0	0	0	1	0
Design concept	1	1	1	1	1	1	1	1	1	1
Poem and painting concept	1	1	1	1	1	1	1	1	0	0
Naturalness	1	1	1	1	1	1	1	1	1	1
Varied spaces with visual devices	1	1	1	1	1	1	1	1	1	1
Borrowed scenery	1	1	1	1	1	1	1	1	1	1
Enframed scenery	1	1	0	1	1	1	1	1	0	1
Opposite scenery	1	1	1	1	1	1	1	1	1	1
Contrast	1	1	1	1	1	1	1	1	1	1
Deep implication	1	1	1	1	1	1	1	1	1	1
Abstract geometrical composition	1	1	1	1	1	1	1	1	1	1
Miniature of natural landscapes	1	1	1	1	1	1	1	1	0	0
Boating pond	0	0	1	0	0	0	1	1	0	1
Stepping stones	1	1	1	1	1	0	1	1	0	0
Yellow painted wall	1	1	1	1	1	0	1	0	0	0
Unpainted structures or elements	1	1	1	1	1	1	1	1	1	1
Fall color of plant material	1	1	1	1	1	1	1	1	1	1
Metal components in wooden structures	1	1	1	1	1	1	1	1	1	1
Courtyard/atrium	1	1	1	1	1	0	1	1	0	1
Wooden /bamboo fence/railings	1	1	1	1	1	1	1	1	1	1
Bench	0	1	1	1	0	0	0	0	0	1
Pagoda	1	1	1	1	1	1	1	1	0	0

Table 3 (cont'd)

Adjacent to burial site	1	1	1	1	0	1	1	1	1	1
Stairs	1	1	1	1	1	1	1	1	1	1
Geomancy rules/Fengshui	1	1	1	1	1	1	1	1	1	1
Stone lanterns	1	1	1	1	1	1	1	1	1	1
Wooden lanterns	1	1	0	0	0	1	1	0	1	1
Trellis/pergola	0	1	1	1	0	1	0	1	0	0
Obviously exposed drainage ditch/gutter	1	1	1	1	1	1	1	1	1	1
Signage stone	1	1	1	1	1	1	1	1	1	1
Elevation change	1	1	1	1	1	1	1	1	1	1
Plaque	1	1	1	1	1	1	1	1	1	1
Lifted base of building	1	1	1	1	1	1	1	1	1	1
Building partially painted in red	1	0	0	0	0	1	1	1	1	1
Strings implied enchantment boundary	0	0	0	0	0	0	0	0	1	1
Raked sand design	1	1	1	1	1	0	1	0	0	0
Stone hand wash basin	1	1	1	1	1	1	1	1	1	1
Well	1	1	1	1	1	1	1	1	1	1
Bell	1	1	1	1	0	1	1	1	1	1
Shishiodoshi	0	0	0	0	1	0	0	0	0	0
Grouping stones	1	1	1	1	1	1	1	1	0	0
Ophiopogon japonicus	0	0	0	0	0	0	0	1	0	0
Hydrangea	1	1	1	1	1	1	1	1	1	1
Japanese Maple	1	1	1	1	1	1	1	1	1	1
Moss	1	1	1	1	1	1	1	1	0	1
Azalea	1	1	1	1	1	1	1	1	1	1
Trimmed plant material	1	1	1	1	1	1	1	1	1	1
Weeping form plant material	1	1	1	1	0	1	1	1	0	1
Multiple layers of entry sequence	1	1	1	1	1	1	1	1	1	1
Multiple layers of edges	1	1	1	1	1	1	1	1	1	1
Control view point	1	1	1	1	1	1	1	1	1	1

Table 3 (cont'd)

Foreground, Midground, and Background	1	1	1	1	1	1	1	1	1	1
Large scale	0	1	1	1	0	1	1	1	0	1
Small scale	1	0	0	0	1	0	0	0	1	0
Located on the foot of mountain	0	1	1	1	1	1	1	1	1	1
Location adjacent to Shinto Shrine	1	1	1	1	1	1	1	1	1	1
Curved roof	1	1	1	1	0	1	1	1	1	1
Chinese characters	1	1	1	1	1	1	1	1	1	1
Wabi-sabi	1	1	1	1	1	1	1	1	1	1
Religious property	1	1	1	1	1	1	1	1	1	1
Tea	1	1	1	1	1	0	1	1	0	0
Sense of sacred place	1	1	1	1	1	1	1	1	1	1
Animistic believes	1	1	1	1	1	1	1	1	1	1
Buddhism	1	1	1	1	1	1	1	1	0	0
Shinto	0	1	0	0	0	1	1	0	1	1
Confucianism	0	0	0	0	1	0	0	0	0	0
Imperial background	1	1	1	1	1	1	1	1	1	1
Simplicity	1	1	1	1	1	1	1	1	1	1
Tranquility	1	1	1	1	1	1	1	1	1	1
Harmony	1	1	1	1	1	1	1	1	1	1

To standardize the variables, combine Table 2 and Table 3 as one data set and put it into SAS (version: 9.4 TS Level 1M2, X64_8PRO platform, English, Copyright© 2002-2012 by SAS Institute Inc., Cary, NC, USA.) to generate means and standard deviations. The output is listed in Table 4.

Table 4: Means and standard deviation of the corresponding variables from the SAS software program.

Design elements	**Mean**	**Standard Deviation**
The great halls (ting tang)	0.7222222	0.4608886
Covered stone boat (fang)	0.0555556	0.2357023
Viewing towers (lou ge)	0.7222222	0.4608886
Studies (shufang)	0.7222222	0.4608886

Table 4 (cont’d)

Covered walkways (lang)	0.6666667	0.4850713
Pavilions (ting xie)	0.6666667	0.4850713
Viewing terrace	0.6666667	0.4850713
Black tile pavement	0.2222222	0.4277926
Brick paving	0.2222222	0.4277926
Cracked ice stone paving	0.5	0.5144958
Pebbles area	0.7222222	0.4608886
Mosaic pave with special pattern	0.2777778	0.4608886
Whitewashed walls	0.7777778	0.4277926
Grey stone walls	0.4444444	0.51131
Openwork brick walls	0.3888889	0.5016313
Curved top walls	0.1111111	0.3233808
Zigzag wall	0.2222222	0.4277926
Meandering walls	0.1111111	0.3233808
Bamboo paved pathway	0.0555556	0.2357023
Boardwalk	0.0555556	0.2357023
Curved Pathway	0.8333333	0.3834825
Straight Pathway	0.8888889	0.3233808
Zigzag Bridge	0.2222222	0.4277926
Semi-circular bridge	0.3333333	0.4850713
Straight Bridge	0.6111111	0.5016313
Wall holes with symbolized shape	0.2222222	0.4277926
Lattice window	0.7222222	0.4608886
Moon Gate	0.1666667	0.3834825
Wood carvings	0.6666667	0.4850713
Glass carvings	0.1111111	0.3233808
Brick carvings	0.2222222	0.4277926
Reflecting Pond	0.8888889	0.3233808
Stream	0.6666667	0.4850713
Fish pond	0.7222222	0.4608886
Wetland	0.1111111	0.3233808
Island	0.6111111	0.5016313
Artificial mountains	0.1666667	0.3834825
Sculptural rocks	0.9444444	0.2357023
Pond bank rocks	0.6111111	0.5016313
Taihu rocks /scholars’ stone	0.1666667	0.3834825
Trees	0.8888889	0.3233808
Shrubs	0.8333333	0.3834825
Ground covers	0.7777778	0.4277926
Turf area	0.2222222	0.4277926
Pine	0.7777778	0.4277926

Table 4 (cont'd)

Bamboo	0.8888889	0.3233808
Plum	0.7222222	0.4608886
Magnolias	0.7222222	0.4608886
Camellia	0.6666667	0.4850713
Crepe myrtles	0.7222222	0.4608886
Sweet osmanthus	0.7777778	0.4277926
Peony	0.2777778	0.4608886
Willow	0.1666667	0.3834825
Lotus	0.5	0.5144958
Reed	0.3888889	0.5016313
Sugar cane	0.0555556	0.2357023
Moon	0.3888889	0.5016313
Clouds	0.4444444	0.51131
Rain	0.4444444	0.51131
Wind	0.2777778	0.4608886
Shadow	0.7222222	0.4608886
Originally private	0.6111111	0.5016313
Public	0.3888889	0.5016313
Located in suburban	0.7222222	0.4608886
Located in urban	0.2777778	0.4608886
Design concept	1	0
Poem and painting concept	0.7222222	0.4608886
Naturalness	0.8888889	0.3233808
Varied spaces with visual devices	0.9444444	0.2357023
Borrowed scenery	0.7777778	0.4277926
Enframed scenery	0.8333333	0.3834825
Opposite scenery	0.8888889	0.3233808
Contrast	1	0
Deep implication	1	0
Abstract geometrical composition	0.8333333	0.3834825
Miniature of natural landscapes	0.6111111	0.5016313
Boating pond	0.3333333	0.4850713
Stepping stones	0.3888889	0.5016313
Yellow painted wall	0.3333333	0.4850713
Unpainted structures or elements	0.7222222	0.4608886
Fall color of plant material	0.7222222	0.4608886
Metal components in wooden structures	0.5555556	0.51131
Courtyard/atrium	0.6111111	0.5016313
Wooden /bamboo fence/railings	0.7777778	0.4277926
Bench	0.3888889	0.5016313
Pagoda	0.4444444	0.51131

Table 4 (cont'd)

Adjacent to burial site	0.5	0.5144958
Stairs	0.7222222	0.4608886
Geomancy rules/Fengshui	0.7777778	0.4277926
Stone lanterns	0.5555556	0.51131
Wooden lanterns	0.3333333	0.4850713
Trellis/pergola	0.4444444	0.51131
Obviously exposed drainage ditch/gutter	0.5555556	0.51131
Signage stone	0.5555556	0.51131
Elevation change	0.7222222	0.4608886
Plaque	0.7222222	0.4608886
Lifted base of building	0.7222222	0.4608886
Building partially painted in red	0.5	0.5144958
Strings implied enchantment boundary	0.1111111	0.3233808
Raked sand design	0.3333333	0.4850713
Stone hand wash basin	0.5555556	0.51131
Well	0.7222222	0.4608886
Bell	0.5	0.5144958
Shishiodoshi	0.0555556	0.2357023
Grouping stones	0.6111111	0.5016313
Ophiopogon japonicus	0.2222222	0.4277926
Hydrangea	0.5555556	0.51131
Japanese Maple	0.7222222	0.4608886
Moss	0.5	0.5144958
Azalea	0.8333333	0.3834825
Trimmed plant material	0.8888889	0.3233808
Weeping form plant material	0.6111111	0.5016313
Multiple layers of entry sequence	0.7222222	0.4608886
Multiple layers of edges	0.7222222	0.4608886
Control view point	0.8333333	0.3834825
Foreground, Midground, and Background	0.7222222	0.4608886
Large scale	0.3888889	0.5016313
Small scale	0.6111111	0.5016313
Located on the foot of mountain	0.5	0.5144958
Location adjacent to Shinto Shrine	0.5555556	0.51131
Curved roof	0.6666667	0.4850713
Chinese characters	0.7222222	0.4608886
Wabi-sabi	0.5555556	0.51131
Religious property	0.5555556	0.51131
Tea	0.5555556	0.51131
Sense of sacred place	0.7222222	0.4608886
Animistic believes	0.7222222	0.4608886

Table 4 (cont'd)

Buddhism	0.5555556	0.51131
Shinto	0.2777778	0.4608886
Confucianism	0.2222222	0.4277926
Imperial background	0.5555556	0.51131
Simplicity	1	0
Tranquility	0.7222222	0.4608886
Harmony	0.7222222	0.4608886

In this analysis, after the means and standard deviations of all significant variables are calculated, this information is then used to generate principal component eigenvalues, which best reveals the covariance of the sample data (Xu Y. , 2015). As shown in Table 5, only the first fifteen principal component eigenvalues are greater than 1.0, which means they are most useful to explain the variance (Xu Y. , 2015). The first three principal component eigenvalues cumulatively covered 63.81 percent of the variance in the sample data, whereas the first principal component covered 43.2 percent of the variance. The fourth to the fifteenth principal components are greater than 1.0, but their proportions are much smaller than the first three principal components. Therefore, only the first three principal component eigenvalues are selected for the calculating principal component coefficient in this study.

Table 5: Principal Component Analysis eigenvalues of the covariance matrix from the SAS Software Program.

	Eigenvalue	**Difference**	**Proportion**	**Cumulative**
PRIN 1	56.1662056	29.375329	0.432	0.432
PRIN 2	26.7908766	17.7501596	0.2061	0.6381
PRIN 3	9.040717	0.6477713	0.0695	0.7077
PRIN 4	8.3929457	3.4082898	0.0646	0.7722
PRIN 5	4.9846559	0.4160248	0.0383	0.8106
PRIN 6	4.5686311	0.7018803	0.0351	0.8457
PRIN 7	3.8667507	0.8990064	0.0297	0.8755
PRIN 8	2.9677444	0.5141437	0.0228	0.8983
PRIN 9	2.4536007	0.3388601	0.0189	0.9172
PRIN 10	2.1147406	0.2062816	0.0163	0.9334
PRIN 11	1.908459	0.3155289	0.0147	0.9481
PRIN 12	1.5929301	0.1353563	0.0123	0.9604
PRIN 13	1.4575738	0.0209401	0.0112	0.9716

Table 5 (cont'd)

PRIN 14	1.4366337	0.2932455	0.0111	0.9826
PRIN 15	1.1433882	0.2990471	0.0088	0.9914
PRIN 16	0.8443411	0.5745355	0.0065	0.9979
PRIN 17	0.2698056	0.2698056	0.0021	1

In the output of PCA as shown in Table 6, none of the corresponding coefficients of the principal components is larger than 0.4 or smaller than -0.4, which means the variance of the sample data is determined by many distinguishable variables together, instead of a few outstanding distinctive variables. The variables with the highest and lowest numbers in the principal component coefficients are the most distinguishable variables and will be used later for suggesting the meaning of the dimensions in the final scatter graphs (Xu Y. , 2015). The largest coefficient of principal component 1 is around 0.13, and the smallest coefficient is around -0.08. In the second and third principal components, the largest coefficients are around 0.15, and the smallest coefficients are around -0.15. The eigenvalue coefficients of the first three principal component analysis will be used later for calculating the site scores of the eighteen selected sites using Equation 2.

Table 6: Principal Component Analysis eigenvalue coefficient for each variable from the SAS Software Program.

Design Elements and Principles	Prin1	Prin2	Prin3
The great halls (ting tang)	0.130476	0.023033	-0.03526
Covered stone boat (fang)	0.012793	0.106904	-0.001937
Viewing towers (lou ge)	0.130476	0.023033	-0.03526
Studies (shufang)	0.130476	0.023033	-0.03526
Covered walkways (lang)	0.115325	0.032365	-0.029995
Pavillions (ting xie)	0.115325	0.032365	-0.029995
Viewing terrace	0.063079	-0.133227	0.11619
Black tile pavement	-0.013109	0.160909	-0.101168
Brick paving	0.031125	0.161275	-0.025306
Cracked ice stone paving	0.04896	0.082795	0.06076
Pebbles area	0.037908	-0.148157	0.048379
Mosaic pave with special pattern	-0.030621	0.152181	0.135471
Whitewashed walls	0.079295	0.03028	0.114183
Grey stone walls	-0.000197	-0.021784	-0.051829
Openwork brick walls	-0.078724	0.13065	0.081931
Curved top walls	0.016686	0.154538	-0.014102

Table 6 (cont'd)

Zigzag wall	-0.009346	0.166475	0.034001
Meandering walls	0.016686	0.154538	-0.014102
Bamboo paved pathway	-0.058808	-0.014097	-0.191336
Boardwalk	-0.058808	-0.014097	-0.191336
Curved Pathway	0.051514	0.026468	-0.169117
Straight Pathway	0.083454	0.02159	0.244795
Zigzag Bridge	-0.009346	0.166475	0.034001
Semi-circular bridge	0.06263	0.057576	-0.00583
Straight Bridge	0.036083	0.072854	0.11728
Wall holes with symbolized shape	-0.009346	0.166475	0.034001
Lattice window	0.130476	0.023033	-0.03526
Moon Gate	0.019605	0.189043	-0.024031
Wood carvings	0.115325	0.032365	-0.029995
Glass carvings	-0.066891	-0.007286	0.221572
Brick carvings	0.031835	0.162186	-0.014781
Reflecting Pond	0.03706	0.034377	0.160483
Stream	0.119064	-0.029195	-0.025043
Fish pond	0.09633	0.032734	-0.11836
Wetland	-0.078476	-0.014226	-0.065983
Island	0.080989	0.005885	0.042502
Artificial mountains	0.019605	0.189043	-0.024031
Sculptural rocks	0.05569	0.015524	0.144519
Pond bank rocks	0.108178	0.053326	-0.014145
Taihu rocks /scholars' stone	0.019605	0.189043	-0.024031
Trees	0.083454	0.02159	0.244795
Shrubs	0.100406	0.021538	0.144469
Ground covers	0.079486	0.032404	-0.02688
Turf area	-0.031626	0.046562	0.136078
Pine	0.11602	0.021383	0.054663
Bamboo	0.083454	0.02159	0.244795
Plum	0.130476	0.023033	-0.03526
Magnolias	0.130476	0.023033	-0.03526
Camellia	0.120103	0.037952	-0.019487
Crepe myrtles	0.130476	0.023033	-0.03526
Sweet osmanthus	0.11602	0.021383	0.054663
Peony	0.043471	0.12873	-0.003882
Willow	0.019605	0.189043	-0.024031
Lotus	0.021541	0.089944	0.131182
Reed	0.007588	-0.073862	-0.03434
Sugar cane	-0.05569	-0.015524	-0.144519
Moon	0.055001	0.026302	-0.043892
Clouds	0.065671	0.012178	-0.042809
Rain	0.075677	0.02657	-0.015644
Wind	0.039999	0.131885	-0.029707
Shadow	0.067843	-0.089983	-0.028109
Originally private	0.108178	0.053326	-0.014145

Table 6 (cont'd)

Public	-0.108178	-0.053326	0.014145
Located in suburban	-0.032962	-0.132783	0.03824
Located in urban	0.032962	0.132783	-0.03824
Design concept	0	0	0
Poem and painting concept	0.070807	0.052928	0.14007
Naturalness	0.06809	0.00849	-0.196042
Varied spaces with visual devices	0.058808	0.014097	0.191336
Borrowed scenery	0.108169	0.017047	-0.143409
Enframed scenery	0.014341	0.049622	0.103526
Opposite scenery	0.083454	0.02159	0.244795
Contrast	0	0	0
Deep implication	0	0	0
Abstract geometrical composition	-0.019605	-0.189043	0.024031
Miniature of natural landscapes	0.108178	0.053326	-0.014145
Boating pond	0.057645	0.050134	-0.011622
Stepping stones	0.081895	-0.077878	0.010753
Yellow painted wall	0.072115	-0.07412	0.005157
Unpainted structures or elements	0.130476	0.023033	-0.03526
Fall colour of plant material	0.130476	0.023033	-0.03526
Metal components in wooden structures	0.102906	-0.121021	-0.01376
Courtyard/atrium	0.104842	0.050013	-0.012316
Wooden /bamboo fence/railings	0.052559	-0.094241	0.205522
Bench	-0.021705	-0.065217	0.202628
Pagoda	0.091426	-0.089466	0.004146
Adjacent to burial site	0.094117	-0.110391	-0.010368
Stairs	0.03655	-0.146899	0.031848
Geomancy rules/Fengshui	0.109887	0.016261	-0.117615
Stone lanterns	0.102906	-0.121021	-0.01376
Wooden lanterns	0.063244	-0.081409	-0.026879
Trellis/pergola	0.073442	0.082069	-0.001974
Obviously exposed drainage ditch/gutter	0.102906	-0.121021	-0.01376
Signage stone	0.102906	-0.121021	-0.01376
Elevation change	0.130476	0.023033	-0.03526
Plaque	0.130476	0.023033	-0.03526
Lifted base of building	0.130476	0.023033	-0.03526
Building partially painted in red	0.073225	0.070826	-0.044972
Strings implied enchantment boundary	0.01815	-0.049893	-0.028311
Raked sand design	0.072115	-0.07412	0.005157
Stone hand wash basin	0.102906	-0.121021	-0.01376
Well	0.130476	0.023033	-0.03526
Bell	0.094117	-0.110391	-0.010368
Shishiodoshi	0.017794	-0.021568	-0.007219
Grouping stones	0.108178	0.053326	-0.014145
Ophiopogon japonicus	0.031835	0.162186	-0.014781
Hydrangea	0.102906	-0.121021	-0.01376
Japanese Maple	0.130476	0.023033	-0.03526

Table 6 (cont'd)

Moss	0.098621	-0.105123	-0.000461
Azalea	0.100406	0.021538	0.144469
Trimmed plant material	0.083454	0.02159	0.244795
Weeping form plant material	0.107777	0.046833	-0.015451
Multiple layers of entry sequence	0.130476	0.023033	-0.03526
Multiple layers of edges	0.130476	0.023033	-0.03526
Control view point	0.097762	0.022034	0.103072
Foreground, Midground, and Background	0.130476	0.023033	-0.03526
Large scale	0.081233	-0.090702	0.006129
Small scale	-0.081233	0.090702	-0.006129
Located on the foot of mountain	0.091001	-0.113464	-0.010545
Location adjacent to Shinto Shrine	0.102906	-0.121021	-0.01376
Curved roof	0.115325	0.032365	-0.029995
Chinese characters	0.130476	0.023033	-0.03526
Wabi-sabi	0.102906	-0.121021	-0.01376
Religious property	0.102906	-0.121021	-0.01376
Tea	0.095049	0.065378	-0.007474
Sense of sacred place	0.130476	0.023033	-0.03526
Animistic believes	0.130476	0.023033	-0.03526
Buddhism	0.10198	0.008273	-0.004773
Shinto	0.053985	-0.078082	-0.024796
Confucianism	0.027379	0.157579	-0.025519
Imperial background	0.102906	-0.121021	-0.01376
Simplicity	0	0	0
Tranquility	0.130476	0.023033	-0.03526
Harmony	0.130476	0.023033	-0.03526

According to Xu's study, site scores should be calculated with the variable values (from Table 2 and Table 3), means (from Table 4), standard deviations (from Table 4) and principal component coefficients (from Table 6) following Equation 2 (Xu Y. , 2015). For example, the Site Score of Humble Administrator's Garden in the first principal component is calculated as below (Equation 2):

$$\text{Site Score} = \left[\left(\frac{1-0.722}{0.460}\right) \times 0.130\right] + \left[\left(\frac{1-0.056}{0.235}\right) \times 0.012\right] + \left[\left(\frac{1-0.722}{0.460}\right) \times 0.130\right] + \ldots\ldots$$
$$+ \left[\left(\frac{1-0.722}{0.460}\right) \times 0.130\right] = 2.879$$

Therefore, a table of site scores corresponding to the first three principal components is generated and shown in Table 7.

Table 7: Site scores in the first three principal components.

Name of the Study Sites	PRIN 1	PRIN 2	PRIN 3
Humble Administrator's Garden	2.878997851	11.47605414	-0.070171415
Master of the Nets Garden	2.026469535	10.25661709	-0.715462914
Lingering Garden	2.27319477	11.28467025	-0.630696698
Bamboo Garden	-10.99618606	-0.581932239	3.651821376
Net. Wet. Garden	-13.23501174	-1.513331994	-6.931290784
Learning Garden	-10.02816392	-0.668559031	6.091662956
Sugar Cane Garden	-12.53322977	-1.666472273	-5.235318345
Landscape New Wave	-10.62584938	-0.404545683	4.920699942
Daitoku-ji	5.534979673	-1.595120163	-0.247457737
Ryoan-ji	6.323252889	-2.981789645	0.580402245
Kinkaku-ji	5.49021076	-3.450533706	0.178561372
Tenryu-ji	5.628313554	-3.013841964	0.560982113
Shisen-do	4.004667988	-2.315315832	-0.261490675
Kiyomizu-dera	5.410253068	-3.041815066	-0.503209831
Daikaku-ji	6.419067306	-3.018152569	-0.426469414
Byodo-in	5.824693684	-1.417633315	0.444542243
Yasaka Shrine	1.791856137	-3.549740329	-1.044909662
Fushimi-Inari Taisha	3.812484892	-3.798556125	-0.362192459

To obtain a more sensitive result from the principal components, a three-dimensional model is built using three two-dimensional charts with each two of the three selected principal components. After all site scores of the first three principal components are calculated, these scores are arranged in three groups named after the order of the principal components: the first and the second principal component; the first and the third principal component; the second and the third principal component. The site scores are located on Excel scatter graphs using the following approach: in the first group, I use the first principal component to locate the sites on the horizontal axis and the second principal component to locate the sites on the vertical axis, and I apply the same process to the other two groups. In this way, three scatter graphs are generated for the cluster analysis as shown in Figure 34, Figure 35, and Figure 36.

Table 8: Corresponding initials of the selected sites as shown in scatter graphs.

Name of the Study Sites	**Initials in Scatter Graphs**
Humble Administrator's Garden	hasg
Master of the Nets Garden	mast
Lingering Garden	ling
Bamboo Garden	bamb
Net. Wet. Garden	netw
Learning Garden	lear
Sugar Cane Garden	suga
Landscape New Wave	land
Daitoku-ji	dait
Ryoan-ji	ryoa
Kinkaku-ji	kink
Tenryu-ji	tenr
Shisen-do	shis
Kiyomizu-dera	kiyo
Daikaku-ji	daik
Byodo-in	byod
Yasaka Shrine	yasa
Fushimi-Inari Taisha	fush

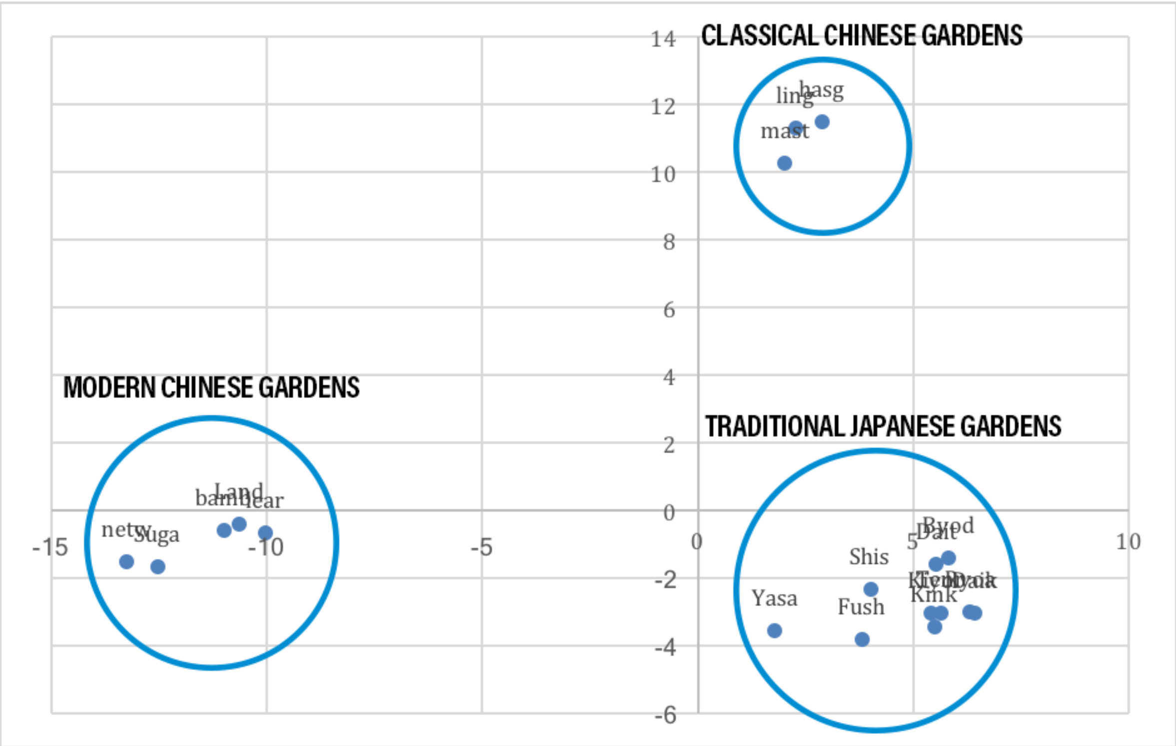

Figure 34: A scatter graph of the correlation between the eighteen selected sites based on the site scores of Principal Component 1 and Principal Component 2.

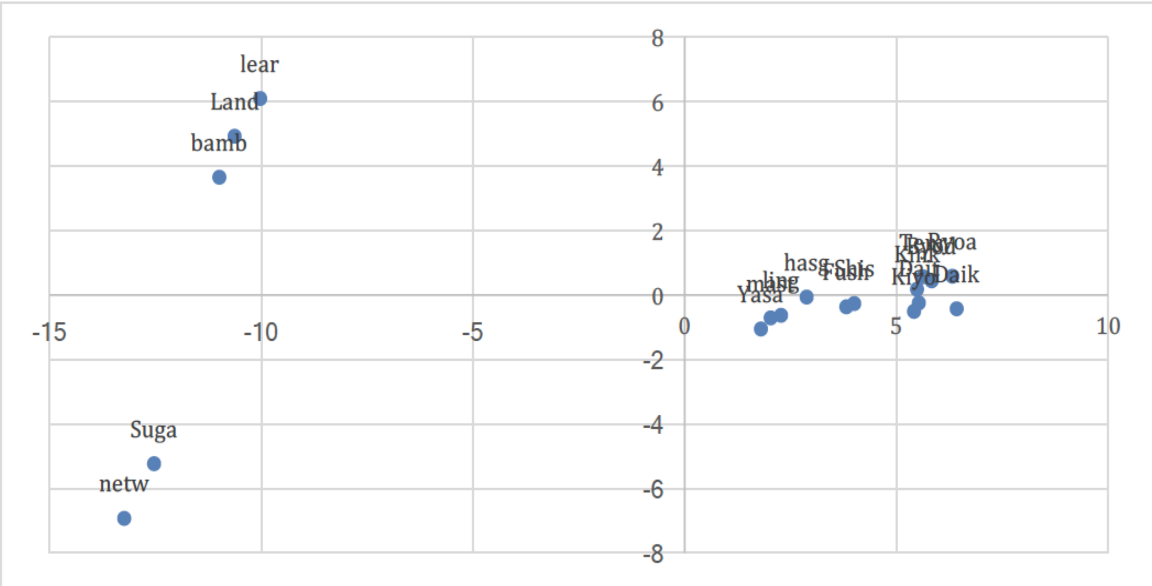

Figure 35: A scatter graph of the correlation between the eighteen selected sites based on the site scores of Principal Component 1 and Principal Component 3.

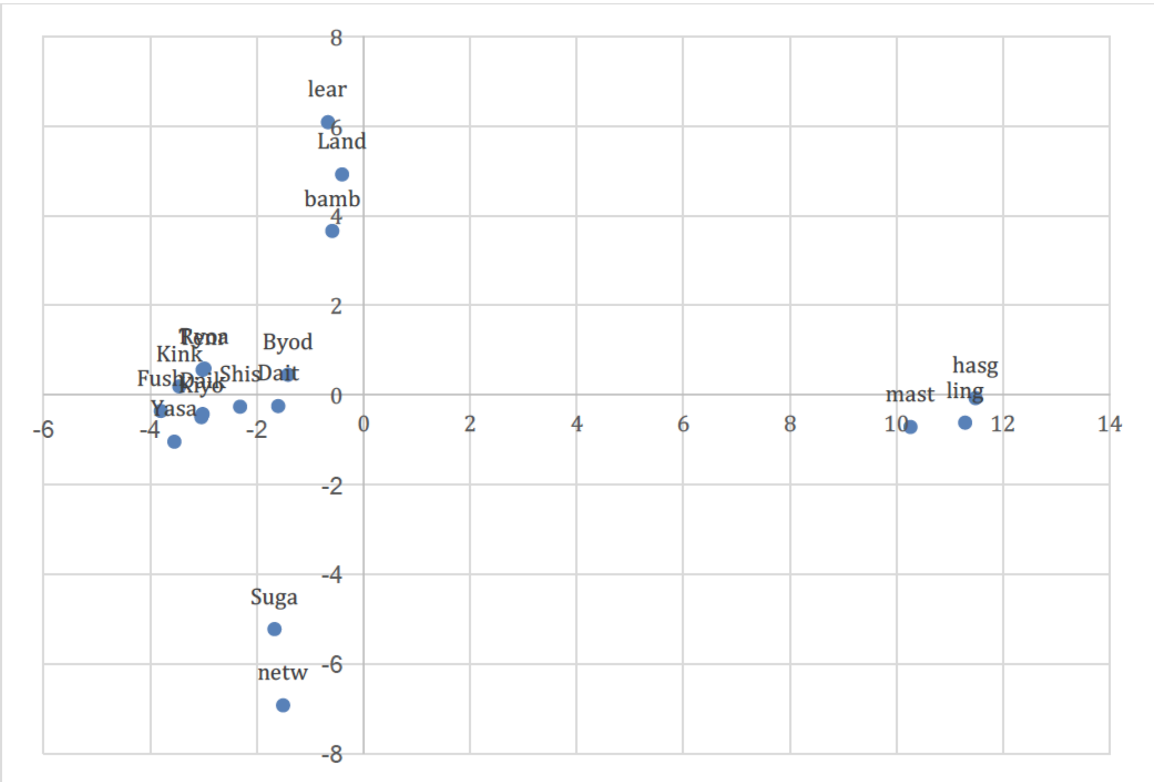

Figure 36: A scatter graph of the correlation between the eighteen selected sites based on the site scores of Principal Component 2 and Principal Component 3.

CHAPTER 4: DISCUSSION

4.1 Cluster Analysis Method in Garden Comparison

This analysis employs the same statistical method from Xu's study, Cluster Analysis, which is used for site evaluation. Prior research has suggested that Cluster Analysis is a useful potential quantitative study method to compare gardens (Xu Y. , 2015). The sample data of the selected Chinese gardens and Japanese sites is collected based on the author's personal understandings and experience of the design principles and elements in oriental gardens. The collected data is then put into the statistical software program SAS (version: 9.4 TS Level 1M2, X64_8PRO platform, English, Copyright© 2002-2012 by SAS Institute Inc., Cary, NC, USA.), which provided output data for generating site scores that represent the dimensions of each site on each corresponding principal component. After the site scores are calculated by the given equations adopted from Xu' study, Excel (Microsoft® Excel for Mac, version: 15.32) is used for arranging the site scores into two-dimensional scatter graphs for final cluster analysis (Xu Y. , 2015).

4.2 Comparison of Gardens and Garden Elements

Scatter graphs of site scores corresponding to the principal component eigenvalue coefficients can be used for identifying clusters visually (Xu Y. , 2015). After the three scatter graphs are generated by the site scores of the corresponding variables, the meanings of the axes are suggested using the most distinctive variables, which are correlated to the eigenvalue coefficients of the first three principal components as shown in Table 6. Table 9, Table 10 and Table 11 list the most iconic variables corresponding to the design elements and principles based on the principal component scores of each variable. The meaning of the positive and negative parts of the axes in the three scatter graphs are suggested by the variables of the highest and lowest numbers in the principal component eigenvalue coefficients.

As analyzed in the previous chapter, the most distinguishable design elements are determined by the largest and smallest coefficients of principal components. In principal component 1, the distinguishable coefficients are around 0.13 and -0.08; in principal component 2 and principal component 3, they are around 0.15 and -0.15. The corresponding design elements of the distinguishable coefficients are listed below in Table 9, Table 10, and Table 11. Since the first two principal components cover 63.81 percent of the variance, this research focuses on the site scores and eigenvalue coefficients of principal component 1 and principal component 2 for further analysis. According to Figure 34, by analyzing the site scores of the first principal component on the horizontal axis and the site scores of the second principal component on the vertical axis, the selected sites are located on the scatter graph and the relationship between these gardens is revealed.

Table 9: List of the design elements corresponding to the largest and the smallest coefficients of principal component 1.

The design elements of largest coefficients	**The design elements of smallest coefficients**
The great halls (ting tang)	Openwork brick walls
Viewing towers (lou ge)	Wetland
Studies (shufang)	Public
Lattice window	Small scale
Plum	
Magnolias	
Crepe myrtles	
Unpainted structures or elements	
Fall color of plant material	
Elevation change	
Plaque	
Lifted base of building	
Well	
Japanese Maple	
Multiple layers of entry sequence	
Multiple layers of edges	

Table 9 (cont'd)

Foreground, Midground, and Background	
Chinese characters	
Sense of sacred place	
Animistic believes	
Tranquility	
Harmony	

Table 10: List of the design elements corresponding to the largest and the smallest coefficients of principal component 2.

The design elements of largest coefficients	**The design elements of smallest coefficients**
Blacktile pavement	Viewing terrace
Brick paving	Pebbles area
Mosaic pave with special pattern	Located in suburban
Openwork brick walls	Abstract geometrical composition
Curved top walls	Metal components in wooden structures
Zigzag wall	Adjacent to burial site
Meandering walls	Stairs
Zigzag Bridge	Stone lanterns
Wall holes with symbolized shape	Obviously exposed drainage ditch/gutter
Moon Gate	Signage stone
Brick carvings	Stone hand wash basin
Artificial mountains	Hydrangea
Taihu rocks /scholars' stone	Moss
Willow	Located on the foot of mountain
Wind	Location adjacent to Shinto Shrine
Located in urban	Wabi-sabi
Ophiopogon japonicas	Religious property
Confucianism	Imperial background

Table 11: List of the design elements corresponding to the largest and the smallest coefficients of principal component 3.

The design elements of largest coefficients	**The design elements of smallest coefficients**
Mosaic pave with special pattern	Black tile pavement
Straight Pathway	Bamboo paved pathway
Glass carvings	Boardwalk
Reflecting Pond	Curved Pathway
Sculptural rocks	Fish pond
Trees	Sugar cane

Table 11 (cont'd)

Shrubs	Naturalness
Turf area	Borrowed scenery
Bamboo	Geomancy rules/Fengshui
Lotus	
Poem and painting concept	
Varied spaces with visual devices	
Opposite scenery	
Wooden /bamboo fence/railings	
Bench	
Azalea	
Trimmed plant material	

Japan and China share many characteristics in terms of traditional landscape design. In 2003, research on the images of Japanese gardens and Chinese gardens analyzed the "country-likeness" through surveys and scientific methods (Zhao, Matsumoto, Liu, Yuan, & Kawata, 2003). The study revealed that there are some specific garden design elements that determined whether a garden is more of "Japan-likeness" and "China-likeness", where sand, water elements, and layout features are thought to be the main factors of "Japan-likeness"; house, bower, stone elements, and shape features are thought to be the main factors of "China-likeness" (Zhao, Matsumoto, Liu, Yuan, & Kawata, 2003). According to the study, the most common impressions among Japanese people of Japanese gardens are purity and stillness, while the primary characteristics of Chinese gardens are thought to be mixture and dynamism. In contrast, the primary impressions among Chinese people of Japanese gardens is include "nature and simplicity", while primary characteristics of Chinese gardens are thought to include artificialness and complexity (Zhao, Matsumoto, Liu, Yuan, & Kawata, 2003). In the cluster analysis performed in the aforementioned study, the distinguishable variables of principal component 2 suggest that in terms of garden design, the "artificial mountain" and "Taihu rock" are more representative of "China-likeness", while "pebble area" and "abstract geometrical composition" are more representative of "Japan-likeness".

In the cluster analysis in this analysis, several design elements and principles are addressed as factors of the garden partitioning. In the first scatter graph (Figure 34), classical Chinese gardens and traditional Japanese gardens share common characteristics used to locate the positive dimension of principal component 1. According to the distinguishable variables listed in Table 9, traditional Chinese garden settings, the favor of plant selection, traditional Chinese culture, and the sense of "sanctification, tranquility and harmony" have strong influences on both classical Chinese gardens and traditional Japanese gardens. In Table 9, it is suggested that traditional Chinese and Japanese gardens are closely related to life consumption, amenity and buildings, while modern Chinese gardens typically function as public spaces. However, the first scatter graph (Figure 34) illustrates that traditional Japanese gardens and modern Chinese gardens are located in the negative dimension because of the low scores in principal component 2, where the variable of "pebble area" and "abstract geometrical composition" are considered as the major factors (where "pebble area" refers to a void, gravel, sandy rocky space).

The five modern Chinese gardens are similar in terms of statistics. Instead of a scattered dispersal in terms of location on the graph, the scores of these gardens are very close in my research and are graphically different from the result of Xu's study (Xu Y. , 2015). The primary reason for the difference in results might be that Xu generated a variable list of the design elements that best describe the unique features of modern Chinese gardens. After the other fifty-nine variables of traditional Japanese garden features are added, according to the site condition data recorded in Table 2, it might be that the "absent" of many of the latter fifty-nine variables makes the modern Chinese gardens scores similar, because they are lacking of many traditional Japanese garden design elements.

In the first scatter graph (Figure 34), modern Chinese gardens are more similar to the traditional Japanese gardens when compared to the classical Chinese gardens, because both groups of gardens are located in the negative dimension of principal component 2. As described in Xu's study, modern Chinese gardens are the result of international culture exchange (Xu Y. , 2015). In the 1920s, Frank Lloyd Wright read a book about Dao (Taoism) and the tea ceremony, named *The Book of Tea,* which was a gift from a Japanese ambassador (Nute, 2000). Wright was amazed by Laozi's ideas of Dao, and he learned about the aesthetics of "naturalness and immediacy" and "non-being" as the principles of space from Laozi (Thompson, 2017). This book deeply influenced the design concerns of Wright, and his design style greatly shifted. Formlessness, naturalness, implication, asymmetry, and transience became the theme of Wright's architectural insights after the 1920s (Nute, 2000). From the results in the third scatter graph, the literature review in Xu's study (Xu Y. , 2015), and the historical significance of Frank Lloyd Wright and his designs, prior research has suggested that under the universal cultural exchange, modern Chinese gardens exhibit the characteristics of western modernism(Nute, 2000).

Moreover, the geometrical concepts, including rectangles and curve-linear lines, are widely applied to contemporary landscape designs (Burley, The Design Concept: Intellectual Landscapes in Michigan, 2006). Modern architecture and landscape designers have turned away from the Beaux Arts traditions, and instead have searched for the possibilities in new patterns and materials (Burley, The Design Concept: Intellectual Landscapes in Michigan, 2006). Concepts are integrated into garden designs; with the development of design concepts, designers are creating spaces that are greater than "a collection of unrelated shapes and forms" (Burley, The Design Concept: Intellectual Landscapes in Michigan, 2006). For example, landscape designs from the old period include Bom Jesus do Monte in Portugal, Xiaoling Tomb in China, Vaux-le-Vicomte in France, Villa Lante in Italy, Tapada das Necessidades in Portugal, Stourhead and Stowe in United Kingdom. All of these landscape designs are valued as experiential projects, which means that visitors must walk through the sites to discover all of the design features. Designers believe that each of these projects have applied different concepts as if applying philosophical guidance to generate the details of each design (Burley & Loures, Conceptual Precedent: Seven Landscape Architectural Historic Sites Revisited, 2010).

Using the definitions of the highest and lowest values of the eigenvalue coefficients, and according to the distinguishable variables listed in Table 9 and Table 10, the dimension of principal component 1 is “traditional oriental garden features and modern Chinese garden features”. In contrast, the dimension of principal component 2 is “Classical Chinese garden design elements, Traditional Japanese garden design elements”. According to Figure 34, eighteen selected sites are clustered into three groups, where principal component 1 can be used to indicate the difference between the group of traditional oriental gardens and modern Chinese gardens; while principal component 2 can be used to separate traditional Japanese gardens and classical Chinese gardens. According to the definitions of principal component 1 and principal component 2, the distinguishable design elements listed in Table 9 and Table 10 can be used as a proposed garden design element list of authentic oriental garden styles.

However, when referring to the distinctive variables of principal component 3 in Table 11 and the third scatter graph (Figure 36), there is no clear indication of garden design preference.

Since the site scores of the first two principal components clearly illustrate a pattern of clusters, this research will primarily discuss the selected sites using the first two principal components. In Figure 34, three clusters of sites are suggested. On the horizontal axis, Humble Administrator’s Garden, Master of the Nets Garden, Lingering Garden, Daitoku-ji, Byodo-in, Shisen-do, Kinkaku-ji, Ryoan-ji, Daikaku-ji, Kiyomizu-dera, Tenryu-ji, Fushimi-Inari- Taisha, and Yasaka Shrine are located in the positive dimension, which are all classical Chinese gardens and traditional Japanese gardens. Bamboo Garden, Learning Garden, Net.Wet. Garden, Sugar Cane Garden, and Landscape New Wave Garden are located in the negative dimension, which are all modern Chinese gardens. Thus, the differences between modern and traditional gardens can be analyzed using principal component 1, which refers to "traditional oriental architecture design elements, oriental garden plant materials, Chinese culture, sense of sacred space, and modern garden features".

As discussed, the variables that have the highest and lowest values of the eigenvalue coefficients are considered distinguishable variables. Thus, the distinguishable variables of principal component 1 are listed in Table 9; the distinguishable variables of principal component 2 are listed in Table 10. These variables are the major factors for the sites scoring high or low. As a result, the variables separate the sites into positive and negative dimensions.

In the first scatter graph (Figure 34), the three classical Chinese gardens have very similar scores; the five modern Chinese gardens are also very close to each other; and the scores of the eight traditional Japanese gardens and two shrines are also similar. These results suggest that the design elements and principles of classical Chinese gardens lack variance, which means they are very similar. The selected classical Chinese gardens follow the same conventional rules, from the distinguishable architectural style to the philosophic guidance, as previously described in Xu's study (Xu Y. , 2015). Similar to the classical Chinese gardens, the traditional Japanese gardens and the modern Chinese gardens have also evolved their branches of conventional styles based on the clusters of gardens in the first results graph (Figure 34), because clustering scores imply that the gardens are very alike.

Traditional Japanese gardens and shrines evolved their own styles under the influence of the authentic Japanese aesthetics and religious concepts. According to the first scatter graph (Figure 34) and the distinguishable elements of principal component 1 listed in Table 9, traditional Japanese gardens are similar to the classical Chinese gardens in architectural form and plant selection. However, the traditional Japanese gardens differ from the classical

Chinese gardens by “locating adjacent to Shinto shrines”, and the “absent” in many of the construction features, including black tile pavement, zigzag walls, artificial mountains, and Taihu rocks listed in Table 10.

In addition, the results demonstrate that the three clusters of sites are different from one another. Compared to the modern Chinese gardens, the architectural structures, including halls, viewing towers, and lattice window are emphasized in the traditional Japanese gardens, classical Chinese gardens, and shrines. As discussed in Xu’s study, modern Chinese gardens lack buildings or any “actual architectures”; there are only simple structures in these gardens to fulfill the functional requirements of dividing space, such as the presence of walls (Xu Y. , 2015).

Moreover, according to Table 9 modern Chinese gardens tend to be small in scale, open to the public and contain wetland. Possible reasons for the differences in the gardens may include the influence of the small number of sample gardens. The small number of sample gardens may be due to the fact that the gardens and shrines in the ancient era were only affordable for the upper class, while the modern gardens are functionally designed to be public spaces and exhibitions of ecological balance. Modern garden design may be representative of educational value and naturalness in terms of design. Compared to the traditional oriental gardens, modern Chinese gardens are mainly created for public use. Modern Chinese gardens typically express the modern thoughts of the natural environment and attempt to get people to enjoy the beauty of wetland, even though wetlands were typically defined as bad places to build gardens in the ancient era.

Based on the sample data (Table 2 and Table 3), Chinese characteristics are very often seen in traditional oriental gardens but are not distinguishable in modern Chinese gardens. The reason might be that the ancient Chinese culture and aesthetics were integrated into Chinese and Japanese garden design during the ancient era, while the modern Chinese gardens were mainly influenced by western culture. Because of the western cultural influence, perhaps the aesthetics of contemporary oriental society no longer focused on using poem design concepts to create a sense of nobility; thus, the Chinese characteristics are not seen in modern gardens as much as in traditional oriental gardens. In general, modern Chinese gardens respond to the needs of contemporary society and ecology. Modern Chinese gardens are designed for everyone to step in and enjoy their time in an open space, while providing an opportunity for people to come into closer contact with the natural environment.

The plant materials also differentiate the selected modern Chinese gardens and traditional oriental gardens. According to Table 9, plum (*Prunus sp. Linnaeus.*), magnolias (*Magnolia sp. Linnaeus.*), crepe myrtles (*Lagerstroemia sp. Linnaeus.*), maple (*Acer sp. Linnaeus.*) and the intended assumption of the fall color of plants compose the main view of traditional oriental gardens, which implies the pursuit of naturalness in traditional oriental garden design and reflect the preference for plant species in ancient oriental countries. However, as discussed in Xu's study, modern Chinese gardens typically use unitary plant species, and they do not focus on providing pleasant views during the four seasons, but strive to achieve simplicity under the influence of the modern western landscape aesthetics (Xu Y. , 2015). It is reasonable to use unitary plant species in modern gardens. The contemporary aesthetic trends focus on very simple, but also very strong patterns to match the architecture style that is diagonal or asymmetrical. Furthermore, in order to provide a sense of urbanism, unitary plant species and forms are often used in outdoor spaces with angular hardscapes.

The other distinguishable variables shown in Table 9 reflect the essence of the traditional approach in creating traditional oriental gardens. In the ancient era, plaques are necessary for labeling the estate; wells are essential for coolness in the hot summer. However, modern Chinese gardens no longer serve as landmarks to honor a place; tap water is provided in urban areas. In traditional oriental gardens, layering can create a sense of ritual, which makes the garden seem more official and high ranking. A sense of sacred space is needed because people want to build gardens in a safe and comfortable place based on geomancy rules and religious beliefs. Foreground, midground, and background are visual techniques that blend the artificial area and the natural environment for a sense of layering and richness. Perhaps these visual techniques are used in traditional oriental gardens to provide the best views with limited resources and cost, under the aesthetics of designing the garden as an ink painting. Animistic beliefs occurred in the design of traditional Chinese and Japanese gardens, which can be used to divide the traditional oriental gardens and modern gardens. According to these distinguishable variables and the literature review, traditional oriental gardens were mainly designed for the minority. Traditional oriental gardens were fostered by the Chinese culture and strongly adhered to conventional rules. Traditional oriental gardens focus on the subtle correlation between elements and people. The sense of tranquility and harmony mostly likely aims to provide people with a peaceful mood to start the day, which could be referred to as religious beliefs and traditional aesthetics.

In Figure 35, the horizontal axis represents principal component 1 and the vertical axis represents principal component 3. The Bamboo garden, Learning Garden, Landscape New Wave Garden, Sugar Cane Garden, Nets. Wet. Garden are located in the negative dimension of the horizontal axis. According to the distinctive variables listed in Table 9 and Table 11, the results suggest that the design elements of openwork brick walls, wetlands, public-use, and small scale have the largest impact on separating the modern Chinese gardens from the traditional oriental gardens. In this graph (Figure 35), the results suggest that the five modern Chinese gardens are divided into two dimensions by principal component 3, while the classical Chinese gardens and traditional Japanese gardens are very similar.

In the cluster of the sites with positive scores on the horizontal axis (Figure 35), the Master of Nets Garden, Humble Administrator’s Garden, Lingering Garden, Kiyomizu-dera, Daikaku-ji, Daitoku-ji, Byodo-in, Ryoan-ji, Tenryu-ji, Kinkaku-ji, Shisen-do, Yasaka shrine and Fshimi-Inari Taisha are located close to the zero number of the vertical axis, indicating that they are all traditional Japanese gardens, classical Chinese gardens, and shrines. Compared to the very high and very low scores of modern Chinese gardens in the vertical axis, the traditional oriental gardens and shrines are clustered around the zero point. In Figure 36, the horizontal axis represents principal component 2 and the vertical axis represents principal component 3. According to the third scatter graph (Figure 36), Master of Nets Garden, Humble Administrator's Garden, and Lingering Garden are clustered in the positive dimension of the horizontal axis with very high scores, and they are all classical Chinese gardens. However, principal component 3 cannot be used to generate clear conclusions due to the unclear result from its corresponding distinguishable elements (Table 11), thus the discussion will not emphasize Figure 35 and Figure 36.

By analyzing the distinguishable variables of principal component 2 shown in Table 10, this result of the first scatter graph (Figure 34) may imply that classical Chinese gardens can be identified by containing traditional garden elements under Chinese culture including blacktile pavement, brick paving, mosaic pave with special pattern, openbrick walls, zigzag walls, meandering walls, zigzag bridge, wall holes with symbolized shape, moon gate, brick carvings, artificial mountains, Taihu rocks, willow (Salix sp. Linnaeus.), wind, Ophiopogon japonicas (L.f., Ker Gawl), and Confucianism.

According to Table 10, principal component 2 also suggests that traditional Japanese gardens and shrines can be identified with the practice of Zen meditation pebble areas and void gravel paving areas in Shinto shrines. Viewing terrace, metal components in wooden structures, and stairs are the most iconic architectural design elements in traditional Japanese gardens and shrines. The aesthetics of traditional Japanese gardens and shrines is closer to Wabi-Sabi and abstract geometrical composition. The traditional Japanese gardens are religious properties and tend to be located close to Shinto shrines and the foot of mountains. According to the literature review, these religious properties are related to the beliefs of the Japanese people that gardens should be set in a sacred place. Thus, the traditional Japanese gardens are also located near burial sites, because people wanted to be buried in sacred places. The fact that stone hand wash basin appeared in traditional Japanese gardens and shrines may be because of the belief that people need to clean their hands before entering a sacred place. Hydrangea and moss are used very often in traditional Japanese gardens and shrines. Compared to the classical Chinese gardens, other distinguishable variables of traditional Japanese gardens and shrines are stone lanterns, obviously exposed drainage ditches/gutters, signage stones and stone hand wash basin. The drainage ditch or gutter in classical Chinese gardens are usually hidden. In classical Chinese gardens, paper lanterns are used under a roof; a plaque with text on it instead of a signage stone is used to label a place.

In general, the evolutionary direction of the selected sites include: modern Chinese gardens are strongly related to public space; traditional Japanese gardens and classical Chinese gardens are connected to life consumption and buildings; modern Chinese gardens and traditional Japanese gardens share similarities in terms of symbolism, abstract geometrical composition, and pebble areas; the design of classical Chinese gardens tend toward the richness of texture, boundaries, and artificial garden elements; and traditional Japanese gardens tend toward more reductive designs, keeping only the essentials, which is strongly related to the implications of sacred space and giving up an opulent design style. Nevertheless, if the number of sample gardens is larger to include more sample data of the a hundred and thirty-four variables, the scatter graph and distinguishable elements of each principal component may be different.

4.3 Future Implication

This research analyzed several Chinese gardens and traditional Japanese gardens with a focus on their cultural context and typical design elements. In addition, this research provided suggestions to help identify Chinese gardens and Japanese gardens using their iconic cultural characteristic values. In addition, the statistic study method, principal component analysis, makes the comparison of these gardens efficient. Future research on landscape architecture may use the same study method to help evaluate and understand the design elements and principles of other sites.

Moreover, in this research, the inner relationship of classical Chinese gardens, modern Chinese gardens, and traditional Japanese gardens was demonstrated in the results of the scientific methodology. Few studies have focused on garden correlation using a scientific method., This research helps to provide the public with an understanding of ancient Chinese culture and aesthetic principles of Japanese gardens using broader dimensions.

Furthermore, this research can be used as guidance for design elements and principles when planning for traditional Japanese gardens and classical Chinese gardens. To create an authentic traditional Japanese garden, according to the literature review, one should define the function of the garden as well as the buildings, respect the geomancy rules and the religious rituals, select the typical Japanese species for plant materials, and understand the spiritual pursuit and aesthetics of Japanese culture. Personal understandings of traditional Japanese gardens may vary, but the sense of Japanese authenticity should be created using the distinguishable design elements originating from the geological environment and the native culture practices in Japan.

4.4 Limitations and Suggestion for Future Research

Principal component analysis has its limitations. For example, the final results may be different if extra objects are included in the same study; in principal component analysis, the dataset is considered “multivariate normal”, which is hard to illustrate across the dataset. The stability of the results of one study are not definitive, and it takes numerous similar studies to make the results close to definitive (Burley, et al., 2009). In this study, the contributions of the variables and the studied sites of different types are counted equivalently in terms of their weights; different results would be generated if the classification and contribution of the gardens is reconsidered based on their types.

In addition, the site scores of three classical Chinese gardens are very close in the three graphs of the cluster analysis, which may not be representative for all classical Chinese gardens. As stated in Xu’s study (Xu Y. , 2015), the small group of sample gardens might be the main factor towards this output. Thus, more classical Chinese gardens can be added in future research to enrich the sample data in principal component analysis, including other famous gardens in Suzhou. Another limitation is that the three-selected classical Chinese gardens are all located in Suzhou; it would be better to select more gardens in the cities with historical heritages, including Beijing, Xi’an, and Hangzhou, for future study to represent the overall style of classical Chinese gardens.

Furthermore, following the same steps in Xu’s study (Xu Y. , 2015), the selection of the variables in garden design isonly based on the author’s personal understandings and experiences using the literature review and site visit. Therefore, the data source in this research is influenced by the author’s subjective thinking. To avoid the effect of the author’s subjectivity, extra variables can be added to enhance the sample collection of future garden research based on this study. In addition, some variables can be subdivided in detail; for instance, the term “geomancy” can be explained as “water stream flows from east to west”, “buildings facing south or east”, “the main hall is located on the top of the contour”, and so on. In this way, a more sensitive criteria list would be generated to better evaluate the sites and eventually gain a deeper insight into the various garden styles. In addition, the term “plum” in the variable list contains all plants of *Prunus* genus in this research. Similarly, “bamboo” includes all kinds of plants in the *Bambusoideae* subfamily. Plant materials are classified by their general forms in this study. Since the number of sample sites is not big, the differences between the similar species are ignored. To generate a more sensitive and accurate result, these variables can be classified into more items of specific species in a larger data base for future studies. Similar to Xu’s study, an agreement in terms of variable selection should be considered in future research (Xu Y. , 2015).

Finally, future studies in the field of landscape architecture and garden design can evaluate other gardens of different cultural contexts in the world with the given equations and statistical methods used in this study. By adding extra sample data on Xu’s study of Chinese gardens (Xu Y. , 2015), new considerations related to oriental gardens are generated in this research. Furthermore, research based on a scientific method of patients with dementia and Japanese gardens discovered that viewing Japanese gardens has positive effects on lowering patient’s heart rate and enhancing behavioral symptoms (Goto, et al., 2016), which provides other direction to take further study on traditional Japanese gardens in the future. Traditional Japanese gardens attract people not only through their design, but also by the sense of nature that they produce (Goto, et al., 2016). In addition, various approaches to garden design include not only visual embellishments, but also include sophisticated and intended sound techniques to create refreshing sceneries in the traditional Japanese gardens (Fowler, 2015). In addition to garden viewing, soundscape and scent are potential areas for future research to gain a deeper understanding of Japanese gardens. Therefore, future studies of site comparison can be conducted by enriching the variable collection and garden samples used in this research.

In this study, the feasibility of using principal component analysis to discover the distinguishable garden design elements of classical Chinese gardens, modern Chinese gardens, and traditional Japanese gardens is displayed. Comparing gardens using scientific method is very meaningful to provide data driven support to analyze the inner relationship of the selected gardens through the distinguishable garden design elements; the results can be described using the scatter graph, where the distinguishable design elements are the major factors making these gardens similar and different. According to the discussion of the results, garden styles can be separated using a scientific method. The evolution directions of different garden styles can also be suggested using the statistical results. Principal component analysis is considered an effective and efficient methodology in this study of garden comparison. Comparing the spread of Japanese gardens and Chinese gardens, the promotion of traditional garden design helped to spread native cultural export in the global exchange; gardens could serve as a useful art product of landscape to improve the international influence of a country.

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