A|Z
ITU Journal of the Faculty of Architecture
Vol 17 No 3 • November 2020

Narrative

ISSN 2564-7474

ITU Journal of the Faculty of Architecture

Vol 17 No 3 • November 2020

Abstracted and Indexed in
Avery Index to Architectural Periodicals
Design and Applied Art Index (DAAI)
Directory of Open Access Journals (DOAJ)
Genamics JournalSeek
International Construction Database (ICONDA)
Scopus
SJR Scimago
ULAKBİM
ISSN 2564-7474

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Editorial

Aliye Ahu AKGÜN • *Editor*

The year of 2020 became the year of nature to respond to our behaviours. What we are experiencing in 2020 has become a dark narrative. We feel lost, uncomfortable and, each day we face an undesired fact that has a great impact on our living conditions. This year will be a negative but an important one for shaping our encounters with the future.

In this issue, much is inspired by lessons learned from the past. In the aftermath of a major earthquake in İzmir just this October, we have been mourning for the victims. The earthquake's damage was caused by faults in constructions of inhabited structures. Göçer's article shows that the damage in traditional masonry caused by earthquakes is mainly dependent on structural irregularities, and offers a lesson from the structures of traditional masonry in Çanakkale. Continuity in structures as well as in traditions is a positive trait. At a different scale, Sağlam looks in his research for the continuity of urban morphology from the past to the future through Galata's urban layout. Thus, he finds out that, despite transformations, Galata's urban layout possesses important traces inherited from ancient times. In addition, Çoban Şahin with her research on historical documentation for Ayasofya District's green areas, concludes that cultures and cultural backgrounds have a great impact on both the negative and positive transformation of urban green areas.

In connection to lessons learned from the ongoing traditions, the transferred is the physical environment and the transformed lies on the socio-cultural background. Tandon and Seghal focus on the impact of both physical and socio-cultural aspects of streets of Puri, India to conclude that socio-cultural aspects are more dominant compared to the physical aspects to indicate the sense of place.

Tavakoli and his colleagues indicate how important social factors are to determine the conditions of built environment. They investigate the socio-spatial vulnerability in association with dilapidated abandoned buildings (DABs) through spatial liminality in Iranian historic cities. Moreover, they suggest that urban regeneration should be carefully conducted to carry historic cities out of the spatial liminality by keeping the heritage value of DABs.

In addition, Adani and his colleagues through their case study from Indonesia, explore the importance of socio-cultural background not only on horizontally developed areas (historic cities, streets etc.) but also for vertical ones (buildings, high-rise buildings etc.). Adani et al. emphasize the importance of socio-economic features shaping the living habits identifying the visibility of space for crime reduction.

It is for sure that we need to change our habits especially to face global challenges such as global warming and climate change. Uçlar and Buldurur in their article show with their case study from Istanbul that the obvious impact of urban form is hand in hand with the apparent impact of human behaviour and socio-economic factors.

To minimize the energy consumption is not the only solution to overcome global challenges. The urban mobility of motorized vehicles is another issue to understand as it seems to be one of the most common pollutants. İnce and Çelik in their article offer a methodological contribution to the literature that guides polices of travel demand management.

The usual travel demand in cities is through the Central Business district (CBD) and easy to observe but its borders are hard to define. Thus, Şıkoğlu et al., offers a new methodology based on Space Syntax. Through their case study from Elazığ, they succeed to determine CBD boundaries but they remain precautious by stating that their methodology needs more cases to be applied in order to reach a robust result.

The blurriness is not only valid for boundaries but also for concepts in our minds. Through our experiences, the explanation and definition of things might change from person to person. Uysal and Pulat Gökmen take minds for a walk on a paper as the terrain. They explore the different narrations of the imagined and the seen. Further-

more, Asar and Dursun Çebi search for the personal language created in architecture through layered representations as the creative tools for design thinking and design act but also as the reflection of explicit and tacit knowledge. By examining Perry Kulpner's works and their narratives, they suggest that although layered representations in architecture produces singularities through personal knowledge, they also include the possibility of creating alternative spatial worlds. Both articles by Uysal and Pulat Gökmen and Asar and Dursun Çebi remind us the beauty and power of architectural drawing and narration.

The best drawers, narrators and space creators are no doubt children. In today's world, with digital settings and also the pandemic, instead of refusing the digital environment, we need to look for a better solution by benefitting from them. Kay and Özkar, after an in-depth research on the interaction of children with tangible objects, explore the capacity of objects as toys for spatial narratives within a blended environment. Their findings provide design principles for a digitally-enhanced environment for children to articulate their spatial narration.

The digitally-oriented life or profession is not only the settings of children but also our everyday settings. In our field, a well-known and most preferred technology is BIM. Much has been said about BIM in recent years. Öztürk provides in her article an overall view on the interoperability in BIM through a scientometric analysis of the broader literature via Scopus. Ardhiati, in her article offers an extended role of BIM and explains how BIM in operation can be useful to disseminate knowledge to the public on the basis of the documentary of the main stadium of Jakarta. Differently, Isanović and Çolakoğlu introduce the inclusion of BIM in the architecture curricula. Both articles, however, bring into discussion the future advancement of BIM through lessons learned from practices of BIM.

Technological advancements in our professional and everyday settings as well as lessons learned from the past are not enough to face the global challenges. We must also include nature as a source of inspiration and a broad understanding and knowledge of the nature itself. In this line, Yılmaz and her colleagues debate the role of nature in design. They observed that students –if they utilize it– benefit from the inspiration from nature especially its capacity to develop design and problem-solving capabilities.

We have a lot more to learn from nature. It is not only an inspiration but a wise teacher. But a good educator sometimes has no mercy, especially when we forget to consider the possible consequences of our behaviours as we fulfil our needs taking the advantage of technology.

Get well soon Izmir!

Get well soon Turkey!

Get well soon The World!

Nature responds to us in the most severe ways and we have to be attentive. Nature talks to us. We can see everywhere the poinsettias blooming as the harbinger of the new season, new beginnings and the new year. Poinsettias are known in Turkey also as Atatürk's flower, Atatürk whom we commemorate on November 10th.

Season's Greetings!

Enjoy reading our new issue!

Stay healthy!

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Structural evaluation of traditional masonry buildings during the February 6 - 12, 2017 Ayvacık (Çanakkale) earthquakes in Turkey

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Received: October 2019 • Final Acceptance: April 2020

Abstract

Throughout history, the town and environs of Ayvacık, a district of Çanakkale in western Turkey, has been home to a traditional style of architecture that represents the integration of cultures originating from different geographies. The medium-sized and major earthquakes that occur periodically in the region constitute a threat to the sustainability of this traditional residential architecture. Four moderate earthquakes having magnitudes of between 5.2 and 5.3 struck the epicenter of Gülpınar - Ayvacık (Çanakkale) over the period February 6 -12, 2017. These earthquakes were strongly felt in the region and in the rural areas, unreinforced stone masonry house structures suffered significant damages. In this study, seventy-two damaged traditional houses were investigated in Yukarıköy district of Ayvacık based on onsite observations, and the types of damage and their potential causes were evaluated according to the data gathered. The reasons for the eleven types of damages were the irregularities present in the formation of the stone blocks of external walls, the sizes of the stone blocks and the irregularities in masonry detailing, the use of weak mud mortar, the lack of tie beams at the floor and roof levels, and the weak connections between different internal wall systems and external walls.

Keywords
Ayvacık earthquake, Earthquake damage, Masonry buildings, Traditional Ayvacık house, Traditional construction techniques.

doi: 10.5505/itujfa.2020.46503

1. Introduction

The North Aegean and South Marmara Regions of Turkey are areas in which many civilizations have existed over the centuries, leaving behind the architectural traces of various different cultures. The Biga Peninsula, in particular, has witnessed the interaction of eastern and western cultures from prehistoric times up to the present. Throughout history, the town and environs of Ayvacık, a district of Çanakkale located in the Biga Peninsula, has been the site of the integration of cultures originating from different geographies, and it is one of the rare areas in the world in which this cultural diversity has been preserved to the present day (Özdemir, 2008). The multitude of data harvested from excavation and surface explorations of prehistoric settlements point to a rich cultural history in the area. These settlements are largely concentrated along the coasts and they openly reveal the effective role Ayvacık played in the interaction of North and West Anatolia and Europe in prehistoric periods (Kocabıçak & Pilehvarian, 2017).

The interchanges of the different coexisting cultures and the footprints of past societies had a great impact on the architectural and structural formation of traditional houses. Besides the availability of local materials, the building techniques used by artisans also influence the architectural and structural configuration of houses and are integral to the emergence of their characteristic features. There are similarities between the architectural and structural features of houses in past settlements and the traditional structures that exist today along the Ayvacık countryside. Earthquakes, both moderate and major, occur in this region at periodic intervals. These earthquakes have destructive and devastating effects on houses and present an important threat to the sustainability of the traditional residential architecture that is so much a part of local architectural heritage.

Turkey is under the influence of three main active seismic belts, namely those of Northern Anatolia, Southeastern Anatolia and Western Anatolia. In the moderate earthquakes that have hit the country throughout history, it has been observed that buildings with a framework of reinforced concrete (RC) in the city centers have suffered slight damage while buildings of masonry in the rural areas have sustained heavy damage and loss of human lives. Scientific studies on these earthquakes have reported that structures using local materials such as stone, mud-brick, and terra cotta have been built without supervisory engineering services. When the possibility of future earthquakes is considered, it is quite evident that structures of similar quality in the rural areas pose the same potential for devastation (Gulkan & Sucuoglu, 1989; Bayraktar et al., 2007; Celep et al., 2011; Sayın et al., 2013; Sengel & Dogan, 2013; Doğan, 2013; Yazgan et al., 2016; Hao et al., 2016; Giaretton et al., 2015; Livaoğlu et al.; 2018; Ismail & Khattak 2019).

Northwestern Anatolia and the North Aegean Sea are the most prominent areas of seismic activity and deformation between the Eurasian and African tectonic plates. The region is under the influence of both the strike-slip tectonic regime that is the general characteristic of the North Anatolian Fault Zone (NAFZ) and the divergent regime of Western Anatolia (Özden et al., 2018). The most destructive earthquakes occurring in the instrumental period (after 1900) were the Aegean Sea Earthquake (M_W=7.2) of 1981, the Ayvalık-Çanakkale Earthquake (M_W=7.0) of 1919, and the Edremit Earthquake (M_W=6.8) of 1944 (Figure 1).

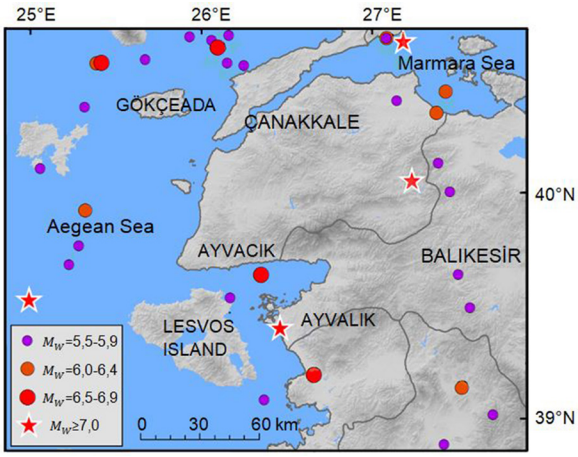


Figure 1. *Instrumental earthquake effectiveness of earthquake region (M≥5.5 after 1900) (adapted from KOERI, 2014).*

In the period February 6 - 12, 2017, four earthquakes having magnitudes of 5.2 and 5.3 took place at the epicenter of Gülpınar-Ayvacık (Çanakkale). In this study, seventy-two damaged houses were investigated in the Yukarıköy district of Ayvacık based on onsite observations. Assessments have been made based on the data collected as to types of damage, causes and the prevalence of the types of damage according to the degree of damage sustained. The effect of the chain of four moderate earthquakes and of magnitudes of approximately M_W=5.2 and 5.3 on the rural architecture in the period of six days was different from the impact wielded by previous earthquakes. The evaluation of these effects is important in ensuring that the structures of masonry built from local stone materials in these rural areas are made to withstand earthquakes of this kind.

2. Traditional Ayvacık houses

2.1. Historical development of the residential architecture of the region

The Neolithic Age (8000-5500 B.C.), a time in which man left behind a nomadic lifestyle of hunting and gathering, putting in its place a life connected to the soil, is a significant period in terms of human history. Village settlements from that era still exist in Çanakkale (Özdemir, 2008). The only settlement representing the Neolithic Age in Ayvacık can be found at Coşkuntepe, situated on a natural hillside close to the village of Bademli. First populated around 6000 B.C., the Neolithic settlement of Coskuntepe as well as the Gülpınar settlement, populated around 4500 B.C. and representing the Chalcolithic period, are the most prominent areas of habitation in the region of Ayvacık that date back to prehistoric times. The Early Bronze Age witnessed the emergence of some major coastal settlements along the west and south shores of the Biga Peninsula. These settlements represent the beginning of the Early Bronze Age and are generally classified in archeological literature as belonging to the era of Troya I (2900-2600 B.C.) (Figure 2). The resurgence in the population of the south coastal region of Ayvacık coincides with the seizure of Assos by the Lydians in 560 B.C. Assos in that period became a major city in the Gulf of Edremit and also the most powerful. Assos was continuously inhabited over the course of the Byzantine era and was used as a center of the episcopate. During this period, various major ports were built by the Christians along the southern shores of Ayvacık (Serdaroğlu, 1996; Aslan, 2008; Aslan, 2012). The area, which had been under Roman rule up until 330 A.D., then passed into Byzantine hands (Deniz, 1998). A great many Turkmen tribes settled in the area in 1092 and in 1288, following the victory of Lemnos, it came under Turkish rule. In 1335, the Ottomans took over and it has remained under Turkish sovereignty uninterruptedly since that time (Gadanaz & Orhan, 2008). From 1924 to 1928, various population exchanges brought compulsory refugees into Gelibolu and Çanakkale. During these transfers, locally settled Greeks went to the opposite shores and the Turks coming in from Crete and Lesvos settled in the places that the Greeks had vacated. A large part of the people being transferred in these exchanges settled in the vacated villages of Ayvacık (Serdaroğlu, 1996).

The town and environs of Ayvacık has been home to a traditional style of architecture that represents the integration of cultures originating from different geographies. The history of residential architecture in the area starts from the settlement of Gülpınar, dated to circa 4500 B.C. Collected data have shown that the walls of the houses in this settlement were made from rubblestone, with corners constructed

Figure 2. *Historic settlements in Ayvacık and its environs.*

of blocks of cut stone (Özgünel & Kaplan 2011). Similarly, it can be said that the flat-roofed stone houses of simple, rectangular form in the settlements of Gökçeada Yenibademli and Troya, dated to circa 3000 B.C., represented the same tradition (Hüryılmaz, 2002). The use of similar building materials and techniques observed in Zagora, dated to the Iron Age, circa ninth century, B.C. is evidence that building techniques have followed a particular traditional pattern in the region and date back to the distant past (Kocabıçak & Pilehvarian, 2017). In the 10th and 9th centuries, B.C., residential architecture on the Aegean islands relied completely on materials of masonry. It has been asserted that this was a matter of necessity because of the geological formation of the land (Eran, 1994). The use of large blocks of stone at the corners of walls (elbow stone) to ensure strength and stability was a largely common application in the area, though not completely in the entire region. It is said that stone was used in the residential architecture of the Western Aegean and Mediterranean region in the Early Iron Age (Eran, 1994).

2.2. Characteristics of today's Ayvacık houses

The houses in the region of Ayvacık are one or two-storied and are evenly situated on a rectangular or square plan, all of them having been built in the masonry structural system in which local stones have been used. The stone blocks used in the buildings are made of ignimbrite or andesite, which is widely found in the region. In erecting the load-bearing walls, the stone blocks are bonded to each other with mud-based mortar. The wall blocks are formed from cut stone and rubble stone. The internal walls of some of the one-storied houses are constructed from manufactured fired clay brick and have a wooden framework that cannot endure the load of either floor or roof. In general, two types of stone forms have been used in the walls. Larger cut-stones called "dirsek taşı" have been used to increase the endurance of the building and its openings, while smaller stones have been used in-between to make up the outer surface. A technique specific to the region known as "ırama" has been used in the masonry bonding. The inner and outer surfaces of the walls have been filled in with a mixture of mud and dried weeds. Tie beams have not been used in many of the load-bearing walls or in the intermediate areas. There are rare examples of houses where a timber tie beam has been employed. Some of the roofs of the houses are flat and have been covered with clay material while some are in the form of a hipped roof that is covered with brick and slopes down in all four directions. The roof covering is made of clayey-earth, which is called "çorak" (wasteland) in the region (Kocabıçak & Pilehvarian, 2017). Çorak is a type of earth in which nothing can be cultivated. The components of the roof construction are made of wood. In the same way, the floor construction and covering materials of the two-storied houses are also made of wood. The main load-bearing timber beams of the roof and floor construction are directly and uniaxially supported on and inside the stone walls. Figure 3 depicts a structure with a hipped roof covered with brick and sloping down in all four directions and the cross-section of a construction system with a flat clay-covered roof.

The characteristics of Ayvacık houses can be seen also in the regions of the Northern Aegean and Southern Marmara, in the traditional residential architecture of Foça, Lesvos, Gökçeada and the Aegean Islands. These houses are built on a square plan from two types of stone. The external walls have unmortared outer surfaces and mortared inner surfaces. Window dimensions are in the ratio of 1:1.5, and other common characteristics include the use of a double-winged window system of woodworking and wall niches. The cross-sectional arrangement of the loadbearing external walls of the houses in this region are formed of rubble-stone plastered one on top of the other and bonded in two rows. The bonding of the two rows is not carried out with large stones or through stones but only with mud mortar. This type of coursed stone building has a long history that can be traced back to the Age of Antiquity. While the walls of temples were

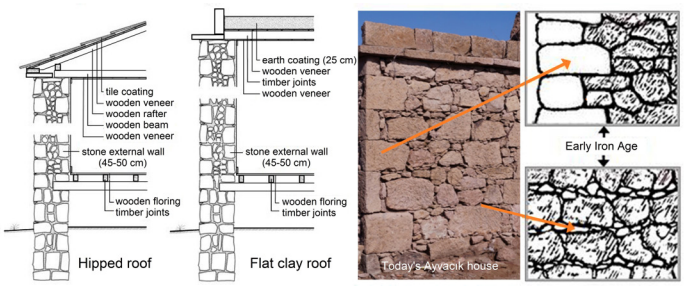


Figure 3. *System cross-section of today's Ayvacık houses and similarities of wall bonding technic between traditional Ayvacık houses and the houses of the Early Iron Age.*

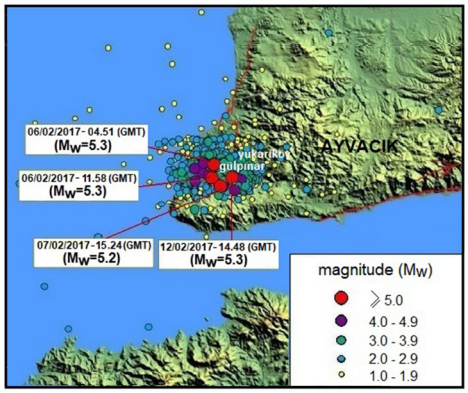


Figure 4. *Distribution of aftershocks of February 12, 2017 Çanakkale-Ayvacık earthquake epicenter (M_W=5.3) and the earthquake of February 6, 2017 (adapted from AFAD, 2017; KOERI, 2014).*

made from rectangular stone blocks, through stones were used in building high walls to ward off the risk of collapse (Saner, 1995; Kolay, 1999).

The houses in today's Ayvacık exhibit various similarities to the historical residential architecture of the region. These similarities point to historical continuity and the most significant can be seen in the system of masonry wall bonding used in external walls. The large stones (elbow stones) used in the Early Iron Age in Western Aegean and Mediterranean houses to ensure strength and stability were widely used, albeit not completely throughout the region (Eran, 1994). Designs were formed on the surface of the wall by placing small stones in between the rubblestone (Figure 3).

3. The Ayvacık earthquakes of February 6-12, 2017

In the period February 6 - 12, 2017, four earthquakes having magnitudes of 5.2 and 5.3 took place at the epicenter of Gülpınar-Ayvacık (Çanakkale). On February 6, 2017, an earthquake of M_W=5.3 occurred at the epicenter of Gülpınar-Ayvacık (Çanakkale) at 06:51 (04:51 GMT) local time. The earthquake was considered shallow, striking at a depth of approximately 6 km. It was felt primarily in Çanakkale as well as in Izmir, Bursa, and İstanbul. On February 6, 2017, at 13:58 (11:58 GMT) local time, a second earthquake of M_W=5.3 was strongly felt in the region and caused panic among the population. This was again created by a normal strike-slip fault. On February 7, 2017 at 17:24 (15:24 GMT) local time, the region was hit with a third earthquake of M_W=5.2. This too was strongly felt in the region and the masonry buildings that had been damaged in the first earthquake were further ravaged. On February 12, 2017 at 16:48 (14:48 GMT) local time, a fourth earthquake of M_W=5.3 struck (Figure 4). This earthquake was created by a normal strike-slip fault (KOERI, 2014).

The assessment of the damage in the area revealed destruction in a total of 24 settlements, particularly in the area of Yukarıköy in the district of Ayvalık, with 480 heavily damaged/collapsed houses, 392 slightly damaged houses, 1 heavily damaged spa, 6 heavily damaged mosques, 75 heavily damaged barns, a total of 1008 structures in ruin (AFAD, 2017).

4. Classification of the house in relation to structural damages

According to the general degrees of damage cited by the European Macroseismic Scale (EMS 98) and the Earthquake Regulations of Turkey, unreinforced masonry buildings sustained five different degrees of damage–slight, moderate, heavy damage, partial or complete collapse (Grünthal, 1998; TEC, 2007). Cracks of a width of less than 10 mm form in the load-bearing walls of slightly damaged structures of masonry. Shear cracks of a width of 10-25 mm in X formation occur in structures of masonry that have been moderately damaged. In heavily damaged buildings of masonry, the width of the cracks is over 25 mm. The load-bearing walls in these structures can sus-

tain vertical displacement, ruptures at corner joints, delamination due to vertical loads, surface ruptures or partial collapse along the plane. In masonry buildings that have partially collapsed, a large part of the load-bearing walls tumble along the plane or collapse in disintegration. Additionally, partial collapse can be seen in roofs and floor structures. In masonry buildings that have completely collapsed, all of the load-bearing external walls lose their load-bearing strength (Bayülke, 1992).

In Yukarıköy, it was determined that the earthquake damaged seventy-two structures in different degrees of impact. The damage was classified in five categories: slight, moderate, heavy, partial collapse and complete collapse. It was observed that the external walls of the slightly damaged houses had one-directional cracks of a width of less than 10 mm. When the forces of the earthquake hitting the structure were parallel to the wall, the cracks were seen to be slanted; when they had a perpendicular impact, the cracks were horizontal and vertical (Figure 5a). The external walls of moderately damaged houses had cracks in the shapes of X'es that measured 10-25 mm (Figure 5b). Some parts of stone walls that were forced to bend out of plane showed signs of delamination and partial collapse. Large cracks of more than 25 mm were observed in the load-bearing internal and external walls, in the body of the walls and at the wall connections of the heavily damaged houses. In addition, it was also determined that the joining points of these load-bearing walls displayed vertical ruptures, divergences from the vertical and partial collapse (Figure 5c). In partially collapsed houses, it was seen that the load-bearing external walls had been partially wrecked or wrecked along the length of the plane and that because of this, the roof or intermediate floor structure had also partially caved in at these regions (Figure 5d). It was determined that totally demolished houses exhibited ruptures at the corner joints of their load-bearing external walls or had been fragmented in the middle of the structure (Figure 5e).

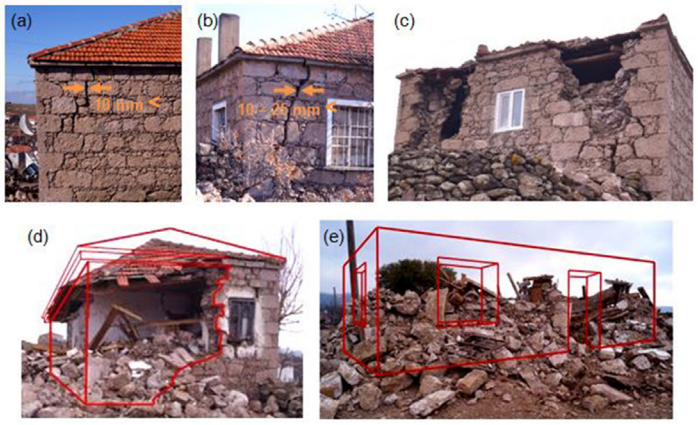


Figure 5. *Building examples of the masonry structure according to the degree of damage: slightly damaged (a), moderately damaged (b), heavily damaged (c), partially collapsed (d), and completely collapsed (e).*

5. Types of damages and an assessment of causes

The rural houses in Yukarıköy were subjected to horizontal earthquake forces from different directions and depending upon their specific structural characteristics, suffered different types and degrees of damage. The lesser durability of the bonding mortar used in masonry systems compared to stone blocks plays a role in the behavior of collapse. Figure 6 shows a section of a partially collapsed load-bearing external wall, where the cracks, disintegration and the wall building system that ultimately caused the wreckage can be seen. The reasons for such types of damage lie in the rubble stone form of the stone blocks and their irregular sizes, the irregularities in the building system, and the unsuitability of the mortar that has been used to bond the rubble stones together. Also, the spaces in-between the rubble stone blocks have been filled in with pebbles and earth, a practice that increases the irregularity of the wall-building system. These small particles of stone have no bonding response and very easily separate from the wall as the result of a vibration, leaving spaces between the larger stones. As can be seen in the closeup of the section of the wall in Figure 6, the mud mortar in section 2 has cracked from the impact of the earthquake and has resulted in a vertical cavity in the midsection. Because of the lack of a tie beam, the partial divergence, disintegration caused by ruptures in the external wall has separated

on a vertical plane into three separate zones. Another important reason for the occurrence of this type of damage was the failure to position the rectangular binding stones at regular vertical intervals on the horizontal plane and along the width of the wall. The spaces formed here constitute the first steps in the occurrence of damage that gradually progresses to the collapse of load-bearing walls. In Figure 7a can be seen the partial rupture and flaking of the load-bearing external wall of a structure that has sustained such damage. The lack of a tie beam at the level of the roof on the external wall is also a major cause for rupture and disintegration. It was observed that the impact of the earthquake also caused the interior spaces of the Yukarıköy houses to sustain heavy damage in the form of partial collapse of fireplace and chimney extensions (Figure 7b). In some buildings, chimneys completely collapsed and in others, deformations occurred. There were partial fractures in the upper sections of the external walls in the parts of the fireplace leading up to the chimney. The reasons for this were the irregular bonding systems used in the region, thinning walls and the drying with time of the mud mortar bonding the stone blocks due to extreme heat emitted from the fireplace. In some structures, wooden lintels were used in the upper parts of the load-bearing walls. Because of the thinness of these wooden lintels and the shortness of the section sitting on the walls, the forces of the earthquake running parallel to the walls caused cracks and partial collapse. This type of damage can be seen in Figure 7c. Using larger sizes of stone materials to maintain the continuity and rigidity of the load-bearing walls would have been a more appropriate solution.

In stone masonry buildings, horizontal loads along the plane of the load-bearing external wall generally give way to diagonal shear cracks. In this earthquake, walls with door and window openings, areas on top or between openings commonly sustained these types of shear cracks. Horizontal forces along the wall plane are concentrated in the upper and lower corners of door and window openings and it

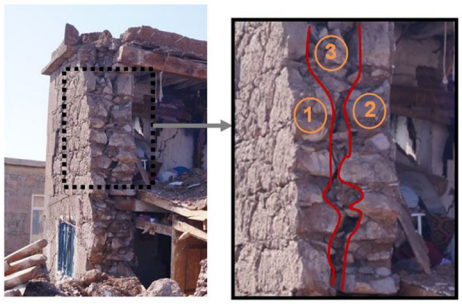


Figure 6. *Size of the stones on the body of the external wall and ruptures in the building system.*

is from here that shear cracks start to appear. These cracks are generally on a diagonal. One of the walls intersecting the diagonal and vertical cracks sustained an impact along the plane and the other perpendicular to the plane. When the vertical crack deepens and fracturing occurs, the connection between the walls falls apart and the independent pieces resulting from the diagonal cracks slide and tumble down due to the horizontal load and the effect of gravity. This type of damage can be seen in Figure 7d.

External walls can become unbalanced due to the disintegration of the bond between the internal and external wall and may consequently fall into an out-of-plane collapse. These types of damage can be seen in the corners of many slender walls. In Figure 7e, the force of the load bearing down perpendicularly on the structure's external wall plane has caused both vertical and diagonal cracks in sections of the lower part of the wall near the joining points and then, a collapse of the wall due to the continuation of tremors. The prevention of this type of damage requires first of all that internal walls are of adequate thickness, that the size of the stone blocks are big enough and of the right formation to ensure rigidity at the joints, that the mud mortar used for bonding is of adequate durability, and that there is a continuity of tie beams at the lower and upper parts of load-bearing walls where they are joined together. Out-of-plane collape could have been prevented if large binding stones had been positioned at vertical regular intervals at the joinings between external and internal walls.The internal wall structures of the houses of Yukarıköy

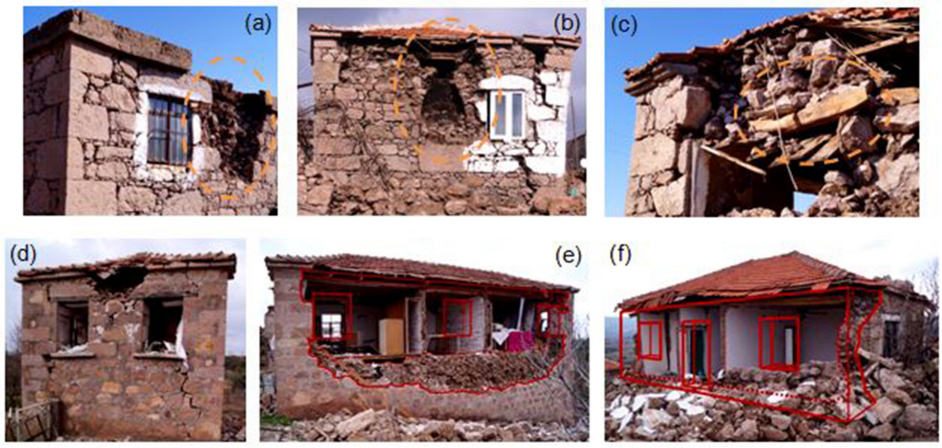


Figure 7. *General damages of body of the external walls: partial collapse and disintegration (a,b,c), diagonal shear crack (d), and out-of-plane collapse (e, f).*

were built from stone, fired clay brick, cement-based briquette blocks and wood. There was no serious damage in the internal walls of these types of buildings. On the other hand, in some buildings, the external walls separated from the internal walls along the plane and collapsed because of the lack of a bonding system that ensured the adequate clamping of internal and external walls (Figure 7f).

The stress on the joining points of the load-bearing external wall increases under the effects of the earthquake. When the corner connections holding up the wall are weak, damage will ensue due to the effect of the different vibrations on walls that are perpendicular to each other. Because of the interaction between these walls, the effects of out-of-plane traction and bending generally cause vertical or diagonal cracks and fractures. In this particular earthquake, the force of the tremors hitting the load-bearing wall plane perpendicularly have generally caused ruptures from bending. In some buildings, disintegration so severe as to cause out-of-plane collapse and ruptures of load-bearing external wall corner joints were observed (Figure 8a, 8b, 8c). The most prominent reason for such disintegration and rupture is the lack of tie beams on the lower and upper parts of load-bearing walls and the absence of an organized pattern of bonding that will ensure the clamping of large blocks of stone. Furthermore, when the size and form of the stone blocks are not reinforced to produce adequate rigidity and bonding is implemented with mud mortar, damage from rupture and disintegration increases. In parts of the load-bearing wall where the roof rafters are perpendicular to the plane, no fracture or out-of-plane collapse was seen because of the decrease in out-of-plane bending moments.

It was observed that some structures in Yukarıköy suffered partial collapse of external walls in the form of pieces that collapse in an upward direction where two walls joined. Figure 8d displays this type of partial collapse. It was seen that this type of damage did not occur in corners sustaining the load impact of the earthquake where large, rectangular stone blocks had been properly bonded together. When window openings are close to corners where walls are joined, the in-plane rigidity of load-bearing walls is reduced. Figure 8e shows a structure where partial collapse has occurred from the impact of the earthquake in the corners where the external walls were joined. Figures 8a, 8c, 8d, 8e and 8f show general damages that were caused by the weak binding at corners . The failure to place binding stones as part of an orderly bonding system at the corner joinings is the main reason for these types of damages. The connections of the roof structure with the load-bearing wall are one of the important factors that impact the earthquake performance of buildings of masonry. The rigidity (i.e. the diaphragm effect) of the floor and roof covering, their integrity and the manner in which they have been bonded to the load-bearing walls

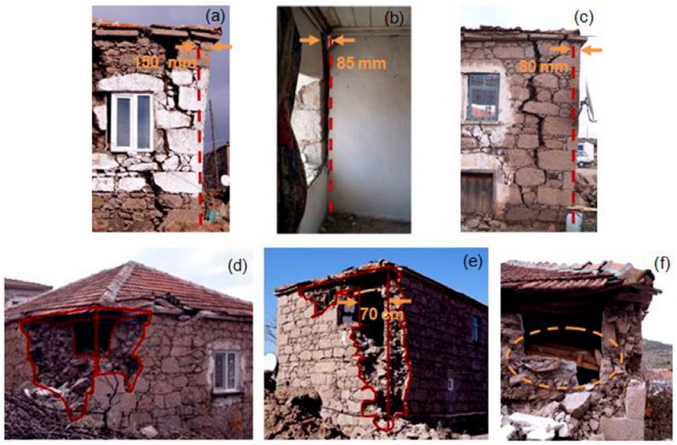


Figure 8. *Vertical displacement of load-bearing external walls (a, b, c) and partial collapse in corner sections (d, e, f).*

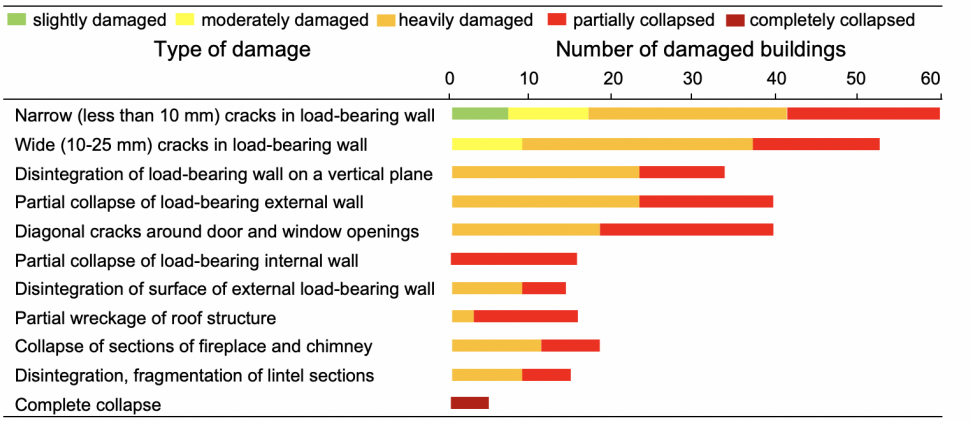
are important elements in preventing walls from separating from each other and disintegrating and in ensuring that the roof does not collapse. If the wooden roof and floor structures had diagonal binding components, neither the roof structure nor the loadbearing wall would have collapsed. In Figure 8f can be seen the damage sustained when ceiling beams of wood directly transfer their load to the load-bearing walls. Here, the lack of connecting beams at the upper sections of the external and internal load-bearing walls, the fact that the wooden beams have been kept shorter than required, the weak connection or the lack of rigidity in the supporting wall are some of the reasons the timber ceiling beams have slipped away from their supports (i.e. unseating) and have partially collapsed. In two-story houses or those where the ground floor level has been elevated, the floor system cannot maintain its rigidity because the floor beams in the intermediate floor systems cannot transfer their load to the walls by means of a tie beam. As a result, the floor construction and the ceiling covering become deformed.

The reason for collapses in the Ayvacık rural houses as a result of the earthquake was the missing technology of masonry bearing wall systems. For example, the absence of large, rectangular binding stones at the corner bindings of loadbearing walls played an important part in bringing about this form of damage. In the same way, on the vertical cross-section, the absence of binding stones binding the internal and external wall facades on the horizontal is a fundamental deficiency. Also, in structures that lacked tie-beams, wooden roof and floor beams were located directly on the loadbearing wall, which constituted another important cause of the damage of collapse. Wooden roof and floor structures that do not exhibit rigid diaphragm behavior should have some stabilizing attributes. Diagonal binding components need to be used in the roof and floor structures to maintain stability. Other causes of this type of damage are the absence of tie beams on the upper and lower sections of the load-bearing walls, the roundness of the stone blocks, the irregularities in the bonding system, and the lack of durability of the bonding material used. Based on the evaluation made according to the data collected from observations, it may be said that there is no need to reinforce the loadbearing walls of the rural houses of Ayvacık that collapsed as a result of the earthquake. Taking into consideration the general evaluation described above in the design and application phases of construction will mitigate the destructive effect of earthquakes to a great degree.

6. Assessment of types of damages and their causes according to the degree of damage

In this section, an assessment of the houses of Yukarıköy was made based on an evaluation of the quantitative data obtained from the distribution of the types and degrees of damage. Seven slightly damaged, nine moderately damaged, thirty heavily damaged, twenty-eight partially collapsed and four completely collapsed buildings, a total of seventy-two houses, were identified in this assessment. At the same time, the prevalence of the structural design and application errors causing the damage have been assessed according to degree of damage. These data, which were produced as a result of the general structural character of Yukarıköy houses, are of importance in ensuring that future reinforcement work and the reconstruction of houses are carried out adequately to maintain durability in the face of possible earth-

Table 1. *Types of damage caused by the Ayvacık earthquake and distribution of degrees of damage.*



quakes. Table 1 displays quantitative data on the general types of damage and the distribution of these types of damage according to the degree of damage resulting from this earthquakes.

Table 2 demonstrates the prevalence of the structural design and application errors causing the damage according to degree of damage. It can be seen that the cause of thin cracks as the only damage sustained in slightly damaged houses is commonly related to the absence of tie beams and sometimes to weak mortar bonding. The same mistakes can be seen in moderately damaged houses but irregular bonding was rarely observed in these buildings. While there were various levels of structural design and application mistakes made in heavily damaged and partially collapsed houses, mistakes in structural design and application were found in all of the completely collapsed buildings.

7. Conclusions

In the review of the rural houses of Yukarıköy that were most impacted by four earthquakes of magnitudes of 5.2 and 5.3 that hit the district of Ayvacık within six days, it was found that damages sustained were largely destructive. An examination of the quantitative data showed that buildings made of unreinforced masonry with stone walls bonded with mud mortar suffered serious damage from horizontal seismic loads. The failure to use large, rectangular binding stones in the L-corners of the external walls and at the joinings of the internal walls played an important role in the occurrence of destructive damages in the houses. The degree of the damage increased when the stone blocks were of rounded form and in the absence of tie beams on the upper and lower sections of load-bearing walls. Additionally, in structures with no tie beams, the wooden roof and

Table 2. *Frequency of structural design and application mistakes by degree of damage.*

Causes of damage	Level of frequency according to degree of damage				
	slightly damaged	moderately damaged	heavily damaged	partially collapsed	completely collapsed
Irregular bonding system	-	rare	common	common	common
Weak mortar	rare	rare	common	common	common
Stone block formation	-	-	common	common	common
Stone block size	-	-	occasional	common	common
Absence of beams	common	common	common	common	common
Corners weakly joined	-	-	occasional	occasional	common
Wall-roof structure weakly joined	common	common	common	common	common
Wall-floor structure weakly joined	common	common	common	common	common
External-internal walls weakly joined	-	-	occasional	occasional	common
Different internal wall system	-	-	rare	occasional	common

floor beams were located directly on the loadbearing wall, which enhanced the destructive effect. The absence of diagonal binding components at the roof and floor levels in structures that had tie beams was a fundamental factor that increased the level of damage.

Such structural errors led to the separation of load-bearing walls from each other on a vertical plane under the impact of the earthquakes, caused partial collapse in external walls along the plane, partial disintegration on the face of external walls, long and thick wall cracks on the diagonal, partial collapse of roof and floor structures, and partial destruction of fireplace and chimney sections due to the loss in load-bearing strength. The degree of damage to such houses is classified as "heavily damaged" and "partially or completely collapsed".

The reason for collapses in the Ayvacık rural houses as a result of the earthquake was the missing technology of masonry bearing wall systems . Related to this, it can be said that there is no need for a reinforcement of loadbearing walls. By remedying the structural and application mistakes described above, the destructive effect of the earthquake will be averted.

It will be beneficial from the perspective of protecting cultural heritage to take into consideration assessments made regarding the impact of the Ayvacık earthquakes on the residential structures in the rural areas and the reasons for this impact as well as to minimize the destructive effects of earthquakes on the traditional houses with similar characteristics that are situated in the region.

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ITU A|Z • Vol 17 No 3 • November 2020 • 13-30

An interdisciplinary experiment for the urban morphology of Galata (Istanbul) and its surroundings during the Late Antiquity and Middle Ages

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Received: January 2020 • Final Acceptance: March 2020

Abstract

During its Byzantine times, Galata was the 13th region of Constantinople, once the illustrious imperial capital now called Istanbul. This part of modern Beyoğlu especially came to the forefront with its prosperous Genoese period, which lasted between 1267-1453. Although Galata had a significant urban and architectural development during that period, there are solid evidence and recent discoveries regarding the phenomenon of spatial continuity. In this regard, it was seen that the Genoese did not found Galata as a colonial settlement from scratch but in fact possessed a well urbanized Byzantine district. In order to display the urban layout of its previous centuries, Galata was formerly subjected to some mapping attempts but few of them were able to accurately detect spatial continuities as well as discontinuities between different historical periods of this neighborhood. Hence, those efforts remained rather inconclusive from an urban point of view. Main reasons behind this failure can be given as the lack of an interdisciplinary approach and proper knowledge of urban morphology. Therefore, this article aims to improve the aforementioned research within the context of discovering the ancient road and water system; and to set a wider spatial connection between the late antiquity and medieval periods of Galata in comparison with modern times. For this reason, primary sources and archaeological evidence were considered for exclusive urban objectives. In the end, related findings displayed that the urban layout of modern Galata and its surroundings not only have strong traces remained from ancient times but also had significant transformations.

Keywords

Galata, Architectural history, Urban archaeology, Urban history, Urban morphology.

doi: 10.5505/itujfa.2020.68916

1. Galata in Ancient Times: Sykai and its surroundings until the Genoese Period

Galata is a northern district of Istanbul, which is located outside the historical peninsula and on the other side of the Golden Horn. As a result of its coastal access to this gulf as well as the Bosporus, Galata has many natural quays. Following an almost plain coastal band all along the localities of Azapkapı, Karaköy and Tophane, the topography rises until reaching a midway hilltop called Kuledibi. After this location, the topography rises further to the north, until Şişhane. Due to its dominant position, Galata offers a clear view of the Golden Horn, Bosporus and Istanbul.

Narratives about the rich natural and built environment of the place now called Galata date back to ancient times. It was formerly called "Sykai" that named after figs. According to Dionysius of Byzantium (2010), Sykai appears as a mere uninhabited place as of the late 2nd century and the oldest settlement of that area was located around modern Tophane, opposite the ancient Byzantium.

The Notitia Urbis Constantinopolitanae indicates as of the 5th century that Sykai, the 13th region of Constantinople was separated by a narrow bay of the sea, therefore reached from the city through regular ferries. It was completely situated on the side of a mountain other than the course of a main street at the sea level, lying along the foot of that mountain. A landing stage for Sykai was in the 6th region right across (modern Eminönü). It had one church; the Baths of Honorius; the Forum of Honorius; a theatre; a dockyard; 431 houses; a large portico; five private baths; one public bakery; four private bakeries; and eight bread distribution centers (Matthews, 2012).

When Theodoric, the king of Ostrogoths had mutinied with his army against Zeno in 487, he occupied Thrace until Melantias and also Sykai opposite of Constantinople, and cut off the city's aqueduct (Malalas, 1986; Marcellinus Comes, 2017). In 528, Justinian I restored the ruined Sykai as well as its theatre and walls. He also built a bridge to go across from Constantinople and accorded the right of being a separate city to this suburb, which was renamed as "Justinianopolis" (Malalas, 1986; Chronicon Paschale, 1989). Afterwards, in 552, he constructed the monumental church of Hagia Irene there (Malalas, 1986; Procopius, 1999).

Elaia (or Elaion) was a sacred and mountainous suburb on the opposite side of Constantinople, which first appears in the 5th century. The church and leprosarium of Saint Zotikos was located there, who lived in the 4th century (Janin, 1969; Mango, 2009). According to Anthony of Novgorod, who visited Constantinople in 1200, the aforementioned complex remained on a hilltop from Pegai (modern Kasımpaşa) (Janin, 1950).

The Church of the Maccabees was another earlier shrine of Sykai from the 4th century but its location was also mentioned as Elaia, as it remained slightly inland from Argyroupolis (modern Tophane) (Mango, 2009). Therefore, the position of Elaia was interpreted as the commanding heights rising above the neighboring Kasımpaşa, Galata and Tophane, like a conical hilltop (Dalleggio d'Alessio, 1946; Janin, 1950; Mango, 2009). The Patria of Constantinople indicates that the leprosarium of Saint Zotikos was rebuilt by Justin II and Sophia during the 6th century (Berger, 2013). Elaia that was named after olives was last seen in a 10th century Byzantine liturgical compilation published by Delehaye (1902).

Afterwards, the location of the aforementioned leprosarium appears as "Herion" in the 11th century, within the context of a Slavic attack in 596. Accordingly, it was soon restored by Emperor Maurice that a second restoration was carried out by John I Tzimiskes in the 10th century (Janin, 1969). As of the late 10th century, Hierion (also called Herion / Gerion) was mentioned as a burial place on the other side of Constantinople by the Patria. It was allegedly named after a priest (ιερεύς) called Iros' statue, which was erected there; and also after the word "tomb" (ἡρῷον) (Berger, 2013; Kimmelfield, 2019). Moreover, "Gerion" was defined as a place right above Galata in a Byzantine patriarchal

document from September 1400 (Janin, 1950). Thus, it was argued by Dalleggio d'Alessio (1946) and Janin (1950) that all those names actually indicated the same place in different times, above Galata.

It is known that Sykai itself was also used as a burial place. For instance, during the disastrous Plague of Justinian in 541-542, burial plots in Constantinople were not enough for the victims. Hence, the towers of Sykai walls were unroofed, entirely filled with corpses and roofed again (Procopius, 2007). Nevertheless, it appears that the walls of Sykai were soon restored to their previous state, as Agathias (1975) indicates that they were manned against Kutrigur raids in 558-559.

"Exartysis" was the site of arming warships and it was placed opposite of Constantinople as of the mid-10th century (Janin, 1950). Then, an "Old Exartysis" was mentioned in the vicinity of Pegai in 1265. As a result, the dockyard of Sykai from the 5th century Notitia, the Exartysis, "vetus Tarsana" (old dockyard) in the west of Galata by May 1303 (discussed in the next section) and recent Haliç Shipyards were all matched with each other by position by Erkal (2016) and Janin (1950).

Especially from the mid-5th century onwards, numerous shrines of Constantinople briefly appeared in historical accounts and with the distinctive statement of "peran" (πέραν = across) for Sykai, Elaia, Argyroupolis and Exartysis, which were all located on the other side of the Golden Horn (Delehaye, 1902; Janin, 1969). Sykai had seven churches and nine monasteries in total as of the 6th century (Janin, 1969).

The exact etymological root of "Galata" is unclear but there are some hypotheses about this subject (Eyice, 1965). It first appeared in the 8th century and after a castle as "kastelliou ton Galaton" during the Siege of Constantinople (717-718) by Arabs. A chain was extended from that fortress to Seraglio Point in order to blockade the Golden Horn (Theophanes the Confessor, 1997). The remained cellar of this fortress now functions as Yeraltı Mosque (Erkal, 2011). The name "Sykai" last appears in the 10th century compilation of Delehaye (1902). It was eventually replaced by "Galata".

The Middle Byzantine period was relatively devastating for the area due to the Battle of Pegai against Bulgarians in 921 (Hupchick, 2017) and the revolt of Nicephorus Bryennius in 1077, which caused a fire that burned all the northern suburbs of Constantinople, opposite the Golden Horn (Kohen, 2007). There are very few primary sources giving information about this period of Galata and its surroundings.

As of the second half of the 12th century, a Jewish quarter in Galata was mentioned by Benjamin of Tudela. It had a community of 2000 Rabbinic and 500 Karaite Jews, where a fence divided them (Jacoby, 1967). During the Fourth Crusade, the Castle of Galata and its naval chain were captured by the Crusaders in July 1203. The Jewish quarter there was sacked and burned. Then, the troops encamped beyond the Golden Horn for a while, before the final siege and sack of Constantinople in April 1204 (Geoffroy de Villehardouin, 2017). In this regard, it has been argued that Galata faced an overall abandonment and neglect during the struggling Latin period in Constantinople, which lasted until 1261 (Jacoby, 1998; 2013).

The foundation process of Sykai in coordination with Constantinople on the other side was discussed by Camiz (2019) that both settlements gradually expanded from the east towards the west during the Early Byzantine period. When the ancient Byzantium grew until the boundary where the Walls of Constantinople are situated, in the meantime, the oldest settlement around modern Tophane then formed Sykai in the west and later continued its growth towards modern Kasımpaşa.

2. Pera on top of Galata: Edicts of May 1303 and March 1304

An alliance was made between Genoese and Byzantines in 1261 against the Latin Empire and the city was recovered in the same year. Later on, Galata was ceded to Genoese in 1267 (Müller-Wiener, 2001). Its fortifications except for the castle were demolished by Michael VIII as a precaution prior the arrival of the Genoese that Galata was officially called "Pera" by them. In July 1296, the colony was devastated by the archrival Venetians (Ey-

ice, 1967; Müller-Wiener, 2001).

The imperial edict of Andronikos II dated May 1303 is an important document due to its contents about precise borders of Pera, which also included metric data and some reference places. It is absolutely necessary to well apply them onto present topography of Galata in order to display the precise urban layout at that time, which naturally had a direct connection with the surrounding area through the supposed main arteries that modern Perşembe Pazarı Street was most probably one of them. The other ones were discussed in following chapters.

Accordingly, and in short, the borderline started in the west, before the landing stage called "vetus Tarsana" (old dockyard). It then climbed northeast and reached the vineyard of Perdikares. Afterwards, it turned east and continued straight towards this direction, which passed through the church of Hagios Theodoros, another vineyard called "Macropita" (belonging to Lips Monastery), the church of Hagia Irene, and two adjacent vineyards of Military Logothete Kinnamos (a Byzantine state official), respectively. In front of the gate of Hagios Georgios (today Sankt Georg), the borderline then made a characteristic double zigzag movement towards the south and east, where the churches of Hagioi Anargyroi and Hagios Nikolaos were bypassed, respectively. It continued towards the east and turned south for a final time and reached the shore, before the Castle of Galata (today Yeraltı Mosque). Finally, it followed the coastline and reached the start point in the west. A buffer zone with a certain depth was to be left unoccupied around the quarter (Fig. 1) (Belgrano, 1877; Sauli, 1831).

The detailed study of Palazzo (1946) in order to apply the aforementioned description on modern Galata achieved partial success and the position of Hagia Irene was well matched with Arap Mosque, known as San Domenico during the Genoese period. However, that characteristic zigzag movement in order to bypass two Byzantine churches was applied with a highly hypothetical manner, as if resembling a map projection error. This mistake was also continued by Balard (1978); causing a situation as if the medieval urban layout was considerably different than present one.

It is known that Yeni Mosque in Galata was built in the late 17th century on a plot formerly occupied by a Franciscan convent with the churches of Sant'Anna and San Francesco from the Genoese period. This area is now a hardware bazaar called Hırdavatçılar Çarşısı (Özgüleş, 2017). Although detailed 17th century site plans of the former convent with two churches were published by Matteucci (1967), modern studies failed to apply them despite the illustration of its characteristic upside down L-shaped plot, which is in fact still present. Hence, it was seen that the churches of Sant'Anna and San Francesco actually corresponded to the churches of Hagioi Anargyroi and Hagios Nikolaos by position, likewise Arap Mosque and its former positional phases. This discovery by Sağlam (2018) secured the precise borders of Pera mentioned in the imperial edict dated May 1303.

Moreover, it was noticed that all the Byzantine shrines mentioned by May 1303 as well as the path of the borderline actually correspond to the grid layout of Galata, which is still present and was even better documented be-

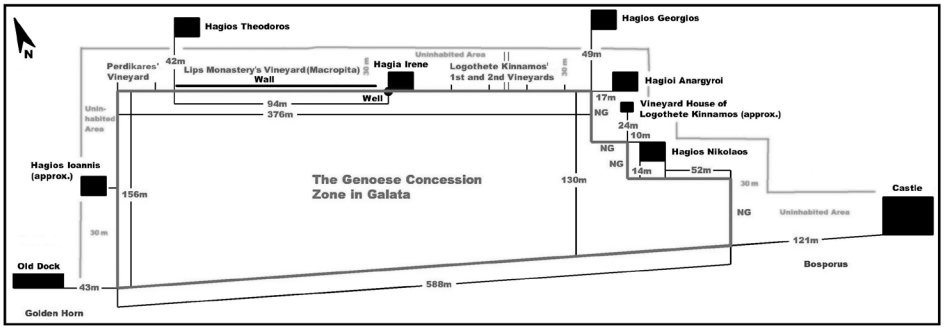

Figure 1. *A sketch of the edict of May 1303 (Sağlam, 2019).*

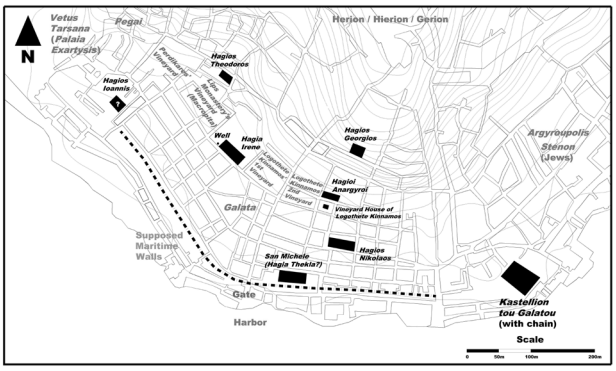

Figure 2. *An accurate superposition of the edict of May 1303 (Sağlam, 2019).*

fore modern demolitions, by Gaitan D'Ostoya and Rose & Aznavour maps from 1858-1860. Thus, it has also been argued by Sağlam (2018) that the characteristic urban pattern of Galata actually predates the Genoese period, as testified by the edict of May 1303 in comparison to all the discoveries concerning the phenomenon of positional continuity (Fig. 2).

It can also be said after the notary acts published by Bratianu (1927) that positioning some Genoese properties of Pera with a precise quadruplet order as of 1281-1284 seems coherent with an antecedent grid layout, as there are regular anterior, posterior and two lateral adjacencies concerning detailed positional descriptions of twelve possessions mentioned by those notary acts.

Besides, due to its central position and likely earlier origins, Perşembe Pazarı Street was supposedly the main marketplace street of Genoese called platea loggia next to the loggia building, the commercial center of the colony (Sağlam, 2018). Moreover, the adjacent vineyards of Military Logothete Kinnamos in the edict of May 1303 were exclusively mentioned as the first and the second along the same linear course, which were located immediately between Hagia Irene and Hagioi Anargyroi that San Domenico / Arap Mosque and Sant'Anna / Yeni Mosque correspond to those shrines by position in later times, respectively. Hence, the aforementioned street also seems as if the pivotal dividing element, namely a cadastral road between two adjacent properties of the same person, therefore two well proportioned plots appeared for those vineyards of Kinnamos between the former Hagia Irene and Hagioi Anargyroi. If there was no urban element in between, it would be pointless to separately mention them one after another (Fig. 2).

With a second imperial edict dated March 1304, Pera was completed to a rectangle, as it was required due to a surrounding moat. Three Byzantine churches remained inside the Genoese quarter that their names were not provided. The Genoese were also allowed to construct strong civil buildings but no city walls (Belgrano, 1877; Sauli, 1831). Although identities of those churches remained unknown, they were apparently the previously mentioned Hagia Irene, Hagioi Anargyroi and Hagios Nikolaos. Therefore, the area later remained inside the well documented rectangular wall circuit with regularly arranged towers was actually ceded to the colonists in two phases; in May 1303 and March 1304. That rectangular form clearly stresses the antecedent grid layout of Galata that can be seen even today (Sağlam, 2018) (Fig. 3).

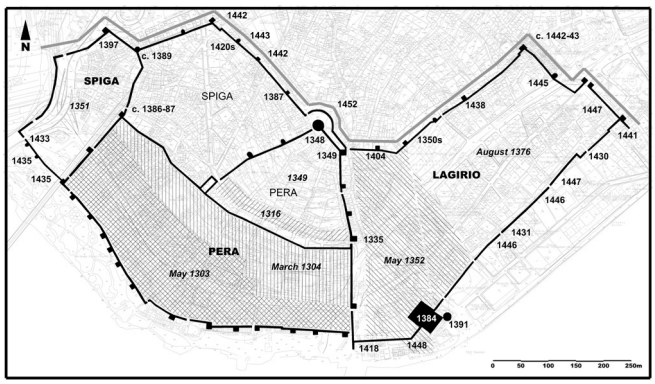

Figure 3. *Main expansion and fortification phases of the Genoese (Sağlam, 2019).*

3. New interpretations concerning the urban morphology of Medieval Galata

Details about the continuity of modern Perşembe Pazarı Street like a main artery of the settlement during the Genoese period can also be found in later primary sources. According to the continued chronicles of Jacobus da Varagine (c. 1230-1298), an accidental fire burned nearly the whole Pera and the communal palace in 1315. Then, the palace was rebuilt in 1316 together with other civil buildings. On the

other side, an inscribed slab also from 1316 tells very similar things but it additionally mentions that "houses next to the moat around the lands of Pera were permitted as a favor" by Emperor Andronikos II, who was highly honored by the inscription on that slab (Sağlam, 2018). A certain part of the former Genoese communal palace is still standing that the building is called "Bereket Han" and located in the junction of Galata Kulesi Street and Bankalar Street (Eyice, 1982). The aforementioned moat was dug sometime before March 1304 and surrounded terrestrial parts of the colony towards the hill. It then caused a second concession, as discussed in the previous section.

It was previously questioned by Sağlam (2018) that those "houses next to the moat" could be the regularly arranged rectangular towers around the first quarter that were well documented by some 19th century maps and photographs. However, they were not only present already in 1306 according to George Pachymeres and Nicephorus Gregoras but also primarily positioned along the Golden Horn, which is certainly not a moat. Hence, the concession of 1316 must be something else, where the emperor's favor was needed.

As of 1316, the moat formed the outermost perimeter of Pera and for the internal area, the colonists were already free to construct any kind of strong civil buildings since March 1304. Soon afterwards, they abused this right and erected tower houses along their quarter, as quoted by Eyice (1967). Therefore, they did not need such a "favor" from the emperor for their own, already walled internal area by 1316, which was devastated by a fire a year ago. In this case, those "houses next to the moat" must be placed just out of the quarter and its moat, like disaster homes.

When considered current position of the communal palace (later Bereket Han) and direct accounts about its construction out of the first quarter in 1316, it appears that houses above a strip of land immediately next to the moat and towards the hill were allowed after the devastating fire of 1315. The positional description mentioned by the slab is especially noteworthy, therefore the palace itself was apparently one of those "houses". A morphological trace that was formed by adjacent longitudinal plots in accordance with dimensions of the former palace is easily detectable in the site (Fig. 3). This area was formerly covered with vineyards but urbanized by the Genoese. As it happened following the official consent of Andronikos II, with whom the Genoese had quite well relations and highly honored on the slab dated 1316, the interpretation of Akyol (1997) about the communal palace that was constructed as an illegal building against the Byzantine authority and as a strong message to them by 1316 remains slightly inaccurate.

In this case, the known dimensions of the former communal palace from 1316 and its elaborate western facade also testify the preexistence of Perşembe Pazarı Street along the same course as well as its northeastern extension. This part is now called Galata Kulesi Street, which continues until the namesake Galata Tower.

To conclude, there are convincing evidences concerning the existence of a much older grid urban layout in Galata before the arrival of the Genoese, and a continuous northeastern axis that corresponds to modern Perşembe Pazarı Street and Galata Kulesi Street. This characteristic morphology most probably belongs to the Early Byzantine period of Galata (Sykai), where its major urbanization took place. This development can be well attributed to the reigns of Honorius (r. 395-423) and Justinian (r. 527-565) with regard to primary sources. By May 1303, predecessor Byzantine properties of Pera were already in a coherent spatial relationship with the aforementioned grid layout, such as Hagia Irene, the vineyards of Kinnamos, Hagioi Anargyroi and Hagios Nikolaos (Fig. 1, Fig. 2). When the Genoese built their new palace out of the colony in 1316, they considered the same road network towards the northeast (Fig. 3).

Moreover, as the main gates of the first Genoese walls directly match with each other through modern Perşembe Pazarı and Tersane streets, they can be supposed as the pivotal axes of the antecedent urban layout as if resembling

Cardo Maximus and Decumanus Maximus (Sağlam, 2018). In this case, the former morphology of Tersane Street with longitudinal city blocks that lasted until the 20th century well resembles the "main street at the sea level, lying along the foot of the mountain", defined in the 5th century Notitia and supposedly included the single large portico of Sykai.

4. Other developments until the Ottoman takeover (1453)

The Genoese period of Galata caused further urbanization on top of an ancient city layout and the emergence of a medieval settlement character, which included both continuity and transformation. For instance, it was previously argued by Sağlam (2018) after some primary sources that Hagia Thekla, the oldest church of Sykai that is known from the 5th century could also be the single church of the suburb mentioned in the 5th century Notitia and it was probably located on the former position of San Michele, the parish church of the colony under the archbishopric of Genoa. Its plot was then occupied by Rüstem Pasha Caravanserai in the mid-16th century.

Major axes of historical cities often keep their original routes, likewise the Mese of Constantinople, which was well displayed by Müller-Wiener (2001) through primary sources and archeological evidence. Thus, as main landmarks of Pera like the loggia, San Michele and San Francesco were formerly concentrated along the supposedly ancient Tersane Street (Sağlam, 2018), it can also be argued that other public monuments of the 5th century Sykai like the Baths of Honorius and the Forum of Honorius were perchance positioned in relation to that major axis with the large portico, and the plots of its later public monuments that are mentioned above.

On the other hand, it appears after the edict of May 1303 that slopes around the first Genoese quarter in Galata were covered with vineyards, which all along delimited the grid layout of the urbanized area. Details about some of them can also be found in the typikon (liturgical book) of the Lips Monastery (today Fenari İsa Mosque), dated 1294-1301. It indicates that a vineyard of 112 modioi and a garden of 3 modioi were located in Galata; also a vineyard of 237 modioi and gardens of 98 modioi (1 modioi = c. 0.1 hectares) (Talbot, 2000). During the same period, the convent of Anargyroi in Constantinople also had two places in Galata, which were a field of 30 modioi and of Barelina of 10 modioi, in which is a bathing place with poor people squatting nearby (Talbot, 2000). The name of the vineyard belonging to the Lips Monastery as "Macropita" (possibly Μακρά φυτεία = long plantation) well matches with the aforementioned modioi of immense agricultural lands. In this respect, a significant portion of these agricultural properties was zoned for construction following the edict of March 1304, when they remained inside the extended Genoese quarter.

Furthermore, according to Nicephorus Gregoras and two construction slabs, the triangular area between the first Genoese quarter and the hilltop was occupied and fortified by the Genoese between 1335-1349 with high towers, ramparts and moats. Meanwhile, John VI Kantakouzenos indicates that a tower was built above the hilltop by the Genoese in 1348 that is known as Galata Tower today (Sağlam, 2018). Then, the Genoese appear as a tax collecting authority in the western borough called Spiga (Pegai) as of 1351 (Balard, 1978). With the treaty of 6 May 1352, the Genoese obtained a certain piece of land delimited by the Castle of Holy Cross (the renamed Galata Castle) (Sauli, 1831), which was discussed in detail by Sağlam (2018).

The administration of the eastern borough called Lagirio (Argyroupolis) was given to the Genoese with another treaty dated 23 August 1376 (Ganchou, 2003). Afterwards, with regard to archival sources as well as a certain group of mural slabs with coat of arms and inscriptions, the aforementioned districts of Spiga and Lagirio belonging to Pera were secured and turned into proper walled boroughs with a series of moats, walls and towers. They were constructed in different phases that lasted until 1452 (Sağlam, 2018) (Fig. 3). Finally, the Ottomans

captured Pera in 1453 together with Constantinople. The colony was surrendered without a battle, therefore secured privileges that Mehmed II introduced with the edict of 1 June 1453 (Şakiroğlu, 1982).

As a result of all those Genoese developments, Galata also kept its typical medieval characteristics even after modern demolitions in the 19th century that similar fortified settlements can be found all along the Mediterranean Sea (Camiz and Verdiani, 2016). Not only medieval but even ancient origins of a city affect modern urban works that can be tracked to some extent (Strappa, Carlotti and Camiz, 2016).

5. Archaeological remnants reconsidered: Water infrastructure

Not many physical traces were recorded from the ancient Galata and its surroundings but there are still sufficient discoveries to give an idea especially about the water infrastructure. For instance, speaking of western territories, being the former Pegai (modern Kasımpaşa), a large cistern probably from the 5th-6th centuries was discovered in 1878 at the bottom of the Ottoman cemetery in Kasımpaşa. It had two rows of roughly shaped and superpositioned marble columns, like the ones of the Cistern of Philoxenos (Binbirdirek), and a ceiling with domed vaults. It was located in Yaşmak Sıyıran Street with an east - west orientation and had a rectangular shape with a width of 17,3 meters and a height of 4 meters. The cistern had stairs on its southern facade and also supportive buttresses. It was listed on 24.03.1968 but then demolished. Some of its columns were moved to Istanbul Archaeological Museum (Envanter, 2019a; Eyice, 1967; Fıratlı, 1969; Forchheimer and Strzygowski, 1893).

Another Byzantine cistern was found in the north of the aforementioned monument, near Kasımpaşa Stadium and 43 meters above the sea level. It was positioned into the bedrock on the western cliff of that extremely steep area. This small, rectangular structure had dimensions of 2,3 x 3 meters. It also had brick masonry walls, a brick vaulted ceiling above, and a small opening on its top. A small, later collapsed aperture towards the cliff was positioned on the southern corner. It was probably reused by the Ottomans as a water distribution center (Envanter, 2019b).

It is known that true to its name, Krinides / Pegai (springs) was rich in natural water resources during ancient times (Dionysius of Byzantium, 2010). Some Byzantine walls and nearby tombs were also recorded in Kasımpaşa, towards further north of both cisterns mentioned above (Envanter, 2019c; Kimmelfield, 2019).

There were some discoveries also in the east, around the former Argyroupolis (modern Tophane) that some scant Early Byzantine ruins and various small artifacts were found. In this context, a large and supposedly mid-5th century cistern was discovered in Sıraselviler Street together with some related foundations and nearby graves, which were attributed to the leprosarium of Saint Zotikos. Brick arched 7th century foundations with adjacent graves in Kadiriler Street, and the 6th-7th century baths next to Meclis-i Mebusan Street with a marble 4th-5th century sarcophagus were further noteworthy ruins from this area (Kimmelfield, 2019). It can be said that the aforementioned attribution of Saint Zotikos is topographically not very accurate with regard to the previously supposed location of Elaia. In addition, some arched Byzantine foundations are still visible along Kemeraltı Street, which were heavily altered during the Late Ottoman period (Envanter, 2019d).

Moreover, foundations of a cylindrical and supposedly single domed structure with a distinctive Byzantine brickwork was seen in the northeast of Galata. This recently restored ruin is located 290 meters northeast of Galata Tower and accessed through Lüleci Hendek Street (Beyoğlu District, Hacımimi Quarter, city block 145, parcel 5). The approximate radius of this structure is 5 meters and its fine brickwork resembles Early Byzantine works.

In Sykai / Galata proper, the collapsed cistern of Saint Benoît with roughly 300 pillars and ruins of the ancient forum, which was located next to the caravan-

Figure 4. *The tunnel beneath Bereketzade Ali Efendi Mosque (Kuş, 2009).*

serai and harbor were mentioned as significant remnants noticed as of the 1540s by Gyllius (2016). In addition, in Bankalar Street and next to Saint Pierre Han, some ruined infrastructures were documented. These were clay brick masonry walls supported by buttresses and covered with multiple barrel vaults that later collapsed to a large extent (Envanter, 2019e). There were also some miscellaneous marble artifacts discovered around Galata, such as a statue base from the 1st century BC; a column dedicated to Pompey; a milestone; an allegoric sculpture; an inscription in Greek from 391; and various unidentified fragments of spolia on Galata Walls and Arap Mosque (Dallegio d'Alessio, 1946; Ebersolt, 1921).

Galata Kulesi'nin altında gizli bir tünele rastlandı

TURİSTİK BİR HALE GETİRİLMEK ÜZERE RESTORE EDİLEN KULENİN AHŞAP İKİ KATI SÖKÜLDÜ

GALATA Kulesinin İstanbul Belediyesi tarafından girişilen onarımına devam edilmektedir. Bu maksatla 90 yıl önce kulenin üzerine ilâve edilen iki ahşap kat sökülmüştür. Kulenin temelini takviye maksadiyle yapılan kazıda ise dört metre derine inilince, kulenin merkezinden geçen bir tünel ortaya çıkmıştır. 70 santim genişliğinde 140 santim yüksekliğinde muntazam taş örgülü olan bu tünelin Cenevizliler tarafından gizli kaçış yolu olarak denize kadar indiği ileri sürülmektedir. Tünelin içinde otuz metre kadar ilerlenebilmiş ve daha

(Devamı Sa. 7, Sü. 3 de)

Gizli tünel : Galata Kulesinin temelini takviye etmek için yapılan kazılar sırasında Cenevizliler zamanında yapılan gizli bir tünel bulunmuştur. Bu tüneli Cenevizlilerin, Galata'nın en hâkim yerinde inşa ettikleri kuleden gizlice denize inmeleri ve icabında eşyalı taşınmak veya kaçmak için inşa ettikleri zannedilmektedir. Tünelin içinde ayrıca kafatası ve insan kemiklerine de rastlanmıştır.

Figure 5. *The tunnel beneath Galata Tower (Hürriyet, 1965).*

Perhaps the most significant ancient remnants are brick vaulted tunnels in Galata. A portion with a width of 0,8 meters and a height of 1,5 meters is located right beneath the minaret of Bereketzade Ali Efendi Mosque (Fig. 4). Having a crook there, the tunnel runs straight towards Galata Tower in the north. It is almost parallel to the southwestern facade of that mosque. After passing it and having a second turn nearby, it then continues towards the Golden Horn in the south, and supposedly all along Bereketzade Medresesi Street. It was dated to Late Antiquity / Early Byzantine periods after small findings and a section of 60 meters was recently restored. Two nearby graves from the same period and scant aboveground foundations with stamped bricks were also found. The mosque building itself was reconstructed in 2006 (Envanter, 2019f; İSTED, 2019; Kuş, 2009).

Another brick vaulted tunnel with a clear north - south direction is located right below the cellar of Galata Tower, which is 1,5 meters high and 0,72 meters wide (Fig. 5). It was discovered before the restoration works of 1960s and interpreted as a Byzantine construction (Anadol, 1964; Anadol and Arıoğlu 1979; Eyice, 1967; Hürriyet, 1965). A small, upper part of its barrel vault is still visible from the nearby public space, as the former ground level in the

Figure 6. *The tunnel in the north of Galata Tower and near a cistern (Sağlam, 2019).*

exterior was lowered in modern times and vaults of the tunnel section out of Galata Tower were destroyed. Dimensions and overall architecture of this tunnel section is very similar to the one discovered below Bereketzade Ali Efendi Mosque.

Finally, in 70 meters north of Galata Tower and next to Küçük Hendek Street (Beyoğlu District, Şahkulu Quarter, city block 283, parcel 56), a ruined tunnel structure was seen during an excavation next to a cylindrical, single domed and due to its bricks supposedly 18th century Ottoman cistern (Fig. 6). Its position well corresponds to the straight northern route of the ancient tunnel below Galata Tower.

It has been said by Ibn Battuta (1929) that a small, dirty river was running through the main marketplace of Galata as of the early 1330s. A visible portion of an ancient aqueduct in the form of an underground tunnel was also noticed during 1540s by Gyllius (2016), which reached the coastal area next to the caravanserai and the supposed ancient forum. These two narrations most probably defined the same thing, which was supposedly the southern end of the water conduit that is known after the previously mentioned archaeological discoveries. The current of its final course before reaching the Golden Horn must have been used by nearby shops during the 14th century for evacuating garbage to the sea.

Although there is little evidence about the water supply of the area in ancient times, it has been questioned by Crow, Bardill and Bayliss (2008) that Sykai must had a well water infrastructure due the Baths of Honorius located there, which was presumably built in 395-423. Hence, the water supply of Byzantine Constantinople from northern resources around Belgrad Forest probably also nourished Sykai and had a similar route with the Ottoman water system (of Taksim) until modern Taksim Square (Crow, Bardill and Bayliss, 2008). It has also been briefly argued by Çeçen (1992) that around the time of the Ottoman conquest in 1453, Galata received potable water from nearby resources and through small galleries inside hills.

A straight connection between all of those Late Antique water tunnels seen in Galata as a part of a very long water system is evident. They were simply subterranean aqueducts once brought potable water to Sykai and apparently also to the Baths and Forum of Honorius in the very central part, near the coast. A construction or improvement to the water infrastructure of Sykai also by Honorius during his reign between in 395-423 is likely due to the Baths of Honorius and the Forum of Honorius that were already present in this suburb, according to the 5th century Notitia.

There are further connections between Honorius and water structures of Constantinople. That is to say, emperors Arcadius (r. 395-408) and Honorius intended to safeguard the aqueducts of Constantinople with a statute dated 29 May 395 and introduced harsher punishments against any violations instead of using public reservoirs. Then, with two laws dated 29 and 31 December 396, both emperors diverted public entertainment expenses to the construction and repair of the Theodosian aqueduct of Constantinople, except for festivities on their own birthdays. A final statute dated 29 October 412 and issued by emperors Honorius and Theodosius II (r. 408-450) was about the construction of a new, elegant portico in front of the Baths of Honorius in Constantinople (Theodosius II, 2001). It should be noted that as of the 5th century, a second Baths of Honorius was located in the 5th region of Constantinople, right across Sykai (modern Sirkeci) (Matthews, 2012).

As previously discussed, the rebel of Theodoric reached Sykai in 487 and the aqueduct of Constantinople was also cut. Then, Sykai had a large scale restoration by Justinian I in 528. These incidents might be relevant to the water supply of Sykai in terms of a probable 6th century repair but there is no archaeological evidence or research so far. This underground water system of Sykai / Galata probably also fed the mentioned bathing place near poor people's houses there, which appeared in the typikon of the convent of Anargyroi, dated 1294-1301.

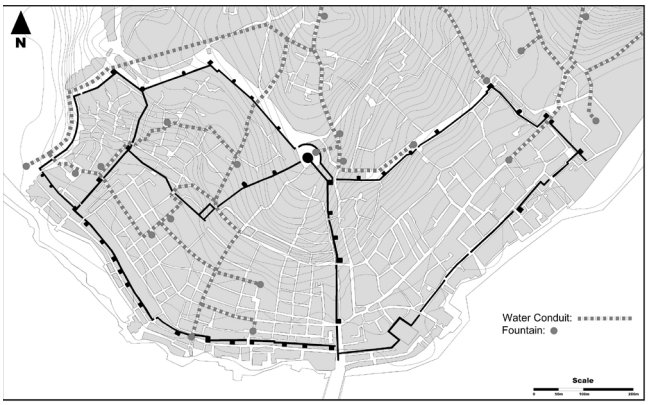

Figure 7. *Ottoman water system of Galata (Sağlam, 2019, after Çeçen, 1992).*

Moreover, according to a treaty dated 5 September 1341 and published by Bertolotto and Sanguineti (1896), the underground water system of Galata was highly likely in use also during the Genoese period. With this treaty, the Byzantine imperial authority obliged the Genoese not to inflict any harm on Greeks while conveying, canalizing and collecting water for Pera. Therefore, the underground aqueducts in question must be used by the Genoese in order to meet this liability.

The Ottoman water supply of Istanbul that originated from northern resources had approached Galata all along modern Taksim Square, İstiklal Street and Galip Dede Street. After a tripartition around Galata Mevlevi House, it supplied the walled quarter through laterals, namely modern İlk Belediye, Lüleci Hendek and Yolcuzade İskender streets (Fig. 7) (Çeçen, 1992; Özgüleş, 2014). Correspondingly, a large section of Ottoman water tunnel was discovered below İstiklal Street in 2012. It is 563 meters long and located between the French Cultural Center and Galatasaray High School (TRT Haber, 2012). A year later, a smaller water tunnel with a very similar appearance to the ones detected in Galata was discovered below Taksim Square (Habertürk, 2013). However, the origin of this section is absolutely uncertain.

Hence, it appears that the Late Antique water system had a different and rather direct route within Galata Walls when compared to the Ottoman water supply system. Yet, it is highly probable that they once had the same route from the main resource until the north of Galata Tower, where the Ottoman system split up for some reason.

6. Burials along the ridge

Concerning another topographical issue, it has been suggested by Dalleggio d'Alessio (1946) that the necropolis of Sykai was located at Kalafat Yeri next to Azap Gate, as abundant funerary debris and sculpted marbles were found there. It should also be mentioned that some ancient funerary debris was unearthed within the plots of Arap Mosque and Yeni Mosque. They included a small funerary stele with an angular pediment, where the relief of a half-draped man with an object on his right hand was placed inside a niche that the lower edge has a Greek inscription; and an elliptical column of grayish marble with another Greek inscription, respectively (Dalleggio d'Alessio, 1946). In this case, it can be said that Sykai, known as a fig orchard by the 2nd century also served as a cemetery to Byzantium until the early 5th century, when its major urbanization took place. The aforementioned sculpted funerary materials apparently belonged to Hellenistic / Roman periods. Yet, it should be noted that the monumental tomb of Hipposthenes, who was a hero from Megara lived in the 7th century BC was accordingly located in the west of Sykai (Dionysius of Byzantium, 2010). Therefore, Sykai perchance had burials even during the Archaic period but this function then continued towards the north, as discussed below.

A larger burial location was detected around the church of Ss. Pietro e Paolo. There were some significant discoveries during its 18th and 19th century restorations, such as a number of

Figure 8. *Funerary steles in the church of Ss. Pietro and Paolo (Sağlam, 2019).*

ancient tombs formed of large bricks, marble funerary steles, and several poorly cooked clay urns in the form of a pot, which contained lachrymatory glasses and bones (Dalleggio d'Alessio, 1946).

Those steles, being four in number are still located above the high wall in the right hand side, after passing the main courtyard gate of the church of Ss. Pietro and Paolo in Galata. They were found during the reconstruction of 1838-1843 (Dalleggio d'Alessio, 1946). Two sculpted artifacts can be safely dated to the Roman imperial period before the foundation of Constantinople (Fig. 8) . Among the remaining two steles with crosses and some inscriptions, one of them was dated to the 6th century by Curtis and Aristarchis (1885), which tells: EN|ΘA|ΔE KATAKI|TE ΣABBA|TIΣ ΠIΣTOΣ (Here lies down Sabbatis the faithful). It can be said that the other one also belongs to the 5th - 6th centuries with regard to its epigraphic style (Fig. 8)[1].

Two Late Antique / Early Byzantine graves discovered near Bereketzade Ali Efendi Mosque together with a section of the water tunnel from the same period were already mentioned in the previous section. Then, towards the southeast of Galata Mevlevi House, today Serdar-ı Ekrem Street no. 30, an Early Byzantine cemetery with triangular graves and stamped bricks was found during the first half of the 20th century (Bardill, 2004; Mamboury, 1951). Further funeral materials were found towards the north, as a terracotta coffin with a skeleton was unearthed in the northern end of Karaköy - Beyoğlu funicular tunnel (Dalleggio d'Alessio, 1946).

Much above, ten Byzantine graves with rectangular bricks forming triangular covers were discovered during the restoration of Casa Garibaldi in 2014, and dated to the 4th-6th centuries after small findings and radiocarbon dating (Radikal, 2015; Hürriyet, 2016; Bornovalı, 2016). Slightly upwards from that location, two funerary steles, nearby human bones and lachrymatory glasses were found during an excavation in Surp Yerrortutyun (Üç Horan) Armenian Apostolic Church. Those steles reportedly depicted the scene of a typical funerary meal, accompanied by Greek inscriptions (Dalleggio d'Alessio, 1946). There were five funeral discoveries around and towards the northeast of that site, all from the 3rd-1st centuries BC (Fıratlı and Robert, 1964).

Finally, a very significant Late Byzantine necropolis including more than 50 burials was found in Taksim. It consisted of 47 brick tombs, 2 stone tombs and many nearby inhumations, which were discovered behind the famous Ottoman reservoir in Taksim Square and dated after various small findings from the area (Envanter, 2019g).

With a series of strict statutes issued between 340-356, Constantius forbade the demolition of tombs and removal of their materials for any purpose but those penalties were mitigated by Julian in 363. Then, in 381, Gratian, Valentinian II and Theodosius I issued a law that burial sites must be placed out of Constantinople due to contamination reasons (Theodosius II, 2001). Finally, in two burial laws issued by Anastasius I and Justinian I in the 6th century, Sykai was considered as a part of Constantinople (Justinian I, 2015; 2018). In this case, the temporary usage of Sykai walls for corpses during the plague of 541-542 can be interpreted as an exceptional situation due to a disaster. Nevertheless, it can be argued that after all the efforts by the aforementioned emperors, new and larger burial sites appeared out of Constantinople as well as Sykai during the Early Byzantine period.

7. Discussing continuities and discontinuities

When considered the funerary discoveries concerning Galata, it can be said that the tombs display a topographical and also chronologically repetitive continuity while moving away from Galata towards the north; from Hellenistic / Roman periods until the Late Byzantine period; and through modern Galata Kulesi, Bereketzade Medresesi, Galip Dede and İstiklal streets, likewise the supposed Late Roman / Early Byzantine water system along Bereketzade Medresesi, Galip Dede and İstiklal streets. That burial site reached modern Taksim from

Galata by Hellenistic / Roman periods. This area was intensely used also during the Early Byzantine period and reached modern Taksim once again by the Late Byzantine period.

It was already revealed in previous sections that modern Perşembe Pazarı and Galata Kulesi streets as well as the characteristic grid urban layout of Galata date back to pre-Genoese times of Galata. In fact, a probable ancient origin of the strong axis that consisted of modern Galip Dede and İstiklal streets was previously set forth by Dalleggio d'Alessio (1946) but lacked a larger scale topographical, chronological and archaeological elaboration. Therefore, when considered all the burials found along the main topographical axis mentioned above, an ancient road can be supposed for the same course, where the Early Byzantine underground water system was also positioned. Such urban elements often superpose, but not always.

Concerning the concentrated cemeteries along the aforementioned route, an ancient road was highly likely in connection with that ridge as an attractor urban element, which supposedly caused adjacent burials in rows for long centuries; all along the ridge between Galata and Taksim. Concerning this phenomenon, it has been argued by Camiz (2018) that mountain ridges are natural continuous attractors, therefore routes within certain conditions take the shape of a continuous attractor. Hence, the "ridge-top theory" formerly set forth by Gianfranco Caniggia in 1976 can also be interpreted as the result of the attraction of geographic features on anthropic routes (Camiz, 2018). Burial sites around Argyroupolis and its urban morphology point a similar situation along a second ridge through modern Necatibey, Defterdar and Sıraselviler streets in the east, which most probably linked to the supposed main axis of Sykai with the large portico, but this subject needs further research (Fig. 9). There were burials along the ridge since the Hellenistic period but victims from the nearby leprosarium of Saint Zotikos from the 4th century supposedly increased the number of burials there. When considered the need of more burial sites of the new imperial capital, that funerary practice on the other side was well continued through centuries. Corpses belonging to the victims of the Plague of Justinian and recovered from Sykai walls, where they were initially disposed were probably reburied towards the hill behind Galata in the mid-6th century. In time, a site formerly known as Elaia that was named after olives then turned into an intense cemetery, and its name was also changed (Hierion) in accordance to the later tradition. This function lasted until the Late Byzantine period and stretched out a distant position (Taksim) once again.

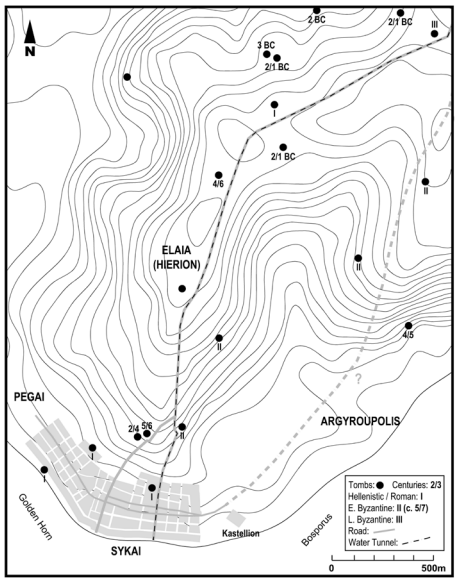

Figure 9. *A hypothetical map for the ancient water and road network (Sağlam, 2019).*

On Tabula Peutingeriana, which is a Roman road map from the 4th-5th centuries, a road reached Sykai after following the Thracian Black Sea coasts until Philia (Karaburun) and then passing Thimea for 12 Roman miles (24 km) (Talbert and Elliott, 2010). "Timaea turris" was located on the western coast of the Bosporus and towards the north, which falls around modern Sarıyer (Dionysius of Byzantium, 2010). In fact, the approximate distance between modern Sarıyer and Galata matches with the related section of the Roman road map. In this case, the supposed ancient axis along the ridge of modern İstiklal Street with regard to topographical and archaeological evidence was perchance the southern end of the ancient road between Sykai and Thimea, known from the contemporary Tabula Peutingeriana.

When considered the known final route of the Late Antique / Early Byzantine water tunnel of Galata, its uncertain northern route can be safely supposed along that ridge due to an evident topographical advantage in order to distribute water effectively to lower suburbs; likewise the Ottoman water system between modern İstiklal Street and Taksim Square. The crook of that ancient water tunnel (together with the antecedent road) in the position of modern Bereketzade Ali Efendi Mosque perhaps intended to reduce the slope and to slow down the water pressure against the steep topography that the nearby Perşembe Pazarı Street also has the same morphology on two spots. In addition, it can be supposed that cisterns of Pegai and Argyroupolis were also supplied by some secondary connections from that major water conduit but it should be noted that Pegai had its own, perhaps limited natural water resources.

The construction of Galata Walls with multiple gates during the 14th-15th centuries but especially Galata Tower in 1348 most probably repelled the antecedent continuous route of modern Galip Dede Street and obstructed its bifurcated continuity towards modern Galata Kulesi and Bereketzade Medresesi streets in the south. Therefore, it seemingly diverted itself towards Yüksek Kaldırım Street, where a Genoese city gate was located, which was called Küçük Kule (Small Tower) Gate during the Ottoman period. However, it can be said that the Early Byzantine water tunnel under the ground safely kept its ancient, straight route along the ridge and beneath the Late Medieval Galata Tower (Fig. 10). It is clear that the Genoese had considered the ancient water tunnel and positioned Galata Tower directly on its top, probably for securing the water resource of the colony as well as the need of the tower itself. In this case, Camiz (2018) argued that the "ridge-top theory" can also be interpreted as a result of the repellence of anthropic routes by anthropic features. Then, a repelled route is inclined to be attracted by a contemporary attractor feature, either anthropic or natural, such as a city gate (Camiz, 2018).

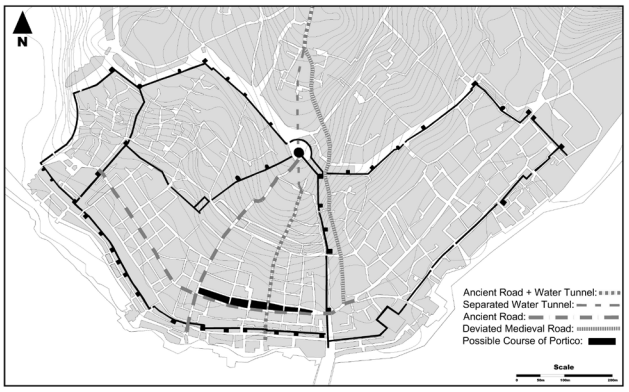

***Figure 10**. A hypothetical map for the continuities and discontinuities (Sağlam, 2019).*

8. The aftermath

For the area immediately outside Galata Walls, a c. 1481 copy of the famous Buondelmonti panorama (originally from c. 1422) shows a Turkish cemetery (sepulcra turcarum) in the west and vineyards (hic sunt vinee burgensium Peyre) in the east, respectively (Buondelmonti, 2005). Similarly, "Vigne de Pera" also appears on many 16th-17th c. panoramas of Istanbul. It appears that the cemetery function of the area from modern Şişhane until Kasımpaşa, formerly used by Greeks and Genoese was continued by the Ottomans as "Küçük Mezaristan" (Small Cemetery) (Eyice, 1996; İşli, 1992; Kömürciyan, 1988).

The Ottomans called the nearby coastal gate of Galata Walls "Meyit" (Death), which recalled that cemetery. Its landing stage was used for disembarking Ottoman funerals brought from the city, which were buried on the other side of the Golden Horn (Kömürciyan, 1988). "Büyük Mezaristan" (Big Cemetery) was located around modern Taksim. Those two cemeteries once occupied a huge area along the topography. Both of them were disappeared in the late 19th century together with the previously mentioned agricultural areas (Eyice, 1996). This hilly region kept a functional and spatial continuity for centuries but had a complete urbanization in modern times.

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Endnotes

I am greatly indebted to Prof. Dr. Serra Durugönül, Assoc. Prof. Dr. Bülent Öztürk and Res. Asst. Bünyat Burak Aykanat for these expert opinions.

ITU A|Z • Vol 17 No 3 • November 2020 • 31-46

Green areas in the Ayasofya District (*Nâhiye*) according to the cadastral survey *(tapu tahrir)* registers of Istanbul waqfs 1546 and 1600

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Received: February 2020 • Final Acceptance: May 2020

Abstract

The aim of this paper is to explore the settlement plan and structure of characteristics, components, continuity and changes of green areas mentioned in quarter (*mahalle*) units of the Ayasofya District (*nâhiye*) according to 'The Cadastral Survey (*Tapu Tahrir*) Registers of Istanbul Waqfs dated 1546 and 1600'.

In order to understand the green areas and make interpretations about them, it was considered necessary to understand the urban characteristics and settlement patterns of the Ayasofya District. To achieve this, the urban elements of the Ayasofya District that may have affected the character of the green areas has been researched and compiled. Then, maps were developed in the GIS (Geographic Information System) program to understand the status of the city when the dates of the cadastral survey registers. Afterward, tables were prepared containing the settlement characteristics, their green areas, and their components and numbers. Tables were compared to each other and to maps, and conclusions were drawn. Then, all data supported by visual and written sources related to the period were evaluated and interpreted considering the respective years that they were registered.

As a result, the general settlement plan of the city and the status character of the green areas in the settled areas as well as the relationship of the green areas with the structures they are attached to was determined. Furthermore, the distribution of the green areas in the quarters, their density and location, and the reasons for the differences between the 1546 and the 1600 registers have been discussed.

Keywords

Ayasofya District, Green areas, Green areas components, The cadastral survey (tapu tahrir) registers of Istanbul waqfs 1546 and 1600.

doi: 10.5505/itujfa.2020.81488

1. Introduction

As Aslanboğa states, the three basic structures that establish the financial mechanism of the Ottoman State are the treasury, the manorial system and the waqf system. In order to be regularly supervised by the state administration, a formal registration process was necessary to place the waqfs in a standardized legal framework. Consequently, waqf (*waqfiye*) descriptions, which are the documents describing waqfs' characteristics and their management, were developed (Öz, 1991 p: 425-426). The state registers on income sources, called "*tahrir*", were registers in the waqfs cadastral survey registers (*tapu tahrir defterleri*) (Aslanboğa, 2018 p: 552).

Apparently, waqfs cadastral survey registers are fundamental sources that reveal the social structure of the time and provide important information about the socio-economic and socio-cultural condition of the state (Özgüdenli, 2012 p: 465-467, Öz 1991, p: 425-426). Those sources from the 16th century are 'The Cadastral Survey Registers of İstanbul Waqfs dated 1546' and dated 1600', and they contain clues about the urban settings, the infrastructure characteristics, the quarter plans of the city, and information about the green areas and their features, as well.

Detailed registers of the green areas reveal Turks attached importance to the green areas because of the income they provided. According to Tanyeli (1986), the expressions of '*bağçe*'[1] in many waqfs suggest the presence of agriculture activity within the city. As Tanyeli stated, the garden in the Turkish home was not an ornamental element but rather an area associated with production, adding that the city had large gardens at that time. Respectively, since the waqf registers of properties were directly linked to the property's income, the waqf registers of trees were mostly related to the opportunity to trade their fruits or timber.

The cadastral surveys of both 1546 and 1600 are divided into 14 districts (nâhiyes); 13 districts are in the historic peninsula and the other 1 is located in Galata.[2] this paper is about the Ayasofya District which is found in the first chapter in both cadastral surveys.

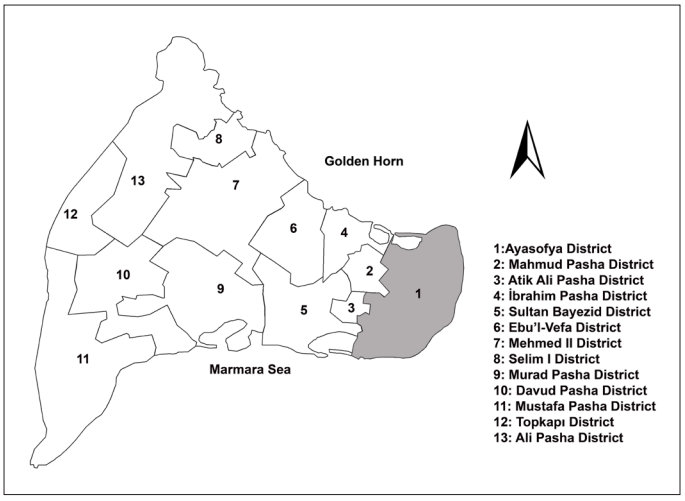

Figure 1. *The Location of Ayasofya District (Prepared by author by İnalcık, 2001, Ayverdi, 1958; Ayverdi and Barkan, 1976, Canatar, 2004) .*

The 14 districts which are mentioned consist of quarters. The Ayasofya District consists of seventeen 17 quarters with 259 waqfs in the 1546 registers and 360 waqfs in the 1600 registers (See Figure: 1 and Table: 1), containing also the data about the green areas

Öztan (1968), Yıldızcı (1978) and Özbilen (1991) defined green areas as places where the existing open spaces in the urban texture are integrated with plant elements. They added that they are divided into three categories: public, semi-private and private. This study focuses on the green areas in the waqfs that are in the housing settelements and are also in the private green areas.

The aim of this paper is to explore the settlement plan and structure of

Table 1. *Quarters and number of foundations of the Ayasofya District.*

Quarters	Number of foundations (1546)	Number of foundations (1600)
Ayasofya Quarter	26	27
İshak Pasha Masjid Quarter	27	27
Sinan Agha Masjid Quarter	13	23
Akbıyık Masjid Quarter	23	43
Güngörmez Masjid Quarter	16	20
Nakılbend Hasan Masjid Quarter	11	20
Hüseyin Agha Mosque Quarter	9	38
Uzun Şüca Masjid Quarter	18	13
Binbirdirek Sinan Agha Masjid Quarter	4	4
Hace Rüstem Masjid Quarter	9	10
Firuz Agha Masjid Quarter	8	9
Üsküblü Masjid Quarter	17	26
Hayrüddin Bey Masjid Quarter	6	13
Karakedi Hüseyin Çelebi Masjid Quarter	15	19
Nevbethane Daye Hatun Masjid Quarter	20	20
Elvanzade Hace Sinan Masjid Quarter	22	20
Hace Üveys Masjid Quarter	15	28
Total	259	360

the characteristics, components, continuity and changes of green areas mentioned in quarter units of the Ayasofya District according to 'The Cadastral Survey Registers of İstanbul Waqfs dated 1546 and 1600'. The study conducts a survey of the waqfs registered in the cadastral survey registers, explaining the factors related to the origin and presence of green areas and their components within the waqfs. Thus, the study will try to attempt to fill this deficiency in the literature.

2. Sources and method

2.1. Sources

The main sources of the research are The Cadastral Survey Registers of İstanbul Waqfs dated 1546 and 1600. Moreover, visual and written sources were also used in order to adequately comprehend the data found in the registers. The Istanbul depictions of Giovanni Andrea Vavassore (c.1480), Matrakçı Nasuh (1533), Melchior Lorichs (1559) and Josephus Grelot (1680) provide clues about the green areas of Istanbul. Additionally, written texts and observations, which include writings by Petrus Gyllius (1544-1547), Pierre Belon (1546-1549), Hans Dernschwam (1554-1555), Ogier Ghiselin de Busbecq (1555-1560), and Evliya Çelebi's Travel Book (1630) as well as Skarlatos Byzantios (1851-1869) provide information about the period.

2.1.1. The cadastral survey registers of Istanbul waqfs dated 1546

The original is located in *Kuyûd-ı Kadîme* Archive of the General Directorate of Land Registry and Cadastre in Ankara (Genç et al, 2010 p: 99). In 1970, it was published in Turkish by Ömer Lütfi Barkan and Ekrem Hakkı Ayverdi and included 2490 waqfs between 1502 and 1546. However, some of the waqf registers do not have a specific registration date.

2.1.2. The cadastral survey registers of Istanbul waqfs dated 1600

The original is located in the *Kuyûd-ı Kadîme* Archive of the General Directorate of Land Registry and Cadastre in Ankara (Genç et al, 2010 p: 99). In 2004, Assoc. Dr. Mehmet Canatar published it in Turkish. It includes 3265 waqfs between 1596 and 1600 and the date of the last waqf is 1600.

In both of the cadastral survey registers, waqfs include the people's waqfs, the components of the waqfs, and conditions governing the waqfs. In 'The Cadastral Survey Registers of Istanbul Waqfs 1546 and 1600', the unified waqf of building groups that were founded jointly are called '*menzil*'[3] (Yilmaz 2009, p: 57). In general, the '*menzil*' consisted of certain types of structures and building sections. Besides the '*menzil*', the waqf registers also indicate garden components such as *bağçe, bağçe-i kebir*[4], *cüneyne*[5], *çerak/çeraklık*[6], *bir-i ma*[7], *çardak/çartak*[8], *eşcar*[9], *eşcar-ı tut*[10], *eşcar-i müsmire*[11], *gayr-i müsmire*[12], *muhavvata*[13], *and zulle*[14].

2.2. Method

This study primarily focuses on the literature review and initially explores the green areas registered in the quarter units of the city. Consequently, the number, the general components, and the settings of the waqfs found in the 1546 and 1600 cadastral survey registers were investigated. In addition, the results of further analyses that reveal the properties of the green areas and their specific locations according to the data provided for the Ayasofya District were shown on two maps using the GIS (Geographic Information System) program. (See: App.-1A and App.-1B).

The topography curves correspond to the map prepared by Muller-Wiener (1998)[15] and the district borders match Halil Inalcik's *Ottoman Period Districts Map* prepared for the Islamic Encyclopedia[16]. The city quarters were defined according to Ekrem Hakkı Ayverdi's map for the book 'Istanbul Quarters at the End of the Fatih Period'[17], whereas the data about the buildings was drawn from 'The Cadastral Survey Registers of Istanbul Waqfs dated 1546 and 1600'. Müller Wiener's book and map of Istanbul were investigated as well. (Those without identification of their location are shown on the map, but indicated as numbers in the table in App.-4).

Moreover, land, sea walls, harbors and roads were determined from the

interactive Byzantine Map[18] developed by the University of Toronto. Cisterns correspond to Kerim Altuğ's 2013 study[19] and the waterway axis to Kazım Çeçen's 1999 book[20] and to the maps supplied by the ISKI (Istanbul Water and Sewerage Administration) archive. City fountains were indicated according to İbrahim Hilmi Tanışık's 1943 book[21].

Despite the fact that the city quarters are identical in the two cadastral survey registers, the quarters in the Ayverdi Map from 1958 and the quarters in the cadastral survey registers differ[22].

The information about the green areas and green area components in the quarters was tabled (See: App.-3) and evaluated in relation to the map (See App.-1A, App.-1B). A table containing the city elements relevant to the period was developed (See: App.-5), and green areas and green area components (App.-3) and the map (App.-1A and App.-1B) were evaluated together. Thus, the continuity and development of the gardens and their relationship with the city elements were investigated.

2.3. Urban elements of the Ayasofya District in the 16th century

2.3.1. Natural elements

Topography, climate, vegetation and streams can be evaluated as natural urban elements that could indicate effective continuity and change of the green areas of the period. For the topography, Eyice (2010) emphasized that important changes, especially in the last fifty years, are evident. Because of this, the evaluation of the historical structures of Istanbul was based on the topographic lines of Müller-Wiener's 1970s map, which indicates the topographic lines before the changes of the last fifty years. In addition, Dionysios of Byzantium (2010) stated that the coastline was more recessed during ancient times and transformed over time.

In addition to topography, Skarlatos (2019) and Kadıoğlu (2009) stated that the living conditions in Istanbul are very favorable in terms of climate. According to data from the Kandilli Observatory and Meteorology Laboratory, there are no climate registers of Istanbul corresponding to the 16th century. Among the sources relating to the period, only Skarlatos (2019) reported that the annual temperature never fell below -4 / -5 degrees and never exceeded 26 degrees. He also registered the annual number of snowy, cloudy and rainy days. However, no data regarding the monthly average temperature and precipitation rate were found.

Table 2. *Istanbul's temperature averages by years and months (The values are degrees Celsius.) (Arıkan, 2019).*

year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
2020	5,54	6,01	7,65	12,02	16,51	20,98	23,35	23,37	20,29	15,97	11,96	8,19
1650	5,16	5,62	7,23	11,56	15,99	20,42	22,76	22,79	19,73	15,46	11,50	7,77
1550	5,36	5,83	7,45	11,81	16,27	20,72	23,08	23,11	20,04	15,73	11,74	7,99
1450	5,52	5,99	7,63	12,01	16,50	20,97	23,34	23,37	20,28	15,96	11,94	8,17

Table 3. *Istanbul's precipitation averages by years and months (The values are in millimeters.) (Arıkan, 2019).*

year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
2020	94,70	62,18	58,45	50,56	29,58	27,66	22,00	21,98	30,58	57,07	85,27	113,17
1650	97,70	84,17	37,18	55,32	25,66	49,46	30,99	14,12	54,06	56,02	88,16	114,19
1550	96,01	66,29	49,68	52,69	26,64	34,39	23,35	15,89	46,29	55,31	86,50	113,77
1450	94,78	62,14	57,81	50,72	28,63	27,62	21,93	21,08	28,34	55,01	85,26	113,19

In this study, the estimated temperature and precipitation monthly and yearly values are based on the Global Circulation Models (GCM), developed by R. Bryson et al., the GCM model system, and the Florya Meteorology station data (providing complete climate registers due to the proximity to the research area) (Table: 2-3).

The interpretation of the values in the table indicates that the climate in the 16th century was similar to that of the present day and was at normal values. Therefore, it could be said that there may be similarities with the present in terms of green areas and vegetation, and no significant differences were determined.

As well as favorable climate conditions, İstanbul had rich vegetation. Depictions of Istanbul by Vavassore (1480), Matrakçı Nasuh (1533), Melchior Lorichs (1559) and Josephus Grelot (1680) as well as written texts of Pierre Belon (1546-1549), Hans Dernschwam (1554-1555), Ogier Ghiselin de Busbecq's letters (1555-1560), Evliya Çelebi's Travel Book(1630) and Skarlatos Byzantios (1869) mention the presence of the following vegetation in the city: cypress (*Cupressus sempervirens*), plane (*Platanus orientalis*) and willow (*Salix alba*) trees were mostly evident around mosques; various flowers,

Table 4. *Fires / years / areas affected in the 16th century Ayasofya Quarter (Cezar, 1963 p: 329-335).*

Year	Area	Statement
1569	South of Golden Horn	One of the most destructive fires that occurred in Istanbul until the 17th century.
1574	Topkapı Palace	Did not exceed the palace borders.
1592	Around Ayasofya	Houses near the Masjid of Üsküblü burned.
1594	Ayasofya	Limited destruction.
1598	Around Ayasofya	Limited destruction.

vegetables and fruit species, colorful blooming trees and grape species were distributed throughout the gardens of residential areas.

Eyice (2010) and (Dinç 2015) stated that there is no natural water source other than the stream called Bayrampaşa (*Lycos*) Stream within the borders of Istanbul during the Turkish period. In addition, Ağır (2009) added that there was a stream dating from the middle ages near the Drungarios Gate (*Odun Kapısı*) which later became dirty water according to the Piri Reis Map. These streams, which do not exist today, reveal that topography and streams have a close relationship. Moreover, topography curves indicate possible streams that have existed in the past and have dried up or started flowing underground over time in the Ayasofya District (See: App.-1A and App.-1B).

2.3.2. Cultural elements

Ports, water sources and water structures are urban cultural elements in the Ayasofya District which cause the green areas to change. Ülgen (1939) mentioned the existence of the Haliç and Kadırga Ports within the boundaries of the quarter. The strong presence of the working class near the ports increased the distribution of dwellings for singles called '*höcre/ höcerat*'[23], which resulted in a distinct building typology. Such buildings led to the investigation of the relationship between port areas and green areas within the district.

According to Yaltırık et al. (1997), the presence of natural water resources as well as the water structures resulted in Istanbul's human-made greenery at the end of the 16th century. Water resources of the 16th century are cistens, waterways and fountains. According to Altuğ (2013), there are 158 closed cisterns within the city wall, and 28 of these cisterns are located within the Ayasofya District (See: App.-5). In addition to cisterns, a few transmission lines that provide water to the Suriçi Area of Istanbul are the Halkalı Water Supply and Kırkçeşme Water Supply Systems (Çeçen, 2002 p: 476). In the 16th century, the Sultan Mehmed Waterway from the Halkalı Water Supply and a branch of the Kırkçeşme Waterways passed through the inside of the Ayasofya District and reached Topkapı Palace (See: App.-1A, App.-1B). Regarding other water sources, there were two fountains within the borders of the research area dating from the 16th century. (See: App.-1A, App.-1B).

2.3.3. Social elements

Population is an important social element for urban development just like green areas. According to Çeçen (1999), the population of Istanbul immediately after the conquest was 40,000, and according to İnalcık (2019), 50,000. Later, in the 16th century a rapid increase in the population of Istanbul took place (Pamuk, 1990 p: 66, İnalcık, 2009 p: 65). With the rise in population, the number of buildings increased and green areas developed.

Together with the population, the economic structure affected the green areas in the 16th century. The most important economic activity in the Ottoman Empire and Istanbul during the 16th century was agriculture (İnalcık, 2009 p: 82). However, when agricultural products started to be supplied from other cities to Istanbul in the first half of the century, agricultural production decreased. In 1588, famine started in Istanbul, resulting in a growing crisis in which the prices of fruits and vegetables tripled. Thus, in the last quarter of the century, agricultural production was resurrected in the cities (İnalcık, 2009 p: 233 Pamuk, 1990 p: 92-93, 101-106).

In addition to natural, cultural and social urban elements, some fires are recorded in Istanbul too. Kuban (1996) declares that there was a decline in urbanization due to fires in Istanbul, and the housing-garden relations were di-

versified. Therefore, the relationship between fires and green areas was investigated.

3. Findings and evaluation

3.1. Green areas in the Ayasofya District according to 'the cadastral survey registers of Istanbul waqfs dated 1546'

According to 'The Cadastral Survey Registers of İstanbul Waqfs Dated 1546', there was a high number of waqfs and '*menzil*'s in the Ayasofya District. This probably is related to the fact that it was one of the first established quarters and is located within the city center.

It is difficult to obtain general characteristics of the buildings through the registers. Although not mentioned in the registers, Kafesçioğlu (2019) stated that the structures were irregular during the period. In the registers, the terminology emphasizes the diversity of structures: *hânehâ-i tâhtanî* (low / lower dwellings), *hânehâ-i fevkânî* (above / upper dwellings) and *höcerât* (small rooms / cells) (App.-2). It is possible to say that these structures emphasize the general characteristics of the district. Moreover, definitions such as '*tâhtanî* (placed below), *fevkânî* (placed above), *süfli* (situated below) defined whether the houses were one or two-storey. Along with the structures, green areas such as '*bağçe*' and '*cüneyne*' are indicated in the waqfs. It is impossible to obtain data regarding the plan and general features of the green areas, except for a few structural and vegetative characteristics.

'*Bağçe*' and '*cüneyne*', one of which is known as '*bağçe-i kebir*', are found in the district in general. The difference in the meaning of '*bağçe*' and '*cüneyne*' is not clear. Investigation of the registers led to no generalization or feature indicators. The '*bağçe*' was common in both the İshak Pasha Masjid and the Karakedi Hüseyin Çelebi Masjid Quarters, while the '*cüneyne*' was only encountered in the İshak Pasha Masjid Quarter.

Investigation into the topographic features of the location of the quarters shows that they were founded on flat areas (See: App.-1A). As Gyllius stated, the houses in Istanbul were always in flatter areas (Gyllius, 1997 p: 37).

Figure 2. *Melchior Lorichs Panorama of the Ayasofya District – general view of green areas (Leiden University).*

Consequently, it could be said that the buildings as well as population were denser in flat areas, and it is possible there were also more green areas. One of the reasons for the density of green areas may be the topographic character of the quarters (App.-1A). Although streams may have already dried out by the 16th century, the existence of streambeds is a possibility. In other words, there may be a relationship between streams and green areas.

It is not possible to identify clues in terms of vegetation characteristics in the district, except for the '*eşcar-ı müsmire*' located in the Nakılbend Hasan Masjid Quarter, mentioned in both of the waqf registers (See: App.-3). The strong presence of Muslim population in the district and the demand for privacy explains the necessity to enclose the green areas in the '*menzil*' structures. Consequently, 86% of the green areas registered in the cadastral survey registers had an 'encircled' typology. In the district, the union of several '*hâne*' (house) surrounded by '*bağçe*' were generally linked to 'menzil' with one '*bir-i ma*' (water well) and, in some cases, '*zulle*'. It is possible to generalize that these '*bağçe*', which characterized the district, were the most common type of green areas.

While the green areas and elements related to the green areas were concentrated near the Ayasofya, they tended to decrease moving further away (See: App.-1A and App.-3). Their number reached a peak in the Ishak Pasha Masjid and Hayrüddin Bey Masjid Quarter. In the parts of Lorichs Panorama which depict the Ayasofya and likely show the İshak Pasha Quarter (right next to Ayasofya), green areas have

been identified within the settled area (Figure: 2). Therefore, data about the district and depictions show that the green areas were concentrated around the Ishak Pasha Masjid Quarter within the district (See: App.-6A, App.-6B).

The Hace Üveys Masjid, the Daye Hatun Masjid and the Elvanzade Hace Sinan Masjid Quarters, which were poor in terms of green areas, were seriously damaged by a fire in 1539 (See: App.-3). The evaluation of the relationship between the development of green areas and fire indicates that there were fewer green areas in quarters which experienced destructive fires. Green areas were adversely affected by fires and significantly reduced in the rebuilding after a fire. Moreover, the destruction level was higher in the quarters where the number of green areas was limited as fires spread more intensely due to the lack of greenery. The presence of cisterns in the same quarters suggests the possibility that they were used for fire fighting and for watering gardens (See App.-3, App.-5).

3.2. Green areas in the Ayasofya District according to the cadastral survey registers of Istanbul waqfs dated 1600

The number of the waqf registers in 1600 exceeded the number of the waqfs registers in 1546 (See: App.-2). The fact that waqfs increased in the quarters further from Ayasofya suggests that new settled areas emerged due to the rise of the population.

The common building typology of the district generally consisted of '*hânehâ-i tâhtanî* (low / lower dwellings), *hânehâ-i fevkânî* (above / upper dwellings), *beyt-i suflî* (lower-story dwellings), *beyt-i ulvî* (upper dwellings) and *höcerât* (small room/ cell) (App.-2). In addition to the complexes of multiple dwellings, constructed from independent sections, single-dwelling structures could also be observed within the district. Moreover, from the small sections identified as '*höcre*' and '*höcerat*', it can be understood that such building types were also frequently utilized. In addition to settled areas, the emergence of new commercial areas within the district is also evident. The new business areas, placed nearby important public buildings such as mosques and public baths and far from settled areas, were not set aside as green areas.

Similar to the 1546 registers, the 1600 registers also provide limited knowledge about and do not contain general data on the characteristics of green areas. Only a '*çerak*', '*bağçe*'s and '*cüneyne*'s were evident (App.-3). The number of '*cüneyne*' was greater than the number of '*bağçe*'. It is difficult to observe similarities or differences between the waqfs in which both were found. The '*bağçe*' were often seen in the Nakılbend Hasan and Hüseyin Agha Masjid Quarters, while the '*cüneyne*' were common in the Hace Üveys, İshak Pasha and Nakılbend Hasan Masjid Quarters. Thus, waqf registers suggest that Nakılbend Hasan Masjid Quarter had quite a high density of green areas. The reduced number of green areas in the Hace Sinan Masjid Quarter may be due to the effects of the fire from the Jewish Quarter[24] in 1569 (App.-5).

'*Escar-i müsmire*' (fruit trees) were recorded in waqfs in the İshak Pasha Masjid, Daye Hatun Masjid and Hüseyin Çelebi Masjid Quarters, and in two separate waqfs in the Akbıyık and Üsküblü Masjid quarters. Despite not detailing the specific type of fruits that the trees give, it is likely that they were one of the naturally growing fruit trees in Istanbul. While '*eşcar-i müsmire*' was registered in four waqfs, '*eşcar*' was indicated in two waqfs in the Nakılbend Hasan Masjid Quarter. Also found in one of the waqfs in the same quarter, the '*eşcar-ı tut*' (mulberry/ Morus alba) demonstrates the abundance and quality of the mulberry, which increased the opportunity for trading. Nakılbend Hasan Masjid Quarter's exposure to the south may explain the intense growth of its trees. In addition to its southern exposure, another reason for such growth may be its proximity to the Langa Gardens.

In general, 61% of the '*menzil*' in the district were enclosed. Although the ratio decreased compared to 1546, still the phenomenon of privacy held high importance. Several 'cüneyne'

Green areas in the Ayasofya District *(Nâhiye)* according to the cadastral survey *(tapu tahrir)* registers of Istanbul waqfs 1546 and 1600

surrounding complexes of houses in the district and having a '*bir-i ma*' (water well), and *some* '*menzil*' with '*zulle*', are evident. It is evident that the most common green area typology in the district was the '*cüneyne*'.

The 1600 cadastral survey registers emphasize that the green areas and the elements related to them were clear evident in the Nakılbend Hasan Masjid Quarter, which corresponded to the area around the Küçük Ayasofya Mosque (the Little Ayasofya Mosque). The 1546 waqfs '*menzil*' consisting of several households decreased in the registers of 1600, and in their place the number of '*höcre*' and '*höcerât*' increased moving away from the center of the district (Ayasofya).

3.3. Continuity and change of green areas in the Ayasofya District during the 16th century

Faroqhi (1997) and Kafescioğlu (2019) talked about intense settlement movements and significant population growth during the 16th century. Consequently, this resulted in the increase in the number of waqfs in Istanbul as well. According to the registers of the cadastral survey registers, the rate of construction in the quarters increased, the gaps decreased, and the quarters spread to wider areas as well. It is observed that '*menzils*' with several households decreased in number in the waqfs of 1600 compared to the waqfs of 1546, and especially the number of rooms called '*höcre*' and '*höcerât*' increased in areas further away from the center of the district (Ayasofya) (See: App.-1A, App-1B and App-2). There was a decrease in the density of '*bağçe*' and approximately a four-fold increase in the density of '*cüneyne*' over time (App-3). An evaluation of 'cüneyne' in terms of small gardens shows that the people gave importance to these, albeit in limited proportions. There was an increase in the number of trees in the green areas within the '*menzil*' and in all green area elements as well. This suggests that the importance given to gardens and greenery by the dynasty and the state in the 16th century was reflected in the common people. In addition, Pamuk (1990) stated that people also invested in the '*bağ*', '*bağçe*' and dairy farms on or just outside the borders of the city. Furthermore, some sources indicate that the decrease in economic activities resulted in rising demand for the trade of 'tree products'. Thus, this contributed to the increase in the number of waqfs in green areas, more variety of tree species, and higher numbers in the 1600 cadastral survey registers. Additionally, during the 16th century the commercial areas were detached from the settled areas, which was possibly an important factor in the decline of relevant green areas.

The number of the *'bir-i ma*' increased particularly in the quarters near the seashore. The reason for this may be the large number of high groundwater areas close to the shore. The comparison of the two cadastral survey registers in Ayasofya District indicate that a person who devoted one *'bir-i ma*' waqf in 1546 added a *'bağçe*' or a *'cüneyne*' to the same waqf in the same quarter in 1600. Thus, it seems likely that there was a relationship between water wells and green area development. The need for water in green areas may have resulted in farming activities. The increase of resting areas like '*zulle*' and *'çardak/çartak*' in the '*menzil*' (See: App-3) emphasize the attempt to create places where people could rest around the settled areas. As Atasoy (2002) states, the house of a person having any status had a garden, whether small or large, and some areas designated to the garden in the '*menzil*' also comprised resting units such as '*zulle*' or *'çardak/çartak*'.

4. Conclusion

In the 16th century, there was a close relationship between the population (the number of waqfs gives information about the population), settlement intensity, and the increase of green areas in the Ayasofya District (Table 5). However, it is not possible to discern a similar relationship in areas where commercial structures and commercial activities were intense (See: Table 5 Hüseyin Agha Mosque, Hace Rüstem Masjid and Firuz Agha Masjid Quarters). One of the most important features where these

Table 5. *Number of waqfs, building types, green areas and green areas components in quarters.*

	number of waqfs		number of housing buildings		number of Höcre/höcerat		number of Dükkan/dekakin		number of green area		number of green area components	
	1546	1600	1546	1600	1546	1600	1546	1600	1546	1600	1546	1600
Ayasofya Quarter	26	27	45	61	25	32	33	32	3	4	10	15
İshak Pasha Masjid Quarter	27	27	40	44	0	9	4	4	13	12	21	24
Sinan Agha Masjid Quarter	13	23	10	53	11	15	0	1	3	11	5	26
Akbıyık Masjid Quarter	23	43	22	76	0	23	4	4	2	9	11	31
Güngörmez Masjid Quarter	16	20	15	40	0	10	0	3	2	3	7	13
Nakılbend Hasan Masjid Quarter	11	20	18	40	13	8	0	0	4	12	9	23
Hüseyin Agha Mosque Quarter	9	38	20	78	34	51	38	34	3	6	8	37
Uzun Şüca Masjid Quarter	18	13	19	27	17	16	6	2	5	3	5	13
Binbirdirek Sinan Agha Masjid Quarter	4	4	0	8	22	22	0	0	-	-	-	-
Hace Rüstem Masjid Quarter	9	10	8	18	42	41	2	2	1	4	2	7
Firuz Agha Masjid Quarter	8	9	54	63	96	63	18	41	1	2	4	5
Üsküblü Masjid Quarter	17	26	33	58	6	4	0	8	-	5	5	17
Hayrüddin Bey Masjid Quarter	6	13	0	28	14	15	1	1	2	7	3	14
Karakedi Hüseyin Çelebi Masjid Quarter	15	19	16	37	9	19	8	3	6	7	5	11
Nevbethane Daye Hatun Masjid Quarter	20	20	20	31	15	15	1	1	3	5	10	15
Elvanzade Hace Sinan Masjid Quarter	22	20	37	22	54	11	3	0	2	6	13	19
Hace Üveys Masjid Quarter	15	28	34	36	9	11	19	17	2	8	17	25

commercial buildings were located is that there were dwellings called *'höcre-höcerat'* rather than housing buildings. This information suggests that commercial areas and residential areas developed in separate areas and had different features in the 16th century. These dwellings, as Çokuğraş (2013) specified, were single rooms, where people working in the harbors, construction sites or commercial areas, settled in solitary. This development probably resulted from the general increase of settled areas, trade and port activities within the city. The mentioned quarters were those close to the southern port area of the city and / or areas where the Grand Bazaar and commercial shops were located. Thus, it is clear that commercial areas were poor in terms of green areas, and green areas were more common in areas where households were located (Table 5).

In the areas where housing settlements were dominant, the density of green areas increased around religious structures such as mosques and masjids and social structures such as baths, madrasah and waterways (for example, İshak Paşa Masjid and Nakılbend Hasan Masjid Quarters). In addition, suitable topography as well as the greater sunlight and the more temperate conditions of the southern quarters can be added as positive factors in the development of green areas (See: App.-3 ve App.-5). Also water, which is one of the most important conditions for civilizations, was essential in the development of green areas. Although fountains were limited in number, other water elements (bir-i ma and waterways) increased green areas and green area components. This situation also suggests the possibility of farming in the green areas in the building settlements due to the economic crisis that emerged at the end of the century.

As Barkan and Ayverdi (1970) mentioned, there was a congested settlement in Istanbul in the 16th century. The increase in construction, which increased towards the end of the century in the wider quarters, verifies this opinion (See: Akbıyık Masjid and Nakılbend Hasan Masjid Quarter in App.-1B, App.-2). Although there was no new settlement, the increase in green areas and green area components is remarkable in some small quarters where the settlement was not dense (Nevbethane Daye Hatun, Elvanzade Hace Sinan, Hace Üveys Masjid Quarter). As a result, people tended to create green spaces such as *'bağçe'* or *'cüneyne'* and develop areas to rest, such as '*zulle*', even in small spaces. Also drilling *'bir-i ma'* made farming activities possible. The increase of '*cüneyne*', which are described as small gardens, strengthened the need to create green areas in more densely populated areas, too.

This study has attempted to understand the characteristics of green areas in the Ayasofya Quarter using cadastral survey registers from the 16th century. Although these registers cannot provide data on the plan and design features, they do enable an understanding of the settlement plan of the city and the relationship between the green areas, the density of the green areas in the quarters, and the general characteristics. The study provides data for periodic changes with records from different dates. Also, as in this study, cadastral survey registers can be uti-

lized in similar studies for different areas as they provide information about the settlement plan of the periods, the relationship of the green areas, the development and properties of the green areas as well as an understanding of the changes over time. In addition, the records contain data which allows the reader to picture the green areas in the excellent area of Istanbul from the Byzantine period to the Ottoman period in the 16th century.

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Endnotes

[1] Persian bağ and diminution attachement –çe forms bağ-çe). It is the original form of the garden word used in the past (Ayverdi, 2005 p: 254).

[2] The chapters of 'The Cadastral Survey Registers of İstanbul Waqfs 1546 and 1600:

1. Nahiye-i Cami-i Şerif-i Ayasofya (Ayasofya District)
2. Nahiye-i Cami'ül-Merhum Mahmud Pasha (Mahmud Pasha District)
3. Nahiye-i Cami'ül-Merhum'ül-Mağfürun Leh Ali Pasha (Atik Ali Pasha District)
4. Nahiye-i Cami-i İbrahim Pasha (İbrahim Pasha District)
5. Nahiye-i Cami-i Sultan Bayezid Han 'Aleyh'ir-Rahme (Sultan Bayezid District)
6. Nahiye-i Cami-i Hazret-i Şeyh Ebü'l-Vefa Rahimehullah (Ebü'l-Vefa District)
7. Nahiye-i Cami'ül-Mağfurun Leh Sultan Mehmed Han Aleyh'ir-Rahmetü Ve'l-Güfran (Mehmed II District)
8. Nahiye-i Cami'ül-Merhum'ül-Mağfürun Leh Sultan Selim Han Tabe Serah (Selim I District)
9. Nahiye-i Cami'ül Merhum Murad Pasha (Murad Pasha District)
10. Nahiye-i Cami'i Davud Pasha (Davud Pasha District)
11. Nahiye-i Cami'i Mustafa Pasha'l Merhum (Mustafa Pasha District)
12. Nahiye-i Bab-ı Tob (Topkapı District)
13. Nahiye-i Cami-i Ali Pasha Der Nezd-i Çukurbostan (Ali Pasha District)
14. Galata

[3] In this study, the term 'menzil' is used for the all components of the properties that were co-founded in the same waqf.

[4] kebir: meaning large (Ayverdi, 2005). Consequently, bağçe-i kebir is possibly used to refer to a 'large garden'.

[5] to fly, garden, very spacious and airy place (Devellioğlu, 2010). 'Cüneyne' is the paradise derived from

Green areas in the Ayasofya District *(Nâhiye)* according to the cadastral survey *(tapu tahrir)* registers of Istanbul waqfs 1546 and 1600

the Arabic diminution. It means little heaven, heavenly, little garden.

[6] -çera-gah/çera-geh- Animal grazing place, pasture. (Nazima and Reşad, 2002).

[7] water well. Bi'r: well, çah (Sami, 2015).

[8] (1) Frame made of trees, flowers and greenery. (2) Canopy made of dry tree branches in front of the buildings, shelter (3) In some areas, open-top covered veils made for drying nuts on the upper floors of the houses (Ayverdi, 2005).

[9] (the plural of Şecer') Trees (Ayverdi, 2005 p:883). Hoops, cells (Sami, 2015).

[10] fruit giving, fruit trees (Ayverdi, 2005 p:2234).

[11] tut: berry giving fruit (Nazima and Reşad, 2002). eşcar: (Şecer' plural) trees (Ayverdi, 2005).Eşcar-ı tut: berry trees.

[12] gayr: somebody else, other (Ayverdi, 2005, p:1005). Müsmire: fruit giving, fruity. gayr-i müsmire: fruit not giving (Ayverdi, 2005: p:2233). Probably used for a tree that is not giving fruits.

[13] walled place, downy (Risale-i Mi'mariyye, p:86). Bonded, surrounded by curtain or wall around it (Nazima and Reşad, 2002).

[14] canopy, wooden covered sofa (Risâle-i Mi'mariyye p:86). Shadow, saye (Sami, 2015). Shadow, protection, ownership (Devellioğlu, 2010).

[15] Müller-Wiener, W. (1998). İstanbul'un Tarihsel Topoğrafyası. İstanbul: Yapı Kredi.

[16] İnalcık, H. (2001). İstanbul. In İslam Ansiklopedisi (Volume:23, p. 240-267).

[17] Ayverdi, E. H. (1958). Fatih Devri Sonlarında İstanbul Mahalleleri, Şehrin İskânı ve Nüfusu. Ankara: Doğuş.

[18] url-1: http://individual.utoronto.ca/safran/Constantinople/Map.html

[19] Altuğ, K. (2013). İstanbul'da Bizans Dönemi Sarnıçlarının Mimari Özellikleri ve Kentin Tarihsel Topografyasındaki Dağılımı. (Unpublished Doctoral Dissertation Thesis). İstanbul Technical University, Graduate School of Science, Engineering and Technology, İstanbul

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[21] Tanışık, İ. H. (1943). İstanbul Çeşmeleri I, İstanbul: Maarif.

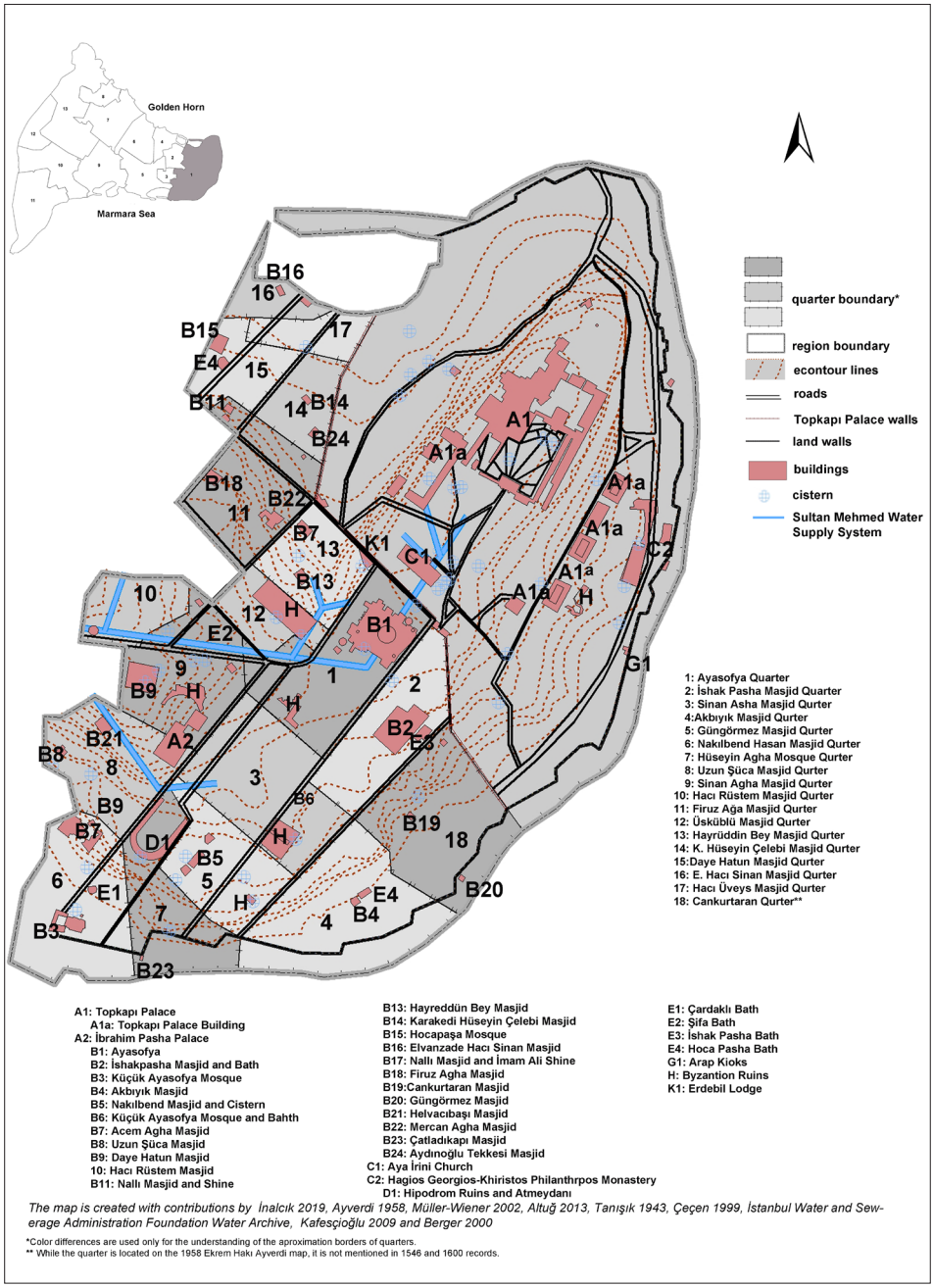
[22] The name and citation of the Cankurtaran Quarter, present in the Ayverdi (1958) map, is missing in both of the cadastral survey registers. Nevertheless, some areas belonging to the Nakılbend Hasan Masjid Quarter are registered in the section of the Hüseyin Agha Masjid Quarter. The presumed quarter borders are marked in the section of the Nakılbend Hasan Masjid Quarter (See; App-1A and App-1B). The names of the two quarters are different on the map and the waqf registers. Within the Binbirdirek section, the Sinan Agha Masjid Quarter is indicated as the Molla Fenari Quarter and is called the Sinan Agha Masjid Quarter in the registers, but it is likely the Kanlı Masjid Quarter on the map.

[23] Small room, hujre (Risale-i Mimariyye p: 87)

[24] The Jewish quarter is located in the area around Balıkpazarı in the south of Zindankapı. (Ağır, 2009 p: 135,141)

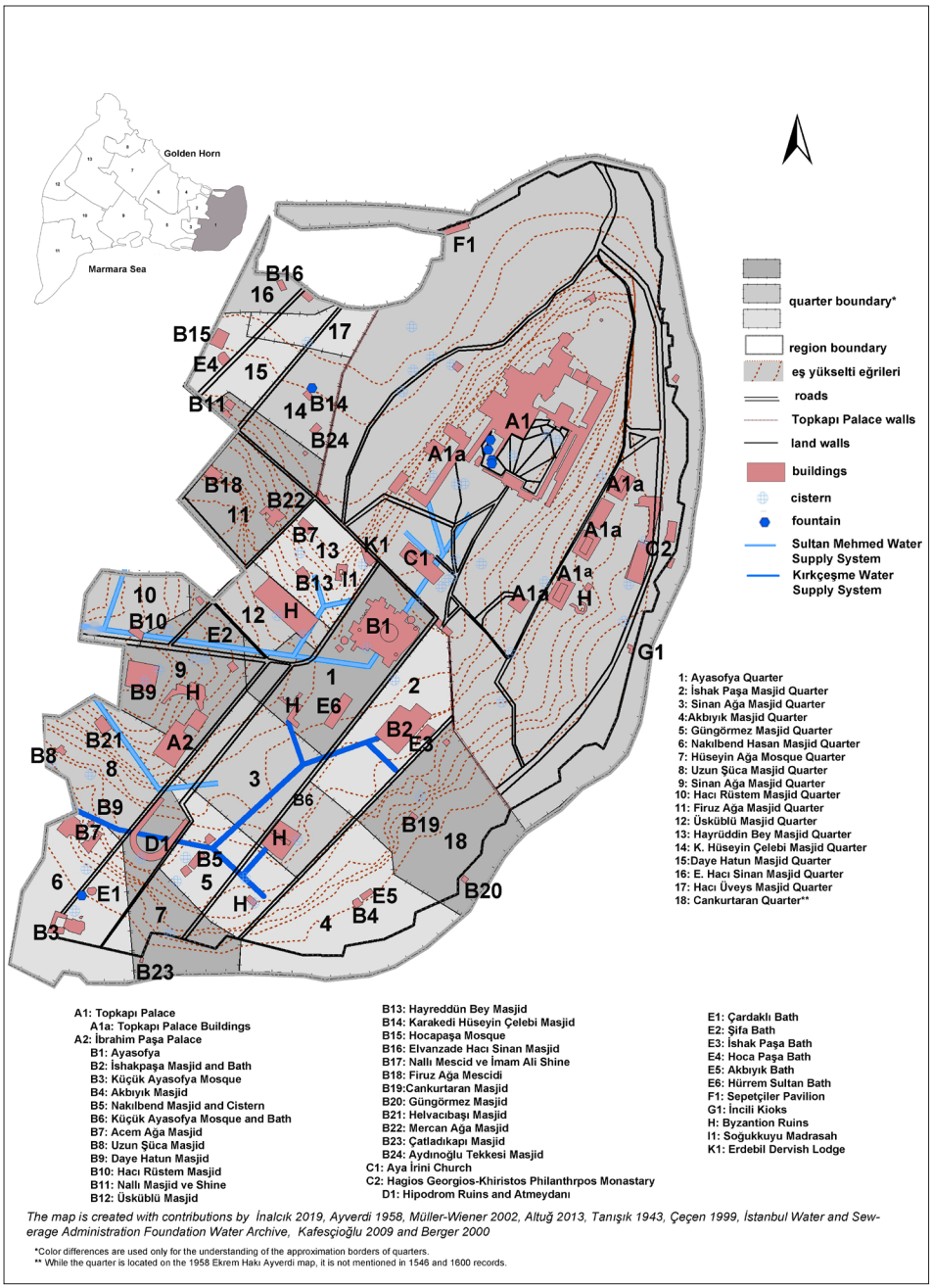
Appendices

Appendix 1A: *The Map Of Ayasofya District With Urban Elements in 1546.*



Green areas in the Ayasofya District *(Nâhiye)* according to the cadastral survey *(tapu tahrir)* registers of Istanbul waqfs 1546 and 1600

Appendix 1B: *The Map Of Ayasofya District with urban elements in 1600.*



The map is created with contributions by İnalcık 2019, Ayverdi 1958, Müller-Wiener 2002, Altuğ 2013, Tanışık 1943, Çeçen 1999, İstanbul Water and Sewerage Administration Foundation Water Archive, Kafesçioğlu 2009 and Berger 2000

*Color differences are used only for the understanding of the approximation borders of quarters.
** While the quarter is located on the 1958 Ekrem Hakı Ayverdi map, it is not mentioned in 1546 and 1600 records.

Appendix 2: *Housing Terms in Ayasofya District .*

	Hâne (dwelling)		*Hânehâ* (dwellings)		*Odahâ* (rooms)		*beyt-i sufî* (lower dwellings)		*hâne -i tâhtanî* (lower dwellings)		*hâne -i fevkânî* (above/ upper dwellings)		*hâne -i sûflî* (Lower room)		*hânehâ -i sufli* (Lower room)		*hânehâ-i tâhtanî* (Lower rooms)		*hânehâ-i fevkânî* (above/ upper dwellings)		*ev* [1] (dwellings)		*Hücre* (small room/ cell)		*Hücerât* (small rooms/ cells)		*beyt-i tâhtanî (lower dwellings)*		*beyt-i fevkânî* (above/ upper dwellings)		*beyt-i ulvi* (above/ upper dwellings)	
Quarter Name	1546	1600	1546	1600	1546	1600	1546	1600	1546	1600	1546	1600	1546	1600	1546	1600	1546	1600	1546	1600	1546	1600	1546	1600	1546	1600	1546	1600	1546	1600
Ayasofya Quarter	-	2	-	8	-	-	8	11	4	-	3	-	-	-	2	2	12	12	14	18	2	2	2	4	23	28	-	-	-	-	-	6
İshak Pasha Masjid Quarter	1	2	1	6	-	-	3	9	2	1	2	1	1	-	-	1	18	11	11	10	1	1	-	2	-	7	-	1	-	-	1
Sinan Agha Masjid Quarter	-	1	-	2	-	-	-	18	2	-	-	-	-	-	-	1	4	6	3	11	1	-	-	4	11	11	-	1	-	1	-	12
Akbıyık Masjid Quarter	-	5	-	9	-	-	-	17	6	4	1	2	1	-	-	-	3	7	8	15	3	-	-	12	-	11	-	1	-	3	-	13
Güngörmez Masjid Quarter	1	2	-	3	-	-	1	6	1	6	1	3	-	-	-	-	4	5	6	7	1	-	-	-	-	10	-	1	-	-	-	7
N. Hasan Masjid Quarter	1	-	1	6	-	-	1	12	3	2	-	-	1	-	-	1	7	7	4	5	-	-	-	-	13	8	-	-	-	-	-	7
Hüseyin Agha Mosque Quarter	-	1	-	-	-	-	-	23	3	4	-	8	-	-	-	-	12	13	5	7	-	-	34	4	-	47	-	-	-	-	-	22
Uzun Şüca Masjid Quarter	2	2	-	-	-	-	-	6	2	-	2	-	1	-	-	4	5	2	7	9	-	-	3	-	14	16	-	-	-	-	-	4
B. Sinan Agha Masjid Quarter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	4	-	-	-	-	22	22	-	-	-	-	-	-
Hace Rüstem Masjid Quarter	-	-	-	5	1	-	-	3	1	-	1	-	-	-	-	-	4	3	1	-	-	7	23	-	18	41	-	-	-	-	-	-
Firuz Agha Masjid Quarter	-	-	-	1	-	-	-	-	2	2	1	1	-	-	-	-	47	6	3	51	1	1	1	1	95	62	-	-	-	-	-	1
Üsküblü Masjid Quarter	1	1	-	-	-	-	-	10	4	3	1	1	-	-	-	-	16	21	11	6	-	4	6	2	-	2	-	4	-	4	-	4
Hayrüddin Bey Masjid Quarter	-	2	1	1	-	-	-	5	3	1	2	-	-	-	-	-	4	4	3	4	-	-	1	15		-	-	-	-	-	-	11
K. Hüseyin Çelebi Masjid Quarter	-	7	1	1	-	-	-	3	-	1	-	3	1	-	-	-	6	6	8	6	-	1	1	11	8	8	-	-	-	2	-	7
Daye Hatun Masjid Quarter		2	2	1	-	-	-	9	-	-	-	-	-	-	-	-	13	6	4	3	1	-	5	15	10	-	-	-	-	-	-	10
E. Hace Sinan Masjid Quarter	1	-	-	2	-	-	-	-	3	2	-	-	-	-	-	2	15	5	17	11	1	-	2	2	52	9	-	-	-	-	-	-
Hace Üveys Masjid Quarter	-	6	4	3	-	-	1	9	4	-	3	1	-	-	-	-	16	5	6	4	-	-	9	5	-	6	-	-	-	-	-	8

[1] *There are many phrases in consecration that mean dwellings. In addition, the term 'ev' is also encountered. Although some terms or group of terms have the same meaning in the dictionary, they are used differently. Since it is not possible to estimate how an expression is attempted while it is being used, the synonym terms are not taken in a single term as shown in the source and their numbers are registered separately.*

Appendix 3: *Green Areas and Components of Green Areas in Ayasofya District.*

	green areas								components of green areas									
	bağçe (garden)		*cüneyne* (little garden)		*çerak/ çeraklık* (pasture)		*bağçe-i kebir* (large garden)		*zulle* (canopy)		*çardak/çartak* (arbour)		*plant names*		*bir-i ma* (water well)		*muhavvata* (walled place)	
Quarter Name	1546	1600	1546	1600	1546	1600	1546	1600	1546	1600	1546	1600	1546	1600	1546	1600	1546	1600
Ayasofya Quarter	3	2	-	2	-	-	-	-	4	2	-	-	-	1	6	12	15	16
İshak Pasha Masjid Quarter	7	4	5	8	-	-	1	-	4	7	2	2	-	2	15	13	15	17
Sinan Agha Masjid Quarter	2	5	1	6	-	-	-	-	2	6	-	6	-	2	3	12	7	23
Akbıyık Masjid Quarter	1	4	1	5	-	-	-	-	5	8	-	2	1	3	5	18	12	23
Güngörmez Masjid Quarter	1	1	1	2	-	-	-	-	3	4	-	1	-	-	4	8	6	10
Nakılbend Hasan Masjid Quarter	4	5	-	7	-	-	-	-	2	5	-	-	2	4	5	14	9	17
Hüseyin Agha Mosque Quarter	2	4	1	2	-	-	-	-	2	9	-	-	-	-	6	28	7	20
Uzun Şüca Masjid Quarter	4	1	1	2	-	-	-	-	2	2	-	5	-	-	3	6	10	6
B. Sinan Agha Masjid Quarter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hace Rüstem Masjid Quarter	1	2	-	2	-	-	-	-	2	2	-	2	-	-	-	3	4	5
Firuz Agha Masjid Quarter	1	2	-	-	-	-	-	-	2	2	-	-	-	-	2	3	4	5
Üsküblü Masjid Quarter	-	-	-	4	-	1	-	-	2	4	-	-	-	1	3	12	12	14
Hayrüddin Bey Masjid Quarter	1	2	1	5	-	-	-	-	1	4	-	-	-	-	2	10	2	6
K. Hüseyin Çelebi Masjid Quarter	5	4	1	3	-	-	-	-	1	2	-	-	-	1	4	8	10	14
Daye Hatun Masjid Quarter	3	3	-	2	-	-	-	-	3	5	-	-	-	1	7	9	8	13
Elvanzade Hace Sinan Masjid Quarter	2	1	-	-	-	-	-	1	5	-	-	-	-	-	8	1	13	5
Hace Üveys Masjid Quarter	2	-	-	7	-	-	-	-	8	4	-	-	-	2	9	9	16	11

Appendix 4: *Religious, Social, Commercial and Educational Buildings in Ayasofya District.*

	religious and social building								commercial building							
	Camii (Mosque)		*Mescid* (masjid)		*Hamam* (bath)		*Han* (inn)		*Dükkân* (shop)		*Dekâkîn* (shops)		*Bedesten* (covered bazaar)		*Bazaar* (market area)	
Quarter Name	1546	1600	1546	1600	1546	1600	1546	1600	1546	1600	1546	1600	1546	1600	1546	1600
Ayasofya Quarter	1	1	2	2	-	2	3	3	4	10	29	22	1[2]	1	-	-
İshak Pasha Masjid Quarter	-	-	1	1	1	1	-	-	2	3	2	1	-	-	-	-
Sinan Agha Masjid Quarter	-	-	1	1	-	-	-	-	-	1	-	-	-	-	-	-
Akbıyık Masjid Quarter	-	-	2	2	-	-	-	-	-	-	4	4	-	-	-	-
Güngörmez Mesc. Mahallesi	-	-	1	1	-	-	-	-	-	-	-	3	-	-	-	-
Nakılbend Hasan Masjid Quarter	1	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-
Hüseyin Agha Mosque Quarter	-	-	2	2	2	2	-	2	2	5	36	29	-	-	-	-
Uzun Şüca Masjid Quarter	-	-	1	1	1	1	-	-	-	2	6	-	1	1		
B. Sinan Agha Masjid Quarter	-	-	1	1	1	1	-	-	-	-	-	-			-	-
Hace Rüstem Masjid Quarter	-	-	1	1	-	-	-	-	2	-	-	2	-	-	1	1
Firuz Agha Masjid Quarter	-	-	1	1	2	2	-	-	2	2	16	39	-	-	-	-
Üsküblü Masjid Quarter	-	-	1	1	-	1	-	-	-	8	-	-	-	-	-	-
Hayrüddin Bey Masjid Quarter	-	-	1	1	-	1	-	-	1	1	-	-			-	-
K. Hüseyin Çelebi Masjid Quarter	-	-	1	1	-	-	-	-	8	1	-	2	-	-	-	-
Daye Hatun Masjid Quarter	-	-	1	1	-	-	-	-	1	1	-	-	-	-	-	-
Elvanzade Hace Sinan Masjid Quarter	-	-	1	1	1	1	-	-	-	-	3	-			-	-
Hace Üveys Masjid Quarter	-	-	1	1	2	2	-	-	2	6	17	11			-	-

[2] *Ayasofya market*

Green areas in the Ayasofya District *(Nâhiye)* according to the cadastral survey *(tapu tahrir)* registers of Istanbul waqfs 1546 and 1600

Appendix 5: *The Factors Which is Affecting the Continuity and Change of Green Areas in Ayasofya Quarters in the 16th Century.*

	gradient change (%)	direction	coastal / central	fires		Topkapı Palace	sea walls	harbour	pier	wall gates	numbers of cistern		Numbers and names of water supply systems				Number of fountain	
Quarter Name				1546	1600						1546	1600	1546	1546	1600	1600	1546	1600
Ayasofya Quarter	7	-	central	-	-	+	-	-	-	-	3 [4]	3	1	FMWSSK	2	FMWSS KÇWSS	-	-
İshak Pasha Masjid Quarter	4-6	-	central	-	-	+	-	-	-	-	-	-	-		1	KÇWSS	-	-
Sinan Agha Masjid Quarter	7	-	central	-	-	-	+	-	-	--	2	2	1	FMWSSK	2	FMWSS KÇWSS	-	-
Akbıyık Masjid Quarter	4-8	east	coastal	-	-	-	+	-	+	3	1	1	-		1	KÇWSS	-	-
Güngörmez Mesc. Mahallesi	5-6	-	-	1489	1489	-	-	-	-	-	1	1	-		1	KÇWSS	-	-
Nakılbend Hasan Masjid Quarter	4-14	south	coastal	-	-	-	+	+	+	1	4	4	-		1	KÇWSS	-	1 [9]
Hüseyin Agha Mosque Quarter	10	south	coastal	-	-	-	+	-			3	3	-		-	-	-	-
Uzun Şüca Masjid Quarter	12-16	-		-	-	-	-	-	-	-	2	2	1	FMWSSK	2	FMWSS KÇWSS	-	-
B. Sinan Agha Masjid Quarter	4	-	central	-	-	-	-	-	-	-	7	7	1	FMWSSK	-	-	-	-
Hace Rüstem Masjid Quarter	4	east	-	1509	1509-1588	-	-	-	-	-	2	2	1	FMWSSK	-	--	-	-
Firuz Agha Masjid Quarter	15	-	-	-	-	+	-	-	-	-	-	-	-		-	-	-	-
Üsküblü Masjid Quarter	5	-	central	1509	1509-1592	-	-	-	-	-	1	1	1	FMWSSK	-	-	-	-
Hayrüddin Bey Masjid Quarter	9	-	central	-	-	+	-	-	-	-	1	1	1	FMWSSK	-	--	-	-
K. Hüseyin Çelebi Masjid Quarter	4	-	-	-	-	+	-	-	-	-	-	-	-		-		-	1 [12]
Daye Hatun Masjid Quarter	6	north	-	1539	1539	-	-	-	-	--	-	-	-		-	-	-	-
Elvanzade Hace Sinan Masjid Quarter	2	north	coastal	1539	1539-1569	+	+	+	-	-	-	-	-		-	-	-	-
Hace Üveys Masjid Quarter	2	north	-	1539	1539-1569	+	-	-	-	-	1	1	-		-	-	-	-

[3] *Fatih Mehmed Water Supply System*
[4] *Kırkçeşme Water Supply System*
[5] *Odungate.-Değirmengate.-Balıkhanegate.*
[6] *The fire which is close to Atmeydanı*
[7] *The fire which is close to Atmeydanı*
[8] *Çatladıgate*
[9] *Rüstempasha Fountain*
[10] *The fire which is close to Bedesten*
[11] *The fire which is close to Üsküblü masjid*
[12] *Serhazin Mustafa Agha Foundation*

ITU A|Z • Vol 17 No 3 • November 2020 • 47-59

Socio-cultural and physical aspects of place-making in three streets of Puri, India

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Received: April 2019 • Final Acceptance: May 2020

Abstract

The aim of this paper is to understand the impact of physical and socio-cultural aspects of streets on sense of place in the streets of Puri, a pilgrimage and a religious city. The three major streets of Puri leading to Jagannath temple, consist of the Bada Danda, Temple and Swargdwara streets. Each of these streets have their own unique spatial quality resulting from their cultural, historical and religious importance, serving as both spiritual and social places for the people. Because of their religious and functional significance, scale and diverse activities, these streets have a strong sense of place. The sense of place on streets of religious cities, which is visited by number of pilgrims on daily basis, thus needs to be assessed not only for physical but also for the fact that these streets be perceptible as a 'place'. The research adopts a mixed method approach: visual survey and a structured questionnaire survey of both pilgrims and residents to achieve at its objective. The result indicates the dominance of socio-cultural aspects more than the physical aspects on sense of place thereby indicating that the improvements in physical characteristics can further enhance their perception about street identity and sense of place in Indian religious cities.

Keywords
Sense of place, Religious cities, Physical aspects, Socio-cultural aspects.

doi: 10.5505/itujfa.2020.85579

1. Introduction

Indian streets are open public spaces that are not only used for movement or commuting but also for various other activities like interaction with others, sleeping, eating, roaming around or simply watching people. Edensor in his study on Indian streets states that, "The multifunctional structure of the street provides an admixture of overlapping spaces that merge public and private, work and leisure, and holy and profane activities" (1998, p.202). In India, it has also been shown that all traditional built environments are basically related to have (as in that of most traditional cultures) a sacred connotation (Rapoport, 1990). Special events like processions and festivals give a strong sense of identity to the street and people associate the street with those specific uses and events. The streets of sacred cities leading to the main religious complex comprise of activities and uses that are related to the rituals associated with the deity like the processional rituals. Though these streets are a route to the religious complex, they seem to enhance the spiritual feelings of people due to distinct happenings and religious activities and provide a sense of place. These streets apart from being active during the entire day are busier and lively in the mornings and evenings with more people moving towards the temple complex. Rapoport (1990) points out that the very first experience we get of Indian streets is generally through the smells of food and incense, both non-visual characteristics. Sivam and Karuppannan (2013) suggest that, "It is the experience one has within the street that creates a strong connection rather than the aesthetic value of the street itself" (p.2). The physical, social and cultural aspects have a strong impact on attachment to the place. The research thus focusses on the impact these aspects have on sense of place in the streets of Puri, a religious and sacred city.

2. Literature study

According to Relph, "places are fusions of human and natural order and are the significant centres of our immediate experiences of the world" (1976, p.141). Space when characterized with meanings and associations become a place. It is thus related to people's perceptions about the place and the way they feel about it. Montgomery (1998) stated three basic principles of place making- activity, image and form.

Sense of place can thus be easily understood as how people relate to a place. Various other concepts like place attachment and place identity also define this relationship. Steele (1981) defined sense of place as "an experience created by the setting combined with what a person brings to it. In other words, to some degree we create our own places; they do not exist independent of us. There are, however, certain settings that have such a strong 'spirit of place' that they will tend to have a similar impact on many different people" (p. 9). He also added that there are various factors that influence the relationship of people with places: history, memory, identity, safety, vitality, liveability, mystery, surprise, fantasy and pleasure. Apart from these, the physical attributes, size of the setting, scale, proportion, distance, texture, diversity, smell, sound, visual variety, colour and temperature also add to sense of place. Steele (1981) suggested physical and social settings in addition to a person's psychological factors that contribute to create a sense of place.

Lynch (1960) also stated that "a place affects us directly through our senses - by sight, hearing, touch, and smell" (p.9). He identified five features paths, edges, nodes, districts and landmarks, which make an environment legible.

Relph (1976) claimed settings, activities, meanings and 'genius loci' or spirit of place as components defining sense of place. According to him, symbols, traditions, rituals and myths too enforce sense of place. Rapoport (1990) suggested that places not only comprise of physical features but also include messages and meanings that people perceive and based on their experiences, expectation and inspirations, decode them. Similarly, Shamai (1991) recognized sense of place as a result of location, landscape and personal involvement. It is felt through all the human senses i.e. sight, hearing, smell, taste and touch. He also argued that sense of place comprised of three

levels: belonging to a place, place attachment and commitment to a place. He further classified it into seven levels: not having any sense of place (value of 0), knowledge of being located in a place, belonging to a place, attachment to a place, identifying with the place goals, involvement in a place and sacrifice for a place (value of 6).

Bott (2000) through her research identified four domains that describe sense of place: physical, cultural, affective and functional. She also developed psychometric scales to evaluate sense of place. Najafi and Shariff (2011) in their review of literature found various factors influencing place attachment, socio-demographic characteristics, environmental experience, culture, place satisfaction, preference and attachment, activity and the place itself. Ja'afar et.al. (2012) stated that in traditional context, combination between physical and social aspects that is inherited creates its own environment and that can be felt by all types of users.

Mazumdar and Mazumdar (1993) in their studies of place attachment to sacred space found that the presence of sacred settings evoke a sense of emotional attachment to the place. People feel connected both at individual and collective level since these places have symbolic meanings expressed through its physical location, architectural design, layout, aesthetics and also its history (Mazumdar & Mazumdar, 2004). They also stated that, "Place and place characteristics are significant in religious place attachment. People develop attachment to sacred cities and sacred structures, in addition to natural places" (p.394). Unlike Shamai (1991) who described sense of place as an individual perception and experience, Mazumdar and Mazumdar highlighted the collective involvements of people related to strong cultural influence of a place. The religious cities are places that evoke both individual (based on an individual's faith and belief) and collective experience and memories (due to rituals, festivals and processions) and hence have strong meanings attached to them. These meanings further enhance the sense of place which these cities have.

Low (1992) asserts six types of bonding that people have: genealogical linkage through family or history, linkage through loss of land or destruction, economic bonding through ownership, inheritance and politics, cosmological bonding, linkage through religious and secular pilgrimage and narrative connection through storytelling and place meaning. The causes of bonding with the sacred places are different for different individuals based on whether they are pilgrims, tourists or residents of these cities. Religious cities thus have strong associations with people due to symbolic ties with these places.

The review indicates that tangible and intangible attributes are significant for a space to qualify as a place.

Physical settings, as suggested by many scholars and theorists, are an important element of a place since they attach meaning to a place. It is the physical setting with its characteristics and attributes that defines whether or not people develop an attachment for the place since it is the first visual feature. Steadman (2003) identified the physical environment and its characteristics constituting sense of place. Hidalgo and Hernendez (2001) too suggested both physical and social dimensions to be important for place attachment. Mehta (2013) in his studies identified street characteristics like density, size, character that too support social behaviour. Bott (2000) recognized characteristics related to natural setting, built environment and character as components that have an impact on sense of place.

The tangible attributes of physical aspects identified for this study include presence of trees and landscape features, light, material, colour and aesthetics of buildings located on either side of the street and intangible factors include cleanliness and maintenance of street, and its liveliness.

Sense of place or place attachment is more than an emotional and cognitive experience, and includes cultural beliefs and practices that link people to places (Low, 1992). Social activities on streets add vitality and liveliness and are a "direct indicator of the satisfaction of people within their physical surroundings" (Mehta, 2007, p.167).

The street not only acts as a commercial realm with a variety of fixed and mobile shops, but is a social space for interaction; a site for entertainment, mundane social activities, domestic activities and a centre of cultural and religious events (Edensor, 1998). They contribute to a collective 'sense of place'. Sense of belonging and care for a place is associated with place attachment and high degree of familiarity (Relph, 1976).

Bott (2000) identified inherent and transactional aspects related to cultural domains contributing to sense of place. Hidalgo and Hernandez (2001) identified social activities, opportunities for social interaction, sense of belonging as major social factors for study of sense of place. The importance of a street or place is directly related to its history and is an important attribute that helps to create a sense of place. Mazumdar & Mazumdar (1993) in their study on sacred spaces identified that people attach to sacred places also because of their cultural and historical significance. Steele (1981), Raymond, Brown & Weber (2010), Najafi & Shariff (2011), Ja'afar, Sulaiman & Shamsuddin (2012), Lai, Said & Kubota (2013), Harun, Mansora, & Saidb (2015) and Conteh & Oktay (2016) proved that places of historical importance create sense of place. The myths, traditions, rituals and symbols (Relph, 1976) followed over the years give the place a historical context.

The intangible attributes of socio-cultural aspects recognized for this study include the historical importance of the place, activities on the street supporting rituals (since this is a study of religious and sacred places), opportunities present on street for interaction and sense of belonging.

3. Method

The research focusses on the physical and socio-cultural aspects of the three selected streets of Puri. The current physical condition of streets was examined by the researcher. According to Rana (2011), "The behavioural dimension acknowledges openly that human action is mediated through the cognitive process of information. This can be explained through the closed-question questionnaires" (p.3). Questionnaire survey was conducted to understand perception and satisfaction level of the users for both the physical and socio-cultural aspects.

The research aims to answer the following questions and adopts a mixed method approach: visual survey and questionnaire survey to achieve its objective:

- What are the indicators for physical and socio-cultural aspects that effect sense of place?
- What are the current conditions and perception of residents and pilgrims about the selected physical and socio-cultural aspects on the streets of Puri?
- What is the impact of the physical and socio-cultural aspects on sense of place and the effective approaches to enhance sense of place in streets of Puri?

3.1. Procedure

The authors conducted the visual survey in the month of October by being on the streets for a period of one week. Apart from this, field notes, photographs and videos were used to collect the data for the visual assessment of the street's physical features. Being a participant on the street, the physical condition of the streets were analysed and recorded for the study to further authenticate the results obtained from the questionnaire survey on physical aspects.

Questionnaire survey was also conducted face to face in the month of October to understand the user's perception about the various physical and socio-cultural aspects of the three selected streets. 318 respondents were selected randomly, approximately 100 respondents per street, based on their willingness to participate in the survey. Since the users on the streets in religious cities mainly consist of pilgrims and tourists apart from the residents and shopkeepers, the questionnaire had two groups: pilgrims and residents. Since it was to be conducted on streets, in an open environment, mornings and evenings were preferred. Respondents were asked to rate the questions as per their individual perception about the street and residents were also inter-

viewed to gather information about other parameters important for them.

For testing the questionnaire using a Likert scale and also evaluate how closely related a set of items are as a group, a reliability test was conducted to evaluate the questionnaire survey's internal consistency through Cronbach's Alpha (α) Value examination and was considered reliable if the alpha value was 0.7 and above.

To evaluate the validity of the questionnaire survey, Kaiser-Meyer-Olkin evaluation of sampling adequacy (KMO test) was also used. The questionnaire survey was considered to be valid if the value was 0.6 and above. Analysis of variance (ANOVA), a statistical tool is used to test or compare the means of several groups for statistical significance and find whether the samples are from the same population or not, using level of significance 0.05. The groups comprise of the samples taken on the three studied streets for evaluating sense of place. Data collected was analysed using statistical evaluates of mean and standard deviation.

3.2. Questionnaire used

The questionnaire consisted of a few demographic questions related to age, sex, frequency of visiting the place by the participant, followed by a series of closed ended, structured questions related to attributes defining both the aspects. The questionnaire also had two open ended questions where the participants gave their opinions about the feelings for these streets in religious precincts and how they were different from other streets. The respondents were above 18 years of age and categorized into six groups: 18-24, 25-30, 31-40, 41-50, 51-60 and above 60. Since the questionnaire comprised of closed ended questions, it was designed using a 5-point Likert scale, ranging from "Completely" (+2) to "Not at all" (-2), with a mid-point rating (0) meaning that the perceptions were "Moderate".

4. Historical background of the city

Puri, also known as Shrikshetra Purosottam Shetra, is one of the Chardhams, (the four pilgrimage sites in India as established by Adi Shankracharya include Puri, Badrinath, Dwarka and Rameshwaram) and an important pilgrimage, religious and sacred city in the eastern coast of India. It is also a processional city known for Jagannath temple and the processional ritual of Rath Yatra. Due to the city being located on the coast of Bay of Bengal with beaches, it is also a destination for the tourists majorly coming from the nearby cities for short durations. But it is more recognized as a religious and historic city.

The planning of the city is based on Vastu Purush Mandala. The city with Jagannath temple on the mound of 'Nilagiri' as the focus, grew around it, the shape being like a conchshell (shankha), having eight concentric rings of neighbourhoods known as Sahis woven together in the urban fabric by the streets. There were seven streets in Puri in 1840-41, according to the map by Survey of India (Barik, 2005).

In Puri, there are various living traditions, festivals and rituals like the Rath Yatra (also known as the Car festival or Chariot festival or Gundicha yatra) , Chandan yatra, Snana yatra, Jhulana yatra and Sahi yatra. As a result, the city is dominated by a number of processional routes like Bada Danda for Rath Yatra, the paths connecting Jagannath to Loknath temple, Swargdwara, Narendra Tank and the seven Sahis. Thus, a strict hierarchy of streets is maintained in terms of accessibility and scale. Because of their religious and functional significance, scale and diverse activities, these streets reinforce the identity and sense of place of the city (Nanda & Khare, 2015). The morphology of the entire city is developed on the basis of its religious beliefs, which makes this place distinct from all other sacred sites (Kar, 2015).

5. The studied streets

The streets selected for study are the three main streets leading to Jagannath temple; Bada Danda, Swargdwara Street and Temple Street, each having its own significance (Figure 1).

Bada Danda (Figure 2), one of the widest roads, the main spine and a sacred ceremonial path connects the Jagannath temple to the Gundicha temple and is famous for Rath Yatra. Rath Yatra, an annual grand processional

festival, lasting for nine days, is celebrated on the second day of bright fortnight of Asadha, in the month of June –July and is a culmination of a series of festivals celebrated over the summer and monsoon months. During this festival, the deities are taken out from the temple, are installed in their respective chariots and then they start their journey to Gundicha temple where they stay for a period of seven days. On the ninth day they return back to the main temple. The wood used for the construction of chariots every year is kept and stored on or along the street and the construction of chariots also takes place on Bada Danda. The Rath Yatra thus gives an identity to the city and the Bada Danda. Nava Kalevara (means New Body), another festival which occurs once in every 12 years (or 8, 16 or 19 years) when old figures of the dieties are replaced by new ones, begins by Bana Jaga Jatra where a group of specific persons start the journey from the temple through Bada Danda for procurement of wood used for making the new idols (Figure 2). The spine is also known as the Grand road comprising of multiple activities like religious (dharamshalas, small temples, mathas), commercial (hotels, restaurants, shopping complexes), institutional (hospitals, banks) and other public and semi-public uses. A number of informal activities also take place all along the stretch thus adding vibrancy and chaos at the same time (Tandon, 2016). The intensity of informal activities near the temple is high. It comprises of vendors selling food items, temple souvenirs, fruits, gifts, toys, handicrafts by either standing or sitting on the floor. The intensity gradually reduces towards Market Chauraha. From here onwards these activities further diminish and we can see vendors selling mainly fruits only. Vehicles are haphazardly parked on either side of the street. The street is a typical example of the grandness of scale and proportions due to a specific ritual.

The Temple street (Figure 3), locally known as Dolasahi since it caters to one of the sahis, Dolamandapam Sahi, which is in axis with the Jagannath temple, is narrow and winding and comprises of majorly residential

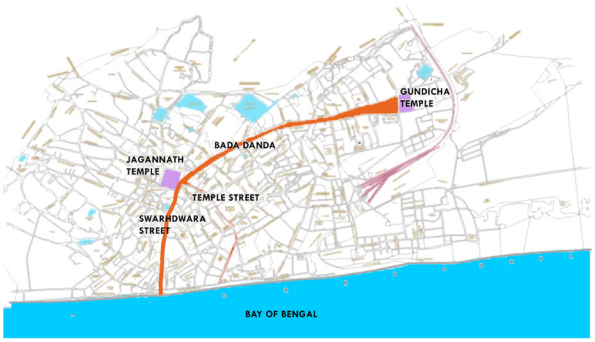

Figure 1. *The Study areas- Bada Danda, Temple and Swargdwara streets, Puri.*

Figure 2. *Bada Danda .*

units having commercial activity on the ground floor. An open space with a square pavilion (known as Janhimundia Chhak or Chowk) after a certain interval gives a pause to the movement and greets one to another group of activities majorly the residences of the Mochis (cobblers) with shops in front, important government and public buildings and Akhadas (places for imparting physical education). The character of the street changes as we move towards the sea (Tandon, 2016). The land use on this street is majorly mixed and residential though towards the end it houses government offices with informal activities happening majorly at the beginning of the street with vendors selling eatables. Auto parking is provided at the Janhimundia Chowk.

Another sacred path of Puri, the Swargdwara road (Figure 4), comprises of a number of temples, important Mathas (monastic houses for imparting education to disciples) and shops. The temples on the street are visited by the images of Lord Jagannath to eat Prasad every fortnight. One of the important tanks the Swetaganga, the

Figure 3. *Temple street.*

sacred bathing pool, also lies on this street and is hidden from view on the street. As the name signifies, this street symbolizes the final journey of man from birth to death beginning from the temple and finally culminating to the cremation ghat and the ocean. The street is one of the most active ones since it connects the temple to the sea via shortest distance. The nature of activity too changes from the more religious ones towards the temple and becoming commercial at the end towards the sea. The intermediate stretch is comparatively less active with shops mainly opening in the mornings and evenings when the movement of people is maximum (Tandon, 2016).The land use on this street is mixed, commercial and residential with the shops selling khajas (Prasad) and other articles related to the temple. The vendors usually line up here to sell these items.

Figure 4. *Swargdwara street.*

The studied streets thus not only function as a channel of movement for everyday life and mundane activities but also incorporate varied significant uses for residents, tourists and pilgrims alike. Various festivals and processions take place on the street itself and people gather in large numbers to celebrate these occasions. The mundane activities take a backstage on these specific days and the street that is used for passage or going to religious places becomes a stage for performing rituals and religious activities. These rituals and related activities develop place meanings and a collective 'sense of place'.

6. Result and discussion

6.1. Visual and physical survey

The main streets in religious precincts are narrow except the Bada Danda which is wide and have evolved organically over a period of many years. The other two streets do not have sidewalks for pedestrians since these streets were made for the people on foot and not vehicles. Similarly other basic amenities like seating, street furniture, shelter and canopies are not present on these streets. Due to the presence of pilgrims and movement of traffic, they are mostly crowded and congested. Maintenance and cleanliness is another problem faced by the people though the streets are regularly cleaned.

Bada Danda which has a unique character owing to the processional ritual of Rath Yatra, does not have any feature that can cause obstructions during the festival. Therefore, the street is devoid of any trees or other street furniture (Figure 2). The informal activities that occupy most of the street cease to happen on the special occasions like Rath Yatra. In order to facilitate the pilgrims to have a view of the festivals and rituals, the buildings have balconies and openings on the upper floors. Millions of people on the street and in the balconies take part directly or indirectly in these events and become a part of it. Similarly, houses on the Temple street (Figure 3) had projecting upper floor with balconies, providing shade on the street. Most of the

historical buildings were architecturally significant and intricately carved but were in dilapidated condition and needed immediate attention. The qualitative data findings are demonstrated in Table 1.

6.2. Reliability and validity test

The reliability test results indicate Cronbach's Alpha value as 0.845 for Bada Danda, 0.893 for Temple street and 0.891 for Swargdwara which is higher than minimum value i.e. 0.7 of alpha and is hence significant for all the three streets.

Also, Kaiser-Meyer-Olkin evaluate of sampling adequacy for validity test has values 0.615, 0.654, 0.735 for Bada Danda, Temple street and Swargdwara respectively. The results are acceptable for the three streets since the values are higher than the minimum scale i.e. 0.6.

According to ANOVA test results, F=0.163. With a critical value of 0.05, the critical F=3.219. Since F < critical value, the differences we get are simply due to random sampling or by chance and the samples are from the same population. This implies that the results (means) obtained from the survey of the three streets are statistically significant.

6.3. Questionnaire survey

The respondents consisted of 76% pilgrims and 24% residents of Bada Danda, 77% pilgrims and 23% residents of Temple street and 72% pilgrims and 28% residents of Swargdwara street. The pilgrim respondents, as can be seen from Table 2, are almost equally distributed in various age groups of 18-24, 25-30, 31-40 and even 41-50. Fewer numbers are in old age groups since most of them nominated the younger ones in their group or family to fill the questionnaire.

Almost equal numbers of male and female respondents were a part of survey as demonstrated in Table 2.

Survey results of pilgrims on Bada Danda indicate that the street is perceived high in socio-cultural aspect with a mean of 0.893 as compared to physical aspects with a mean of -0.119 due to strong historical significance of street pertaining to the Rath Yatra also known as Chariot Festival annually and other rituals and religious activities happening on the street. The road is considered to be sacred and has a very strong identity because it houses the Rath Yatra and the activities associated with the making of the three rathas annually. The shops directly open out on the streets with certain spill over activities happening on the sidewalks and there is a strong interaction between the people on both sides of the street interface. Not only at the street level, the upper floors also have balconies to communicate with the street activities (Tandon, 2016). The activities on the street support the rituals with vendors lining the pathway providing souvenier and colourful items on their carts to the pilgrims, or sitting on the floor with umbrella covers to protect them-

Table 1. *Qualitative Data Findings.*

Bada Danda	**Temple street**	**Swargdwara**
Inadequate public facilities: seating space, toilets, drinking water	Inadequate public facilities: seating space, toilets, drinking water	Inadequate public facilities: seating space, toilets, drinking water
Traffic congestion and haphazard parking	Traffic congestion and parking at Janhimundia Square	Traffic congestion and haphazard parking
Poor management but better in terms of street surface quality	Poor drainage	Potholes and poor drainage provisions
Inadequate shelter	Inadequate shelter	Inadequate shelter
Encroachments	Encroachments	Encroachments
Contrast between the old and new building architectural styles	Garbage thrown here and there on street	Dilapidated condition of old buildings
Nuisance created by roaming animals on street	Nuisance created by animals roaming on street	Nuisance created by animals roaming on street
Presence of historical buildings of architectural significance	Presence of historical buildings of architectural significance some of which are maintained	Presence of historical buildings of architectural significance

Table 2. *Percentage of respondents in various age groups and based on gender.*

Age (years)	Bada Danda,	Temple Street	Swargadwara
18-24	15%	11%	17%
25-30	23%	21%	25%
31-40	17%	29%	21%
41-50	23%	12%	19%
51-60	12%	14%	12%
60+	11%	14%	6%
Gender			
MALE	66%	50%	56%
FEMALE	34%	50%	44%

selves from the scorching heat. Street foods, and even the logs of wood used for making the Rathas find a place here. The physical aspects (the open spaces, the built environment and character of the street) were less identified by the respondents as can be observed in the statement made by many pilgrims, "It is only because of Lord Jagannath that we come to this street…." At the same time, the surface quality of street is maintained and it is smooth without any potholes as can be observed in its mean value (M = -0.119) which is higher than the other two. In addition, the street is cleaned more than twice a day but due to numerous pilgrims visiting the street, it does not remain clean.

According to the residents of Bada Danda, socio-cultural aspects (M=1.620) on this street are more significant than the physical characteristics due to sense of attachment and connection pertaining to their economic dependence and sustenance on the place as a source of income and its strong historical significance. One of the residents explained, "Activities keep happening on the street apart from Rath Yatra like Bhajan programmes 7-8 times a year in Kartik, collection and display of Durga idols made by each sahi near Singhdwara before their visarjan; is also route for murti visarjan after Durga puja …." giving him a sense of pride. Physical features (M=0.060) are again moderate and positive implying its importance on this street. The opinions regarding the changes on the street are conflicting. A strong positive correlation of 0.952 is observed between the perception of pilgrims and residents of Bada Danda.

The results of survey of pilgrims on Temple street indicate that the perception is negative and moderate in socio-cultural aspect with a mean of -0.106 because neither it is known for any specific ritual nor is a route followed by most of the pilgrims. The pilgrims do not feel much associated to this street. The street scored the lowest in physical aspects because of the unhealthy and unhygienic conditions on the street as pointed out by various pilgrims. The visual survey too indicates the same.

But the residents unlike the pilgrims on this street thought it to be comprising of prominent socio-cultural aspects with a mean of 1.460 signifying their length of engagement, stay and frequency of visiting the street which influenced their perception and they are completely satisfied with the characteristics related to this aspect as stated by one of the resident, "Some rituals are also associated with this street and it is also known for Akhadas…." , but have negative perceptions about its physical (M=-0.201) characteristics. As compared to the other two streets, it is perceived to be the lowest in both aspects. There is a strong positive correlation of 0.818 between the perception of pilgrims and residents on Temple street.

Swargdwara like Bada Danda too has strong socio-cultural characteristics as perceived by pilgrims with a mean of 0.741 and is packed with people due to it being known as a 'route to heaven' and is the shortest distance from temple to beach. The presence of Swetganga tank also increases its historical importance. During the day, the people can be seen sitting outside, resting, communicating with each other and also with people walking on the street providing opportunities for interaction. Small shops and vendors on the street sell Prasad and souveniers thus fulfilling the needs of the pilgrims. According to one of the pilgrims on this street, "Spiritual, religious feelings come in mind even if I am an atheist…." clearly signify the importance of the street. Another pilgrim responded, "Condition of road is very bad especially during rainy season and there is a need for beautification and decoration of the buildings on street…. " showing dissatisfaction with the physical aspects (M= -0.473).

From the survey of residents of Swargdwara, socio-cultural aspects with a mean of 1.550 are rated as high since they very much identified with the place and also expressed sense of ownership and pride but they too were not satisfied with the physical aspects (M= -0. 270). The perceptions of pilgrims and residents on Swargdwara have a strong positive correlation of 0.917.

The strong positive correlation between the perception of pilgrims and residents on the three streets indicate consensus among both the groups regarding their opinion about the aspects of sense of place on these streets. The differences in means obtained from survey of pilgrims and residents can be attributed to factors like economic dependence and sustenance, familiarity with the place, length of engagement, stay and frequency of visiting the street, sense of ownership and pride, which are more important for residents than the pilgrims.

Perception of respondents also varies with age though there seems to be a general consensus regarding the negative perception for physical and positive for socio-cultural aspects as can be observed in Figure 5. Respondents in age group of 18-24 years are stronger in their opinions as one of them clearly stated "The street is dirty, stinking, no place to walk; no pedestrian walkways…." about the Temple street. Respondents above 60 years are more sensitive towards social and cultural characteristics clearly indicating the importance these streets psychologically have on the older people where they feel spiritually connected to the divine power as compared to the younger generation. The results also indicate that the young people too are sensitive and spiritual as otherwise thought of.

As per sex, both male and female pilgrims are in agreement regarding the physical characteristics with negative means and socio-cultural characteristics with positive means present on the streets with females having a better perception than males as demonstrated in Figure 6.

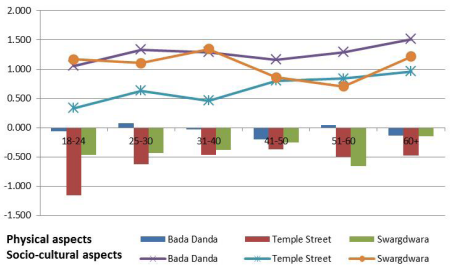

Figure 5. *Means of responses for physical and socio-cultural aspects according to various age groups.*

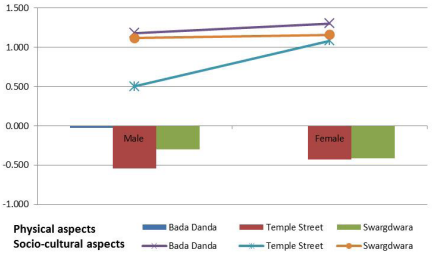

Figure 6. *Means of responses for physical and socio-cultural aspects according to gender.*

7. Conclusion

In this study we evaluated the two aspects (physical and socio-cultural), that contribute to sense of place in the three streets (Bada Danda, Temple Street and Swargdwara) of Puri, a religious city, through the parameters like physical values in terms of streetscape character, landscape features, cleanliness, maintenance and historical significance, activities supporting rituals, opportunities for interaction, sense of belonging for socio-cultural values that these streets have.

The study demonstrates that both pilgrims and residents respondents perceive that the characteristics related to socio-cultural aspects are dominant and strongly associated with sense of place on streets in pilgrimage cities. Residents are stronger in their perceptions as compared to pilgrims. The historical importance, activities that support the needs for the rituals, opportunity for interaction with others on the street and also sense of belonging influence the perception of people and sense of place (Table 3). The sense of place rooted in the past is, therefore, what constitutes the essence of place (Ujang, 2014) and determines the identity of a place (Relph, 1976). The religious activities (rituals, activities catering to the needs of pilgrims for performing the rituals) are more prominent near the religious complex. They change their character as the distance from the complex increases and are an important factor in contributing to sense of place on streets in religious cities.

The socio-cultural (Relph, 1976; Steele, 1981; Low, 1992; Mazumdar & Mazumdar, 1993, 2004; Edensor, 1998; Hidalgo and Hernendez, 2001; Mehta, 2007) and physical aspects

Table 3. *Means of response for Socio-cultural aspects on the three streets.*

Socio-cultural aspects		Bada Danda	Temple Street	Swargdwara
Historical importance	Mean	**1.638**	**0.479**	**1.613**
	SD	0.557	1.040	0.738
Activities supporting	Mean	0.763	-0.225	0.709
rituals	SD	0.846	1.190	1.111
Opportunities for	Mean	0.667	-0.038	0.654
interaction	SD	1.040	1.216	1.074
Sense of belonging	Mean	0.380	-0.641	-0.013
	SD	1.029	0.953	1.217

Notes. *Likert scale ratings : 2= Completely agree, 1= Very much agree, 0= Moderately agree, -1= Slightly agree, -2= Not at all agree*

Table 4. *Means of response for Physical aspects on the three streets.*

Physical aspects		Bada Danda	Temple Street	Swargdwara
Lighting	Mean	0.500	-0.125	0.012
	SD	0.827	0.624	0.698
Landscape features &	Mean	-1.333	-1.413	-1.213
trees	SD	0.935	0.688	1.064
Buiding material and	Mean	-0.263	-0.963	-0.763
colour	SD	0.759	0.665	0.984
Attractive buildings	Mean	-0.463	-1.138	-0.778
	SD	1.018	0.670	0.975
Cleanliness and	Mean	-0.244	-1.375	-0.963
maintenance	SD	1.164	0.848	0.955
Alive	Mean	**1.090**	**0.063**	**0.864**
	SD	0.885	1.276	1.046

Notes. *Likert scale ratings : 2= Completely agree, 1= Very much agree, 0= Moderately agree, -1= Slightly agree, -2= Not at all agree*

(Lynch, 1962; Relph, 1976; Steele, 1981: Rapoport, 1990; Hidalgo and Hernendez, 2001; Steadman, 2003) are equally important and significant to have sense of place as discussed in the literature review. Though the three streets are valued socio-culturally due to them being associated with a religious and sacred place, the physical aspects are likewise vital for them. Walking barefoot is a ritual which the pilgrims follow thereby experiencing the transition from mundane to sacred and hence the surface of the street should be comfortable to walk on implying the prominence of physical character of the street to perform an activity. Streets in religious precincts should be easily accessible and if possible should be pedestrianized for the pilgrims to walk safely and comfortably to the religious complex.

Both visual and questionnaire survey reflect the unsatisfying conditions of physical parameters on these streets which deter the sense of place, thereby signifying the improvements required to further enhance the quality, identity and sense of place on these streets (Table 4). To improve the physical conditions of the streets, the people together with the government need to take initiatives. The built environment which at present comprises of some dilapidated buildings needs to be taken care of and strict bye-laws regarding new constructions should be followed. The dilapidated structures should either be removed or renovated based on their importance historically or architecturally. Improvements in streetscape and conservation of distinctive features such as old and historical building façades will make places more legible and attractive.

Basic amenities should be provided for the pilgrims including provisions for keeping footwear before going to the temple, dustbins, seating space, drinking water and toilet facilities. The streets should be cleaned frequently depending upon the footfall of the pilgrims on a regular basis. The character of the streets can also be achieved by cleanliness and maintenance so that the pilgrims who come here in large numbers with spiritual feeling carry a positive image pertaining to its character. Further by providing landscape features, semi-fixed street furniture that can be removed during the processions, public art and open spaces, the physical aspects can be enhanced without destroying the essence of the religious character of the street.

The streets of religious cities are thus rich in social and cultural values (intangible aspects) and also clearly indicate the importance of the tangible aspects that have a very strong influence on people's perception of the street and sense of place. The pilgrims visit these streets because of the presence of religious structures and their beliefs and faiths. At the same time, they wish for the improvement in the physical condition of the street and built form to

make their visit more experiential, interesting and fulfilling. The physical, social and cultural attributes further enhance the sacred character of the place. The streets in religious precincts though lacking in physical qualities have a strong sense of place due to the social, cultural and religious beliefs.

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ITU A|Z • Vol 17 No 3 • November 2020 • 61-78

Socio-spatial vulnerability and dilapidated abandoned buildings (DABs) through the lens of spatial liminality: A case study in Iran

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Received: December 2019 • Final Acceptance: May 2020

Abstract

This article explores the association between socio-spatial vulnerability and dilapidated-abandoned buildings (DABs) through the lens of spatial liminality in historic Iranian cities. It deliberates how DABs are accompanied by several deleterious effects, created as a result of modern socio-spatial transformation. An interdisciplinary approach was employed in this study, which recognises liminality as a condition of socio-spatial vulnerability applicable to historic cities. In this case, spatial liminality in historic cities has become associated with the influx of non-local disadvantaged residents who compete for cheaper housing options while remaining in a state of limbo. The study is quantitative in nature and consists of a questionnaire survey and on-site observation. The investigation was conducted in twelve urban blocks, located in two significant historic cities: Yazd and Kashan. Results demonstrate a significant association between the extent of DABs, the overall distribution of liminal refugees and the proportion of refugee settlements, almost in all sample blocks. Such spatial liminality accompanied by the accumulation of refugees, indicating DABs as liminal urban fabrics that need to be re-utilised while maintaining their heritage value. This study allows practitioners, policymakers and academicians to comprehend the revitalisation of historic cities through the lens of spatial liminality and this, in turn, opens up discussion on how urban regeneration methods can inform socio-spatial governing context to move historic cities, out of spatial liminality.

Keywords

Dilapidated-abandoned buildings (DABs), Revitalisation of historic cities, Socio-spatial vulnerability, Spatial liminality.

doi: 10.5505/itujfa.2020.60243

1. Introduction

Today, Iranian cities have become subject to an unprecedented phenomenon, initially occurred at the beginning of the 20th century when for the first time modernity was introduced in the Middle East. In this sense, the old city walls were demolished, and this development dramatically changed the physical-spatial configurations of historic cities (Pakzad, 2015). It is essentially acknowledged that from the 1920s to 1960s (and during the period spanning the Pahlavi Kingdom, 1925--1979) exogenous socio-spatial movements reshaped historic cities. Ever since, traditional cities have been carved out and transformed under capitalism and modernity to accommodate vehicular access and modern infrastructure (Habibi, 2005). Therefore, historic cores in Iranian cities have mainly been subject to gradual decay, with an exodus of population and abandonment of buildings for more than half a century (Ehlers & Floor, 1993). In this sense, a direct correlation between the urban transformation process and lack of urban identity can be identified in historic cities (Gür & Heidari, 2019)

As a result of unprecedented contemporary urban transformation, today large areas of historic fabrics can be considered as dilapidated-abandoned buildings (DABs), while some disused areas have existed for few decades (Faghih, 1976; Güler & Kâhya, 2019). Mirmiran (2011), for example, suggested that in Kashan 12.7% of all historic areas are made up of DABs. In Yazd, Behzadfar (2012) also indicated that about 15% of all historic fabrics are surveyed as DABs, which can attract antisocial behaviour, poor communities and generate a perceived or actual lack of safety (Figure 1).

Today, due to a vast proportion of DABs, historic Iranian cities have been transformed into disaggregated and fragmentary fabrics, which have remained unattended for decades or have been filled by new developments that have inharmonious relationships with surrounding environs. Thus, DABs and relevant redevelopment regulations pertaining to them are conceptually challenging and have been largely neglected within the socio-spatial planning context of historic cities (Masoud & Beigzadeh, 2012).

Figure 1. *Today, the formation of DABs (mainly generated as a result of new road developments) has become a major socio-spatial problem in historic Iranian cities, such as in Kashan (right) and Yazd (left), (Source: the lead author).*

Inside Iranian cities, socio-spatial marginality is clearly evident and relevant to the cluster of low-income disadvantaged communities; these mainly comprise an extremely poor urban social stratum, encompassing families whose household incomes position them as marginally above or below the official poverty line (Curtis & Hooglund, 2008). Such disadvantaged communities may be attracted to settle in cheaper urban areas such as historic fabrics, and because of their poor financial situation can not maintain their houses and/or properties (Behzadfar, 2012).

Today, it is estimated that about one and a half to two million undocumented Afghani refugees are present in Iran (Lomax, 2018), of which 98% are living in cities (Naseh et al., 2018). Inside Iranian cities, there are meaningful grounds on which to believe that poor nonlocal residents, ethnic minorities and refugees are gradually occupying heritage fabrics while original residents are leaving these areas (Tavassoli, 1987b).

For example, from 1996 to 2006 in Yazd, the local (Yazd-born) population declined from 54,287 to 42,868, of which about 14% were identified as refugees living inside the old city of Yazd (Behzadfar, 2012). Such an influx of refugees could be considered as a phenomenon which is strongly linked to the accumulation of cheaper housing opportunities inside such urban areas (Tavassoli, 1987 a). For those whose lives are unstable in the diaspora, it is best to seek sanctuary within historic

Figure 2. *Refugee settlements within dilapidated-abandoned buildings can represent socio-spatial vulnerability inside historic Kashan (left) and Yazd (right), (Source: lead author 2018).*

zones with minimal living facilities, which could be quite tolerable to them, either due to their original life in villages or severe poverty and homelessness (Mirmiran, 2011), (Figure 2).

1.1. Research context

As argued earlier, the simultaneous growth of DABs and mass immigration of exogenous disadvantaged communities to historic areas today can be respectively interpreted as a state of socio-spatial vulnerability (Tavassoli, 1987 b). Such transitory situations can form a deleterious, circular phenomenon, through which inefficient planning models can diminish the value of land, that in turn encourages emigration of original residents and facilitates the immigration of non-Iranian disadvantaged communities to historic cities (Behzadfar, 2012).

Therefore, DABs become a tangible-dependent variable suspended between past and present, which arguably accelerates the formation of socio-spatial vulnerability (Mirmiran, 2011). Such undesirable socio-spatial conditions have been suspended between traditional and contemporary urban contexts for some time, and this has created physical dilapidation, uncertainty, stigmatisation, racism, marginality, dissatisfaction on the part of residents, crime, and so forth. Thus, DABs can attract even larger clusters of refugees and disadvantaged communities into historic cities (Behzadfar, 2012).

As a result, the correlation between the extent of DABs, and the formation of such detrimental conditions, need to be considered as a deleterious phenomenon that reflects real-life vulnerability in historic Iranian cities. Therefore, the broad aim in this paper is to provide an innovative method for understanding socio-spatial vulnerability associated with DABs that can facilitate strategies for revitalising historic cities. Thus, the research investigates the correlation between the extent of DABs versus transitory residents across several case studies.

The scope of the work in this study is limited to collecting and analysing several socio-spatial datasets in twelve urban blocks in two historic Iranian cities. A case study selection procedure is specified by studying the maximum variation of DABs on sample blocks. Two methods of data collection are implemented in this research including street surveys and field observation. Data analysis has utilised ArcGIS, SPSS, presented in spatial and demographic strata.

1.2. Socio-spatial rehabilitation of historic cities

Since the 18th century, several global movements have reiterated a need for revitalisation of heritage sites and cultural properties (Murray, 2008). Today, methods of urban revitalisation in historic cities may include several approaches, from mere preservation to physical intervention or a combination of both (Doratli, 2005). Levels of intervention for the revitalisation of historic cities should be directed by cultural heritage value, and any intervention which would lessen or compromise cultural heritage value is objectionable and should not occur (ICOMOS, 1993).

In Iranian cities, three major government agencies are in charge of regulating and managing heritage districts[1]. Revitalisation programs in historic cities have aimed to document historic contexts, provide building regulations, and define heritage buffer zones. Programs also have concentrated on pedestrianisation, place-making, façade restoration, repaving and regeneration of cultural-historic axes (Habibi, 2010). Programs also focus on developing infrastructure, adaptive reuse of historic buildings, and have facilitated infill residential-mixed use buildings, identity generation and promotion of tourism activities (Hanachi & Fadaei Nezhad, 2019).

Today, the rehabilitation of historic cities in Iran is not seen as a priority among relevant government agencies

(Pakseresht, 2017). Such oversight can happen either because of the obsolete image of historic areas among the public or lack of technical and/or institutional capability (and capacity) to come to grips with such a complex mix of physical and social problems (Balbo, 2012). Whether the issue is wholesale demolition or widespread neglect of DABs, the common problem is that most decision-makers identify with a development process that is alien to cultural traditions of their societies. In this sense, the decision-makers are rarely provided with technical approaches and institutional tools which could demonstrate the viability of alternative, more appropriate models of intervention (Bianca, 2000).

Historic urban cores in Iranian cities have been undermined by various moves for redevelopment. There has been an underlying emphasis on physical-linear regeneration (e.g. by implementing urban design methodologies adapted from Kevin Lynch's environmental psychology, which emphasises urban imageability amongst space users) and delivery of flagship projects as a prevalent approach, mainly employed by the central government (Masoud & Beigzadeh, 2012).

Such urban revitalisation projects inside historic cores principally remain freestanding, bounded within physical structures and organisational political perspectives. Thus, despite great efforts, such an inharmonious state of affairs has further segregated historic cores and underutilised heritage urban fabrics (Andalib, 2010). Furthermore, current preventative building controls have discouraged building investments in historic areas and this has led to further devaluation of land, which may in turn yield more deteriorated fabrics (Izadi, 2008), (Figure 3).

Figure 3. *Current revitalization programs in Iranian historic cities, such as in Yazd (right) and Kashan (left) mainly have focused on enhancing physical structures rather than considering the grassroots of socio-spatial matters in neighbourhoods.*

2. A theoretical framework for revitaling historic Iranian cities

From the early 19th century to the Amsterdam Charter (1975), it took about seven decades for regeneration programs to evolve from single building restoration to holistic and sustainable agendas for revitalising historic cities (Behzadfar, 2012). Such progressive development brought awareness of the impossibility of separating historic centres (either in analytical or in planning terms) from their municipal, territorial and social contexts, which are linked by mutual, deep relationships (Lazzarotti, 2011; Zain & Andi, 2020).

In that regard, urban transformation in historic cities of Europe began with the Renaissance in the 14th century and continued with the Enlightenment, culminating in the late 18th, 19th and 20th century Industrial Revolution (Voegelin, 1982). Therefore, the whole process of urban transformation, including the adoption of economic, political and cultural aspects of modernity by Western cities, had materialised in about five centuries, which has allowed a reasonable amount of time for socio-spatial integration of historic cities with their surrounding modern built environments.

In contrast, the whole process of modernisation in Middle-Eastern cities, launched since the beginning of the 20th century, radically transformed traditional structures in just a few decades (Bianca, 2000). The rapid and unfiltered adaptation of modernity entailed the progressive demolition of historic fabrics as a result of demographic changes, migration, breakdown of traditional tribal structures, the introduction of mechanized transport, destruction of city walls and so on; and devalued land and properties, which generated massive socio-spatial degradation and assisted rural immigration in old urban contexts (Mahdy, 2017).

The dynamic of socio-spatial change produced by the Industrial Age found its physical expression in the radical transformation of historic urban fabrics in Iranian cities, despite the fact that during previous centuries changes

in architectural fabric had always occurred as a result of the natural/organic evolutionary process (Faghih, 1976). Such socio-spatial disruption generated an ever-widening chasm between past and future, which pulled present historic cities apart, emptying them of many essential qualities; and therefore, historic urban areas can be assumed to be entities suspended in-between pre-modern and contemporary epochs (Bianca, 2000), (Table 1). This uncertainty represents transitionality, not unlike the concept that Szakolczai (2017) describes as a state of permanent suspension. Besides, the challenging presence of refugees in such informal refugee camps is clearly evident in the concept of in-between-ness (Manjikian, 2010).

Here, such limbo can create vulnerability, where societies everywhere acknowledge transition in the social status of people, by symbolically noting their separation from a previous state in the social structure, and subsequent incorporation of a new social state (Van Gennep, 1960). Therefore, historic zones in heritage cities can be seen as transitional entities, because they accommodate uncertain conditions in life and settlement fabrics (Mozaffari, 2016). In anthropology, liminality is used as a measure for understanding vulnerability of being limbo among human beings (Szakolczai, 2015). Thus, this research suggests liminality as a proper tool for understanding socio-spatial vulnerability in the context of urban regeneration in historic Iranian cities.

Accordingly, this article presents an approach for studying vulnerability in historic Iranian cities, whereby DABs can meaningfully reflect the liminal qualities of life. Here, a gap in the relevant scholarship is the relationship between the extent of DABs and the formation of socio-spatial vulnerability, while such an examination can be undertaken specifically through the lens of spatial liminality. In response to the proposed research project, this paper proffers two significant questions for investigating aspects of socio-spatial vulnerability in historic cities. Firstly, "to what extent could liminality be identified and documented against the formation of DABs in historic Iranian cities?" and secondly, "to what extent can liminality, as an analytical tool, inform revitalisation projects and processes in historic urban fabrics?".

Table 1. *Timeline comparing socio-spatial transition in Iranian and European cities.*

Epoch	Time period	Socio-spatial transition in European cities	Socio-spatial transition in Iranian cities
Premodern	Renaissance	The ongoing adoption of economic, political and cultural aspects of modernity by Western cities made cities sensitive to/aware of exogenous/global movements	Changes in architectural fabric had always occurred as a result of the natural/organic and endogenous-evolutionary process
	Enlightenment		
	Industrial revolution		
	The 19th century	Single building restoration along with the generation of surrounding modern structures in the city	
Modern and contemporary	The 20th century	New approaches merged the planning of historic cores with the larger built environment	Radical transformation of traditional structures generated socio-spatial disruption, DABs and immigration of disadvantaged communities to historic areas
	The 21st century	Holistic and sustainable agendas for revitalising historic cities	Historic urban cores are suspended in-between pre-modern and contemporary epochs in a transitory limbo for several decades that can create socio-spatial vulnerability

3. Application of liminality in urban studies

Van Gennep first coined liminality in Les Rites de Passage (1909), translated into English as The Rites of Passage (1960) (cited by Thomassen, 2014). He distinguished rites that marked the passage of an individual or social group from one status to another (e.g. childhood to manhood), from those which mark transitions in the passage of time, for instance, harvesting time and New Year (cited in Thomassen, 2012).

Emphasising the importance of transitions in any society, Van Gennep (1960) singled out 'rites of passage' as a special category, consisting of three sub-categories, namely 'rites of separation', 'transition rites' and 'rites of incorporation' (Szakolczai, 2015, p.141). He called the middle stage a liminal period. He referred to transition rites as 'liminal rites', and the rites of incorporation 'post-liminal rites' (Thomassen, 2012, p.23). By analysing rites of passage, Van Gennep introduced a new approach: instead of utilising priori categories as units of his taxonomy, he

abstracted these units from the structure of ceremonies themselves (Darity, 2008).

Van Gennep was impressed with the prominence of transitional or liminal phases within a ceremony. He noticed, within tribal rituals, that when individuals or groups are in a state of suspension (separated from their previous condition and not yet incorporated into a new one), they constitute a threat to themselves and the entire group. As such, they are outside the sphere of normal control and must be reintegrated to avoid becoming disruptive (Van Gennep, 1960) (Figure 4).

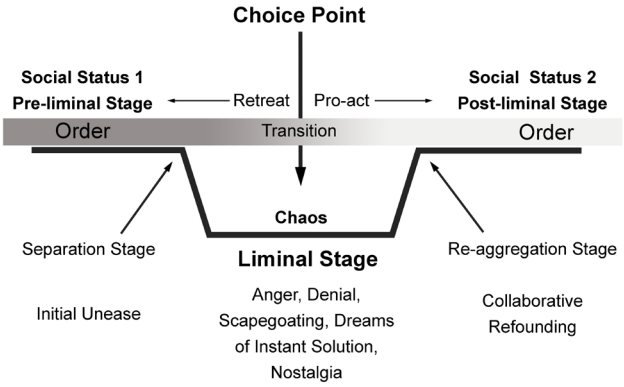

Figure 4. *The three phases of liminality as described by Van Gennep (1960).*

3.1. Place as the third dimension of liminality

By coining spatial liminality, Thomassen (2014) indicates the third dimension of liminality as Place, moving beyond Van Gennep's dichotomy of Time and Event as the very foundations of liminality. Thomassen notes Van Gennep's specification that liminality is essentially a spatial concept; and perhaps the physical passage of a threshold somehow preceded the rites that demarcate a symbolic or spiritual passage. In his original book, Van Gennep introduced his analysis of ritual transition by devoting a complete chapter to the territorial passage, and by asserting that 'a rite of spatial passage has become a right of spiritual passage'. In this sense, the study of 'spatial liminality' represents an opening for 'theorising space' (Thomassen, 2014, p.91).

A concrete manifestation of such liminal-spatial passage is the case of refugee camps, where Mortland (1987, p.379) argues that the characteristics of liminality are applicable to asylum seekers confined to refugee camps. She indicates that the loss and confusion experienced by refugees after separation from their homeland, unfamiliarity and strangeness of the refugee camps and uncertainty about the future create a social atmosphere of enigma, anxiety and timelessness for refugees, which cannot be overcome as long as they remain in the camps. In this case, refugees exist in a state of suspension where they have lost their former status as members of a community, but have also not been able to join members in the surrounding society in their new location. In this respect, 'one form of the refugee camp prototype takes the conditions of transition existing in refugee camps and attempts the transformation of refugees into new beings' (Mortland, 1987, p. 380).

Nevertheless, an accumulation of refugees and disadvantaged non-local residents is a widespread phenomenon experienced in many historic cities today (Balbo, 2012). Thus, referring to Van Gennep, Thomassen and Mortland, it is argued here that spatial liminality, in both historic areas and refugee camps, could be acknowledged as sharing several similarities. In each case, the situation of non-local disadvantaged communities can be described as liminal for at least six reasons:

Firstly, people who have been involved in both types of spatial liminality have inevitably turned out to be refugees or non-local migrants. Secondly, both types of refugees are living inside a segregated zone, generated by physical boundaries. For instance, at the present time, residents in core historic areas in Iranian cities can be seen to be semi-restricted and vulnerable, due to lack of vehicular accessibility (Tavassoli, 1987a), which is indeed comparable to physical barriers in refugee camps. Thirdly, in terms of physical qualities, both types of refugees are exposed to poor housing, marginality and segregation. Fourthly, these people could participate in real-life events, including compulsory and indefinitely deferred transition. In this sense, refugees in both cases will continue to remain suspended between their previous social status and becoming a citizen of the

new land. Fifthly, these two types of spatial liminality more or less occur on a similar scale, whether it be a real-life refugee encampment or several interconnected refugee settlements (e.g. clusters of houses) in historic fabrics. Finally, within a real-life liminality context, previous achievements, skills and statuses of exogenous communities, either living in a refugee camp or inside historic fabrics, no longer apply, while both are suspended. Thus, the formation of spatial liminality can fittingly become evident inside many historic cities.

3.2. Spatial liminality as a framework for understanding historic cities

Thus far, this paper has identified spatial liminality as a deleterious condition of socio-spatial vulnerability, where non-Iranian disadvantaged communities tend to immigrate to historic cities, to obtain affordable housing opportunities in order to survive. This quality was elaborated earlier intertwined with DABs that can create disorganisation, imbalance, a decline in socio-spatial characteristics and poverty (Faghih, 1976). As a result, the argument here suggests spatial liminality as a theoretical basis for investigating the vulnerability associated with DABs in historic cities. Since liminality is largely a social-spatial phenomenon, the system of inquiry, as proposed here, is required to conduct an independent survey for understanding liminality in historic cities. Accordingly, survey items may be thought of as falling into three general content categories: demographic, factual and attitudinal (Edwards, 1997).

Factual liminality can question spatial realities via a spatial inquiry, and can be relevant in identifying current conditions of land use, by focusing on the current extent of DABs and refugee settlements, which in turn reliably measures the extent of spatial liminality. Demographic liminality can provide descriptive information about the respondents, commonly including inquiries regarding their ethnicity, which can measure spatial liminality as a condition of vulnerability amongst non-Iranian disadvantaged residents in historic cities. Nevertheless, attitudinal aspects of spatial liminality among subjected groups remain outside the scope of this research, because of the unreliability of answers that may be received from liminal residents.

4. Methodology

The current research aims to analyse specific issues within the boundaries of historic urban areas. It contains an exploratory-interpretive case study that investigates a distinct phenomenon characterised by a lack of detailed preliminary research. For measuring spatial liminality associated with DABs, three quantifiable tools are proposed in this inquiry, indicating the number of refugees per urban block and the extent of refugee settlements and DABs within case studies.

4.1. Case study selection

The case study selection procedure and objectives in this research aim to cover a wide range of urban population densities in historic Iranian cities. Kashan and Yazd were selected as larger case studies that accommodate lower and mid-range populations respectively, while possessing the largest areas of urban heritage fabrics. In this case, the results of the research cannot be generalized on a country basis. The selection procedure at the next level aims to capture the maximum variation of DABs in historic cities, thus singling out urban tissues with higher, medium and lower percentages of DABs in Yazd and Kashan. As a result, Darb-i-Isfahan, Mohtasham and Posht-i-Mashhad-i-paeen are selected as urban tissues that respectively developed higher (27%), medium (15%) and lower (4%) percentages of DABs in Kashan as measured by Behzadfar (2012). Godal-i-Mosalla, Dolat-Abad and Gonbad-i-Sabz were selected as urban tissues that respectively developed higher (25%), medium (17%) and lower (10%) percentages of DABs in Yazd as calculated by Mirmiran (2011).

After selecting a variety of urban tissues (that characterise a broad range of DABs effects), smaller urban elements that can be systematically investigated as actual case studies are selected. In Middle-Eastern historic cities, an

urban block could be conceived as a group of several dwellings including semi-private and in-between spaces (Mortada, 2003). Such clusters thus best represent the smallest identifiable urban component that forms traditional neighbourhoods, known as urban blocks (Hakim, 1986).

Consequently, two urban blocks were nominated in each selected urban tissue, which should have developed a higher and lower percentage of DABs per block, to capture the maximum variation of disused areas. The selection criteria were based on two logical phases: (1) reliable size of urban blocks (should have areas between 15,000 to 60,000 m2), and (2) intact quality of roads and physical structures, which can indicate public segregation, as a result of lack of vehicular accessibility. Based on this procedure, twelve sample blocks were chosen for further investigation. Among all selected cases, six blocks are positioned in Kashan (B-1 and B-2 in Darb-i-Isfahan urban tissue, B-15 and B-16 in Mohtasham urban tissue, B-3 and B-5 Posht-i-Mashhad-i-paeen urban tissue), as calculated by Mirmiran (2011). Another six blocks are located in Yazd including Godal-i-Mosalla (B-30 and B-43), Dolat-Abad (B-9 and B-28) and Gonbad-i-sabz (B-8 and B-47) urban tissues as measured by Behzadfar (2012).

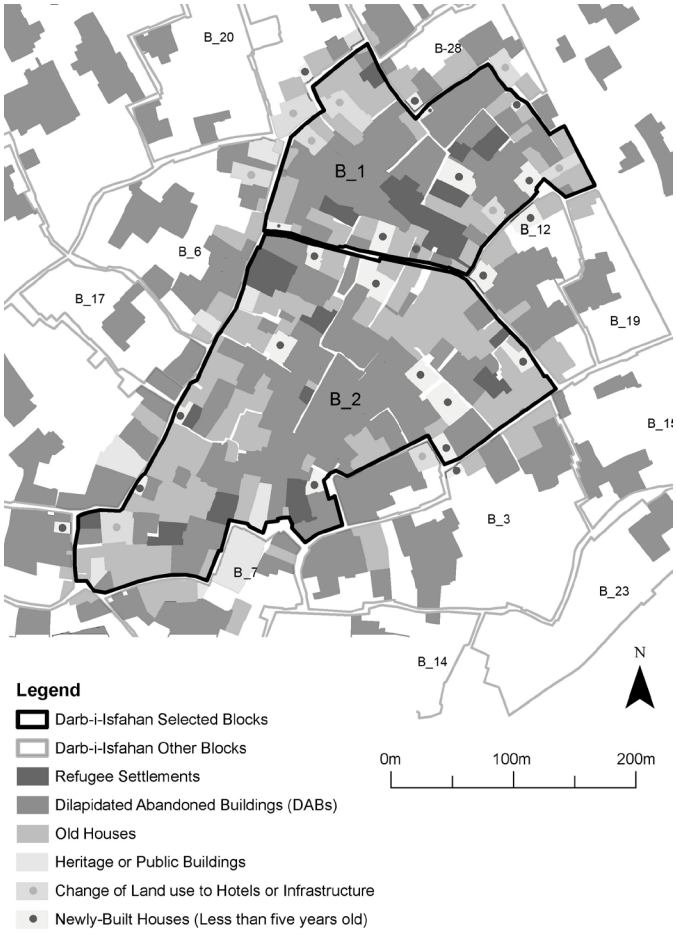

Figure 5. *Mapping spatial liminality in Darb-i-Isfahan urban tissue, Kashan, 2018 (Appendix A1) (source: lead author).*

4.2. Data collection and analysis

Two primary methods of data collection were implemented in Yazd and Kashan (March--May 2018) by the researchers, included street surveys and field observations. As a result, two categories of data were gathered, namely spatial (factual) and demographic. Spatial data was collected via field studies along with the observation of non-participant behaviours, conducted simultaneously during street surveys (see Appendices). The field observations aimed to explore spatial adjacencies between DABs and refugee settlements[2] , measure the proportion of DABs and examine areas accommodated by refugees in selected blocks (Appendix A1).

Demographic data was collected via street surveys conducted in selected blocks, while residents in properties randomly were asked to answer the question of "what is your ethnicity?" (Appendix A2). Based on a method adapted from Mortland (1987), the survey directly disclosed the number of refugees or disadvantaged non-Iranian immigrants, as an indicator of the liminal population in historic areas. Since the average number of properties (i.e. statistical subject matter in this research) in each sample block can reach about 100, the overall statistical target population reached about 1200, wherein street surveys also needed to be conducted. In a statistical target setting with a population of about 1200, the optimal sample size of about 120 properties (10% of the overall statistical population) seems reliable (Edwards, 1997). Thus, street surveys were conducted with residents of 141 properties including 60 residences in Kashan and 81 residences in Yazd.

In this research, spatial analysis examines possible relationships between the percentage of DABs per block ver-

Figure 6. *Mapping spatial liminality in Gonbad-i-sabz urban tissue, Yazd 2018 (Appendix A1) (source: lead author).*

sus the extent of refugee settlements in 2018. Spatial analysis also discloses physical adjacencies between DABs and refugee settlements in 2018. Demographic analysis examines possible relationships between the extent of DABs in 2018 versus the overall distribution of refugees per block amongst 141 participating residents.[3] At this level, data clustering and segmentation techniques are utilised to extrapolate outcomes.

5. Results

In all sample blocks in historic Kashan, a close association was apparent between the formation of refugee settlements and the extent of DABs. The nature of such a correlation can be identified here as a type of coexistence, in which refugee settlement fabrics in almost all cases abut boundaries of DABs (Figure 5). Such spatial adjacencies may contain a partial, or complete association. It is demonstrated that in many cases refugee settlements may bridge the gap between DABs, and generate informal access (such as pedestrian shortcuts) between some thoroughfares, establishing socio-spatial interconnections between clusters of refugee settlements. In this case, as a result of the complex interplay between the characteristics of such residents and the effects of the broader social and environmental context, such associations between non-Iranian disadvantaged communities are outside the scope of this research.

Not unlike historic Kashan, inside surveyed sample blocks in Yazd in five cases (B-8, B-9, B-43, B-47 and B-30) a clear coexistence between the extent of refugee settlements and DABs was identifiable. During street surveys it became evident that, since 2015, refugees had been forced to move out of the urban block B-28, thus no refugee settlements were apparent (Appendices A1 and A2). In the centre of B-47, several refugee settlements were observed to be non-adjacent to DABs (Figure 6). However, it should be noted that the whole western half of the block formerly comprised DABs, which have recently been re-utilised as indoor and outdoor public playgrounds.

5.1. DABs and the proportion of refugee settlements

In Kashan, a strong relationship was observable between the extent of DABs and the average proportion of refugee settlements. In urban blocks with the highest percentage of DABs (B-1 and B-15) about 7% of all land areas were refugee settlements, while in urban blocks with a medium (B-2 and B-3) and lower (B-16 and B-5) percentage of DABs this proportion respectively reached 5% and 2% (Table 2). In Yazd, there was a correlation between the higher extent of DABs in one-third of urban blocks (B-43 and B-8) and a greater extent of refugee settlements per block (17%). The result suggests that DABs can engender a liminal condition, which is meaningfully related to the size of refugee settlements in historic cities.

5.2. DABs and overall distribution of refugees

In Kashan, about half of liminal residents are accumulated in one-third of urban blocks with the highest percentages of DABs (45% and 44%), while the remainder have settled in two-thirds of urban blocks with smaller proportions of DABs (Table 2). In Yazd, a stronger association between the distribution of refugees and the percentage of DABs can be reconfirmed, where 72% of all refugees have gathered in one-third of urban blocks with the largest areas of

DABs (B-43 and B-8), and the remainder live in two-thirds of urban blocks with smaller percentages of DABs. This quality demonstrated the relevance of the formation of spatial liminality to the proportion of DABs in case studies.

5.3. Inferential analysis

A Pearson correlation test was run to verify the association between the percentage of DABs and factual aspects of spatial liminality (i.e. the extent of refugee settlements) in sample blocks, corresponding to street surveys in two historic cities (Appendix A3). In Kashan, a positive-strong association ($r= 0.666$, $N=61$, $p < .01$, $R^2=0.443$) was observed between the percentage of DABs and the proportion of areas in which non-Iranian disadvantaged residents have been accommodated. This correlation also remains strong and positive in Yazd ($r= 0.546$, $N=80$, $p < 0.01$, $R^2=0.298$).

6. Discussion

This article has offered a methodology for understanding socio-spatial vulnerability, by proffering a specific focus on the correlation between DABs and spatial liminality in two historic Iranian cities, where it is concluded that space can exceed time and event and generate spatial liminality, indicating real-life transitions among residents. Spatial liminality elaborated how current revitalisation policies and methods (yet to be implemented in historic areas) have predominantly engaged with visual-physical aspects of cities, rather than cultural and liminal aspects.

Along with spatial liminality, the research has verified DABs as a phenomenon which has exacerbated socio-spatial vulnerability. By measuring the rate of proliferation of DABs in historic cities (an average of 14% from 2008 to 2018), the research revealed the unsuccessful aftermath of contemporary revitalisation projects and processes in two historic cities in Iran (Appendix A1).

Here, spatial liminality discloses the reality of historic cities through a method that Szakolckzai (1998, p.211) has described as 'empirical, lived reality', and pronounced influx of refugees to historic urban areas. In such circumstances, refugees are suspended between their past and future and merely want to survive, while they have no idea about cultural values in historic contexts. Liminal-vulnerable settlers, along with impoverished local owners, cannot afford to repair their homes in historic urban areas, and this exacerbates the process of deterioration-dilapidation of buildings.

Table 2. *Analysing the correlation between DABs, the average extent of refugee settlement fabrics and the overall distribution of refugees per urban block in historic Kashan and Yazd (Appendices A1 and A2).*

Historic Kashan			
Variables / **Levels of DABs**	The average extent of refugee settlement per block	The overall distribution of refugees in the historic city	Surveyed Blocks
High: 44%<DABs	7% (High)	50% (High)	(B-1 and B-15)
Medium: 21%<DABs<44%	5% (Medium)	33% (Medium)	(B-2 and B-3)
Low: DABs<21%	2% (Low)	17% (Low)	(B-16 and B-5)
Historic Yazd			
Variables / **Levels of DABs**	The average extent of refugee settlement per block	The overall distribution of refugees in the historic city	Surveyed Blocks
High: 39%<DABs	17% (High)	72% (High)	(B-43 and B-8)
Medium: 32%<DABs<39%	2% (Low)	11% (Medium)	(B-30 and B-28)
Low: DABs<32%	4% (Low)	17% (Medium)	(B-9 and B-47)

We have suggested that historic Iranian cities can be considered as liminal places because they accommodate liminal residents or refugees in semi-restricted areas, who are isolated through the lack of vehicular access and adequate public transport. As argued above, these socio-spatial conditions can be reasonably compared to liminal communities constrained in actual refugee camps. In both cases, subject communities are forced to live in ghettos or camps, and have entered into a suspended state of liminality in their attempted passage between their previous social status and an unknown future, seeking to become citizens of the new land.

Through the discourse of liminality, Victor Turner (1974) and Arnold Van Gennep (1960) both suggested that during liminal rites of passage, masters of the ceremony (principally elders of the community), whether implicitly or explicitly, must teach rules and supervise neophytes. Thus, it becomes a notable point that contrary to refugee

camps, where processing centres act as masters of ceremony, inside historic urban fabrics, ritual rules and instructions regarding rites of passage – here interpreted as "rules of the game" – are unknown to neophyte refugees, who have been removed from their elders.

This lack of supervision among refugees in historic cities concurs with Szakolczai's (2015) argument, that in the absence of masters of ceremony liminality will not be restricted to a temporary crisis followed by a return to normality, but can be perpetuated endlessly. In a parallel context, inside historic urban areas, it can also be claimed that if place initiates spatial liminality, upcoming socio-spatial events are arguably impulsive, dangerous or even criminal with respect to drug lords or ghetto owners.

Thus, the notion of permanent liminality, as described by Szakolczai (2017), becomes not dissimilar to high levels of socio-spatial vulnerability, deprivation, residents' dissatisfaction, poverty and crime in historic areas, which has been documented by many Iranian scholars since the beginning of the 20th century (Tavassoli, 1987a). Szakolczai (2017) argues that permanent liminality can be initiated within the three phases of rites of passage if any of these (separation, liminality and re-aggregation) becomes frozen, as if a film stopped at a particular frame, that can occur both with individuals undergoing initiation rites, and with groups participating in a collective ritual.

This condition of spatial liminality in refugee settlements in Iranian cities poses a threat to both refugees and original residents, and in the way that Szakolczai (2017) suggests, it could become permanent liminality due to the absence of masters of ceremony, mutually respected community leaders and family patriarchs and matriarchs who are possibly absent in refugee ghettos/camps (Nowak, 1984).

Thomassen (2012) also warns that without proper re-integration liminality is pure danger. In this sense, how to end such liminality or to leave it as permanent liminality becomes crucial (Szakolczai, 2017). Thus, if stakeholders within the realm of building, construction, architecture, planning and policy-making understand the need to end such permanent spatial liminality, the definition of spatial liminality moves beyond its early initiation in anthropology and arguably becomes a guideline in urban planning and design of historic cities, and can be seen as a driver of social welfare policies, informed by sociological research.

Given the criticality of spatial liminality as a guideline, DABs thus need to be re-utilised as active land resources to prevent liminal effects. In this sense, morphologically informed design methods need to be developed in historic areas, specifically where there is a lack of reasonable economic stimulation for re-utilising DABs. The transformation of DABs into active urban land resources may conceivably lead to a considerable reduction in crime and socio-social problems, and effectively diminish the ratio of urban sprawl in historic cities.

By studying the current implication of DABs through the lens of spatial liminality, the paper has identified the re-utilisation of DABs as a suitable method for regenerating historic cities. However, this argument may raise the objection that the article is advocating gentrification and the replacement of refugee settlements with financially profitable precincts. In this sense, further research needs to suggest tactics through which the redevelopment of DABs might encourage the overcoming of their liminal state which needs to provide fair opportunities for both non-Iranian and local Iranian residents in historic urban areas.

7. Conclusions

This article identified a gap in the knowledge in which the argument, approach and methodology that until now have been presented by contemporary urban design and planning perspectives should be enhanced and fine-tuned, before being applied to the revitalisation of historic Iranian cities. The research has emphasised the need for new epistemological tools in urban studies, suggesting that liminality can be a useful analytical tool for understanding and treating historic cities.

The paper has elaborated spatial liminality as a contextually ground-

ed theory. The correlation of spatial liminality and formation of DABs, as identified in this study, is argued to be a significant finding that adds to the current body of research and architectural theory. The discussion and findings allow practitioners, academics and policymakers to understand socio-spatial equations in historic cities in a real-life context. In this case, spatial liminality is associated with the influx of refugees and non-local disadvantaged residents in historic cores, not unlike refugees living in a state of limbo in refugee camps.

The discourse in this paper provides empirical evidence wherein interrelations between spatial liminality and the extent of DABs in historic cities have become crucial, and can inform future revitalisation initiatives. This correlation creates a new perspective for policymakers and practitioners to consider DABs as liminal urban fabrics in historic Iranian cities and similar urban contexts in other countries, and can lead to the provision of a new generation of regulatory models that specifically focus on re-utilising DABs. However, further research about DABs should be conducted in relation to socio-spatial effects and how they can inform and enrich such anticipated regulations and programs.

Throughout the paper, spatial liminality has proven to be an amorphous socio-spatial phenomenon that applies to historic urban areas alongside physical transformations. Thus, several inevitabilities point to re-examination of the current discussion by conducting further studies. The results, analysis and discussion pertaining to the limited urban samples discussed here will need to be reassessed in relation to other historic cities, and conducted amongst a larger cohort of participants. In this case, the demographic and spatial evaluations are incomplete to generalize the results of the research on a country basis.

The research, for the first time, identified spatial liminality accompanied by DABs in historic cities, while exceptionally contributing to contemporary urban studies. This, in turn, would enhance current urban public policies, by highlighting unnoticed socio-cultural aspects of historic cities. In line with spatial liminality of DABs, other cultural, social and financial implications of disused buildings need to be further scrutinised to improve the theory of spatial liminality in conjunction with spatial-cultural affairs. For instance, questions such as "where do the migrants go from DABs?", "how can morphological studies be combined with liminality studies to hypothesise culturally informed approaches?" and "how can populations in a state of suspended liminality transition into a more physically and socially integrated population?" become critical. These types of questions are related to larger political-spatial arrangements pertaining to the implementation of socially suitable architecture, appropriate change in land use and adaptive reuse of existing structures, as well as generating affordable housing and employment opportunities for both local and non-local disadvantaged communities in historic cities.

The study of spatial liminality as an analytical tool offers great potential for redeveloping DABs in historic cities, and specifies other cultural--financial dynamics that need to be investigated and regulated. Further questions could be: "who are the owners of DABs?", "in whose interest is it for new buildings to be developed inside DABs?", "who should pay for it?", "why should public-private developers be interested in new projects unless current undesirable populations are removed?", "are DABs an opportunity for implementing required infrastructure, or a new form of affordable housing?" and so forth. Such questions raise several political, economic and multicultural aspects, while the entire situation can be seen as an unforeseen outcome of incomplete processes of modernity in historic cities of Iran and the Middle East.

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Endnotes

[1] These include the Iranian Cultural Heritage, Handicrafts and Tourism Organization (ICHHTO), local municipalities and the Department for Roads and Urban Development.

[2] In this research residents are classified into two major groups: (a) refugees or non-Iranian disadvantaged communities, and (b) local Iranian residents. To avoid complications, the first group then is recognised to be the subject of spatial liminality in historic cities, although in many circumstances Iranian residents could also be liminal.

[3] This research includes interaction by the researcher with human participants; thus, ethics approval for human subjects was sought, indicated no more than low risk for research participants by Office of Research Ethics, Compliance and Intergrity, The University of Adelaide, on 9 March 2018.

Appendices

A1. Conditions of land use in six sample blocks in historic cities						
Six urban blocks (Kashan) (m2)	**B_1**	**B_2**	**B_15**	**B-16**	**B-3**	**B_5**
All block area (m2)	28770	55180	46559	34047	56303	22365
Dilapidation abandonment per block by 2008	12834	12400	9513	4515	7252	2349
New dilapidation by 2018	4291	14515	12105	4140	12153	3115
Reinstated dilapidation by 2018	8700	8804	8515	2960	6230	1064
Dilapidation abandonment per block by 2018	12991	23319	20620	7100	18383	4179
Active urban areas per block 2018 (accommodated by local Iranian residents)	12218	27882	24780	26380	35926	17780
Areas accommodating old housings per block by 2018	6693	18582	14989	17821	20916	9439
Areas accommodating foreign refugees or illegal migrants by 2018	3561	3979	1159	567	1994	406
Areas accommodating single elderly or died per block by 2018	658	470	425	693	0	417
Change of land use to hoteling per block by 2018	1379	695	0	1683	755	0
Change of land use to storage or irrelevant uses per block by 2018	0	0	0	0	0	0
Change of land use to infrastructure per block by 2018	356	0	0	0	1872	0
Change of land use to carpark per block by 2018	0	0	0		0	0
Local mosque or religious centre per block by 2018	0	757	0	745	1282	521
Listed heritage building per block by 2018	0	263	674	422	0	0
Newly built housing per block by 2018	1648	3666	5783	3003	6476	6029
Roads and urban spaces	1484	3449	2909	2013	4625	1374
Six urban blocks (Kashan) %	**B_1**	**B_2**	**B_15**	**B-16**	**B-3**	**B_5**
All block area (%)	100%	100%	100%	100%	100%	100%
Dilapidation abandonment per block by 2008	45%	22%	20%	13%	13%	11%
New dilapidation by 2018	15%	26%	26%	12%	22%	14%
Reinstated dilapidation by 2018	30%	16%	18%	9%	11%	5%
Dilapidation abandonment per block by 2018	45%	42%	44%	21%	33%	19%
Active urban areas per block 2018	42%	51%	53%	77%	64%	79%
Areas accommodating old housings per block by 2018	23%	34%	32%	52%	37%	42%
Areas accommodating foreign refugees or illegal migrants by 2018	12%	7%	2%	2%	4%	2%
Areas accommodating single elderly or died per block by 2018	2%	1%	1%	2%	0%	2%
Change of land use to hoteling per block by 2018	5%	1%	0%	5%	1%	0%
Change of land use to storage or irrelevant uses per block by 2018	0%	0%	0%	0%	0%	0%
Change of land use to infrastructure per block by 2018	1%	0%	0%	0%	3%	0%
Change of land use to carpark per block by 2018	0%	0%	0%	0%	0%	0%
Local mosque or religious centre per block by 2018	0%	1%	0%	2%	2%	2%
Listed heritage building per block by 2018	0%	0%	1%	1%	0%	0%
Newly built housing per block by 2018	6%	7%	12%	9%	12%	27%
Roads and urban spaces	5%	6%	6%	6%	8%	6%

A2: Comparing the cluster of refugees in historic Kashan and Yazd (2018)			
Crosstab (ethnicity of residents, Kashan)			
Count (local Iranian residents)			
	Types of residents		
	Local Iranian residents		Total
Areas of DABs 2018	45% (B-1)	6	6
	44% (B-15)	7	7
	42% (B-2)	10	10
	33% (B-3)	7	7
	21% (B-16)	10	10
	19% (B-5)	9	9
Total	49		49
Count (refugees)			
	Types of residents		
	Foreign refugees or illegal immigrants		Total
Areas of DABs 2018	45% (B-1)	3	3
	44% (B-15)	3	3
	42% (B-2)	1	1
	33% (B-3)	3	3
	21% (B-16)	1	1
	19% (B-5)	1	1
Total	12		12
Crosstab (ethnicity of residents, Yazd)			
Count (Local Iranian residents)			
	Types of residents		
	Local Iranian residents		Total
Areas of DABs 2018	44% (B-43)	8	8
	39% (B-8)	11	11
	36% (B-30)	10	10
	36% (B-28)	13	13
	32% (B-9)	13	13
	13% (B-47)	7	7
Total	62		62
Count (Refugees)			
	Types of residents		
	Foreign refugees or illegal immigrants		Total
Areas of DABs 2018	44% (B-43)	6	6
	39% (B-8)	7	7
	36% (B-30)	2	2
	36% (B-28)	0	0
	32% (B-9)	1	1
	13% (B-47)	2	2
Total	18		18

Six urban blocks of Yazd (m2)	B-30	B-43	B-9	B-28	B-8	B-47
All block area(m2)	36058	35979	24066	16954	20838	28394
Dilapidation abandonment per block by 2008	14351	9658	6183	2559	4889	798
New dilapidation by 2018	3034	7809	5058	3910	3649	3585
Reinstated DABs by 2018	9980	8057	2573	2266	4452	0
Dilapidation abandonment per block by 2018	13014	15866	7631	6176	8101	3585
Active urban areas per block 2018	21588	15153	15967	10778	8643	23127
Areas accommodating old housings per block by 2018	12052	10420	9020	7929	3917	7784
Areas accommodating foreign refugees or illegal migrants by 2018	1456	4960	468	0	4094	1682
Areas accommodating single elderly or died per block by 2018	2143	81	749	901	485	677
Change of land use to hoteling per block by 2018	2994	2204	0	382	421	0
Change of land use to storage or irrelevant uses per block by 2018	1227	0	0	0	0	0
Change of land use to infrastructure per block by 2018	0	0	133	0	0	12421
Change of land use to carpark per block by 2018	560	1169	131	0	0	0
Local mosque or religious centre per block by 2018	0	0	0	0	0	0
Listed Heritage building per block by 2018	0	622	0	0	0	0
Newly built houses per block by 2018	869	0	5166	785	2330	1645
Roads and in-between spaces	1743	657	768	781	1490	600
Six urban blocks (Yazd) %	**B-30**	**B-43**	**B-9**	**B-28**	**B-8**	**B-47**
All block area (%)	100%	100%	100%	100%	100%	100%
Dilapidation abandonment per block by 2008	40%	27%	26%	15%	23%	3%
New dilapidation by 2018	8%	22%	21%	23%	18%	13%
Reinstated DABs by 2018	28%	22%	11%	13%	21%	0%
Dilapidation abandonment per block by 2018	36%	44%	32%	36%	39%	13%
Active urban areas per block 2018	60%	42%	66%	64%	41%	81%
Areas accommodating old housings per block by 2018	33%	29%	37%	47%	19%	27%
Areas accommodating foreign refugees or illegal migrants by 2018	4%	14%	2%	0%	20%	6%
Areas accommodating single elderly or died per block by 2018	6%	0%	3%	5%	2%	2%
Change of land use to hoteling per block by 2018	8%	6%	0%	2%	2%	0%
Change of land use to storage or irrelevant uses per block by 2018	3%	0%	0%	0%	0%	0%
Change of land use to infrastructure per block by 2018	0%	0%	1%	0%	0%	44%
Change of land use to carpark per block by 2018	2%	3%	1%	0%	0%	0%
Local mosque or religious centre per block by 2018	0%	0%	0%	0%	0%	0%
Listed heritage building per block by 2018	0%	2%	0%	0%	0%	0%
Newly built houses per block by 2018	2%	0%	21%	5%	11%	6%
Roads and in-between spaces	5%	2%	3%	5%	7%	2%

Distribution of refugees in six sample blocks in historic cities%		
Kashan	Local Iranian residents	Foreign refugees or illegal migrants
DABs=45%	14%	25%
DABs=44%	16%	25%
DABs=42%	23%	8%
DABs=33%	16%	25%
DABs=21%	23%	8%
DABs=19%	21%	8%
Overall	100%	100%
Yazd	Local Iranian residents	Foreign refugees or illegal migrants
DABs=44%	13%	33%
DABs=39%	18%	39%
DABs=36%	16%	11%
DABs=36%	21%	0%
DABs=32%	21%	6%
DABs=13%	11%	11%
Overall	100%	100%

Appendix A3: Pearson Correlation

Table E-1: Correlation between factual aspects of spatial liminality (i.e. the extent of refugee settlements) and the percentage of DABs per sample block in Kashan and Yazd, based on six categorical results amongst 141 participating residents

Kashan		Area of DABs 2018	Area accommodated by all refugees
Area of DABs 2018	Pearson Correlation	1	.666*
	Sig. (1-tailed)		.000
	N	61	61
Yazd		Area of DABs 2018	Area accommodated by all refugees
Area of DABs 2018	Pearson Correlation	1	.634*
	Sig. (1-tailed)		.000
	N	80	80

* Correlation is significant at 0.05 level (1-tailed)

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Analysing implications of visibility for crime occurrence in low income vertical rental-housing complex

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Received: October 2019 • Final Acceptance: March 2020

Abstract

This study analyses the correlation between visibility level and crime occurrence inside a particular vertical rental-housing complex. The basic concept of living free from crime as explained by Newman in Defensible Space (1973) is explored with the main emphasis on residents gaining control over their living environment. This concept has been developed into a strategy called 'crime prevention through environmental design' (CPTED), which also considers the importance of not only physical design but also social development within the building. Visibility has become a central focus of living free from crime as it enables people to gain control over their environment. A case study of visibility levels was conducted in Jatinegara Barat Vertical Rental-Housing Complex, Indonesia. Residents in this housing complex are low-income people. They have adapted over time as the current housing type (vertical) differs from their previous housing type (horizontal). An analysis of visibility using a VGA with DepthmapX was conducted to provide specific data regarding visibility levels inside the building. The visibility graph identified a place that was vulnerable to crime occurrence inside the building because of its low visibility caused by its spatial configuration. In addition, some areas' visibility levels were defined not only by their physical properties but also by their residents' living habits. Further studies are required to analyse social background features when interpreting similar spaces because of their effect on visibility level in various ways.

Keywords
Visibility, Defensible space, Crime occurrence, Low income people, Vertical housing.

doi: 10.5505/itujfa.2020.89266

1. Introduction

Visibility is a factor in many design concepts related to the discussion of crime prevention. In particular, it is crucial in order to increase the natural surveillance of an area. One of the concepts that highlight the importance of natural surveillance is 'defensible space' by Oscar Newman (1973). This theory was well-known during the urban renewal era when there was a movement to relocate communities from areas considered to be slums to other locations as part of the slum clearance policy (Michalos, 2014). His study, for example, found that Pruitt-Igoe has been categorised as an unsafe area (Newman, 1996). Newman warned that failure could result from housing design that neglected its socio-cultural context. The development of crime prevention design concepts is now termed 'crime prevented through environmental design' (CPTED). This concept has developed over time and consists of several key components that relate to the physical appearance of an area as well as the role of the community.

This study relates a specific, ongoing analysis in a low-income vertical rental-housing complex located in Jakarta, Indonesia. Indonesia's Central Bureau of Statistics (2018) reports that Jakarta in 2017 has the highest population density of any province in Indonesia; it reached 15.624 person/m2. This high population density requires Jakarta's government to strategise on how to fulfil housing needs. In order to improve land use efficiency, residential needs are met through vertical housing. Vertical housing is classified as a housing type according to article 1 paragraph 1 of Law number 20, 2011, of the Republic of Indonesia. These vertical housing complexes consist of several types: vertical-public housing, vertical-specific housing, vertical-state housing and vertical-commercial housing. The building we analyse in this study can be categorised as vertical-public housing type.

One of the vertical housing projects in Jakarta is the Jatinegara Barat Vertical Rental-Housing Complex. This complex, occupied since 2015, serves as a relocation area for residents of Kampung Pulo. Kampung Pulo was a densely populated residential area located on the banks of the Ciliwung River that frequently suffered from flooding. The building's design was chosen during a design competition held by the government. As the building developed over time, residents seemed to adapt their previous habits and group activities to the current building's form. This adaptation led to unique living habits that impacted territoriality and visibility levels. Therefore, this study aims to analyse the correlation between visibility levels and crime occurrence inside a low-income vertical rental-housing complex by considering not only its physical appearance but also its social activities.

2. Methods

The site observed in this study was Jatinegara Barat Vertical Rental-Housing Complex, which is located in Jatinegara Barat street, Jatinegara, Kampung Melayu, East Jakarta as shown

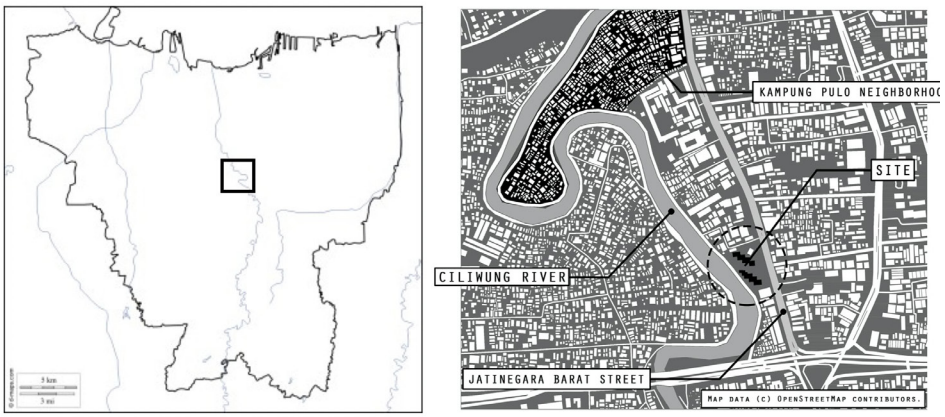

Figure 1. *Location map of Jatinegara Barat Vertical Rental Housing Complex. The map data has been modified from the original source openstreetmap.org.*

in figure 1. This building comprises two towers, namely, Tower A and Tower B. The building is located adjacent to several areas, such as a residential area, shopping centres and also within easy reach of public transportation facilities. Generally, the first floor and the second floor have been established as semi-outdoor areas that contain an office, a commercial area and public space. Meanwhile, the third floor through to the sixteenth floor contains residential units that can be accessed through elevators and emergency stairs. Our examination focused on the residential unit floors that have identical plans for each floor.

The residents of the Jatinegara Barat Vertical Rental-Housing Complex are mostly former residents of Kampung Pulo and surrounding areas who were relocated in 2015. The buildings in that area typically had one to three floors and were usually inhabited by more than one head of household. According to recapitulation data obtained from the local residents, there are now 2,203 people who occupy the Jatinegara Barat Vertical Rental-Housing Complex. They work in various professions (trade, services, or formal sector). The monthly income of most residents in the neighbourhood is around $73.2–$219.5 per month, which can be categorised as below Jakarta's minimum wage ($288.5 per month in 2019).

First, to gain an understanding of the site, a study was conducted by using field observations and interviews. Generally, the observations focused on how residents lived their daily life and how the built environment worked both spatially and visually. Observations were conducted on weekdays and weekends to understand differences in residents' activities, visitors and crowds. The interviews were conducted qualitatively in the form of deep conversations with the head of the neighbourhood association and several residents. An interview with the head of the neighbourhood association was conducted to gain information regarding residents' general statistics and crime occurrence. Meanwhile, the interviews with residents were conducted to gain information regarding their daily lives, how they used to live before they moved into their current housing and crime occurrence. Following this process, we made a map of crime occurrence that was based on the information that we gathered at the site.

An analysis of visibility was conducted by Visibility Graph Analysis (VGA) using DepthmapX software (Turner, et al. 2001). VGA generates a graph of mutual visibility between sets of isovists (Turner, et al. 2001). We created the VGA by using computational software, DepthmapX, which operates in a 2-D area of spatial configuration. The visibility relationships generated by the setup grid included all the spaces that could be analysed from every other point (Lee and Ha, 2015). VGA can be used to assess architectural projects or can be directly applied to the design process (Arnold, 2011).

We developed a layout to make a graph comprising several conditions based on an issue that we found in the building. First, overall views of isovists inside the building were generated from the closed geometry of the identical plan of the building while eliminating the door. This served two purposes: one where we ignored window function and another where we used window function. We set up grids in a dimension of 0.04. The VGA used greyscale, which indicated that the darker the colour the fewer the number of corresponding points in the areas and therefore the lower the visibility. On the other hand, the brighter the colour the more corresponding points in the area and the greater the visibility.

Following the visual graph analysis, the results were analysed using the concept of defensible space and CPTED, focusing on the relationship between visibility features and crime occurrence inside the building.

3. Literature study

3.1. Vertical housing for low income residents and crime safety

Vertical housing, especially high-rise housing, is useful for its ability to occupy a smaller footprint in comparison with low-rise and mid-rise housing (Gifford, 2007). This leaves more open space for greenery and parks in a city (Broyer, 2002, stated in Gifford, 2007). Yet it also has some adverse impacts

on its residents. Residents of high-rise buildings tend to have higher rates of stress, schizophrenia and phobias relative to their broader community (Husaini, Moore & Castor; Husaini, Castor, Whitten-Stovall, Moore et al., 1990, quoted in Gifford, 2007). The design of vertical housing is considered to cause low coherence and low control in the residents (Mazerolle and Terill, 1997, quoted in Rephann, 2009).

James Lynch, as quoted in Maxfield (1987), has suggested that people who are involved in different levels of social activity experience different levels of crime risk. For example, in a residential domain, single parents who are the only adults in their households are usually unemployed and often victims of crime (Maxfield, 1987). This often make low-income housing bears a stigma of criminality in society (von Hoffman, 1996, quoted in Tillyer and Walter, 2019).

Yet a study by (Tillyer and Walter, 2019) has shown that this stigma is not entirely true, because not all low-income housing is crime-ridden. The potential and actual rates of crime in a housing complex are influenced by the building's security and design development as well as by the character of the people who occupy the area (Tillyer and Walter, 2019). Different building designs can bring out different strengths and weaknesses in people (Sinnett, Sachson & Eddy, 1972, quoted in Gifford, 2007). Furthermore, low-income housing is not an isolated and stand-alone system; rather, it is a part of the larger community in which low-income residents live, and this larger community affects the vulnerability of their living environment (Tillyer and Walter, 2018).

In Indonesia, the definition of Vertical Housing is specified in Law No. 20 of 2011. The types of vertical housing consist of vertical-public housing, vertical-specific housing, vertical-state housing and vertical-commercial housing. On the basis of the Regulation of Minister of Public Works and Housing No. 01 of 2018, vertical-public housing is intended for low-income residents, most of whom receive subsidies from the government. Vertical rental-housing is one means by which the Indonesian government can fulfil its people's need for housing, which has significantly increased, especially in urban areas. Most vertical rental complexes built by the government can be categorised as high-rise buildings. The majority of residents of these buildings were relocated from areas that are now considered slums or from riverbank areas.

3.2. Visibility role in defensible space and CPTED concept

Visibility in designing with crime is about crime being at the back of one's mind as one essential subject. The earlier works referred low visibility or surveillance as a parameter related to criminal behaviour (Lee and Ha, 2015). The concept of defensible space, which is directly related to the environmental context of design, is considered to be more applicable than sociological theory in addressing the problem of crime (Reynald and Elffers, 2009). The defensible space concept comprises four key concepts, namely, territory, natural surveillance, image and milieu and safe area. Natural surveillance is the residents' ability to naturally control and observe their neighbourhood (Newman, 1973). The quality of natural surveillance in the building is thus affected by both physical and socio-cultural elements of the building. Newman (1973) describes the need for design after considering the visibility of physical elements such as the visibility of vertical and horizontal access, the visibility of the building by pedestrians and the visibility of public areas.

The concept of design to prevent crime gradually developed into CPTED, which is more advanced. It evolved over years of discussions and is now in its third generation (Mihinjac and Saville, 2019). Newman's defensible space was one of the foundations of CPTED. The first generation of CPTED comprised seven dimensions, including territoriality, surveillance, access control, target hardening, legitimate activity support, image management and geographical juxtaposition (Cozens and Love, 2015). However, it attracted criticism because it ignored social factors and was overly focused

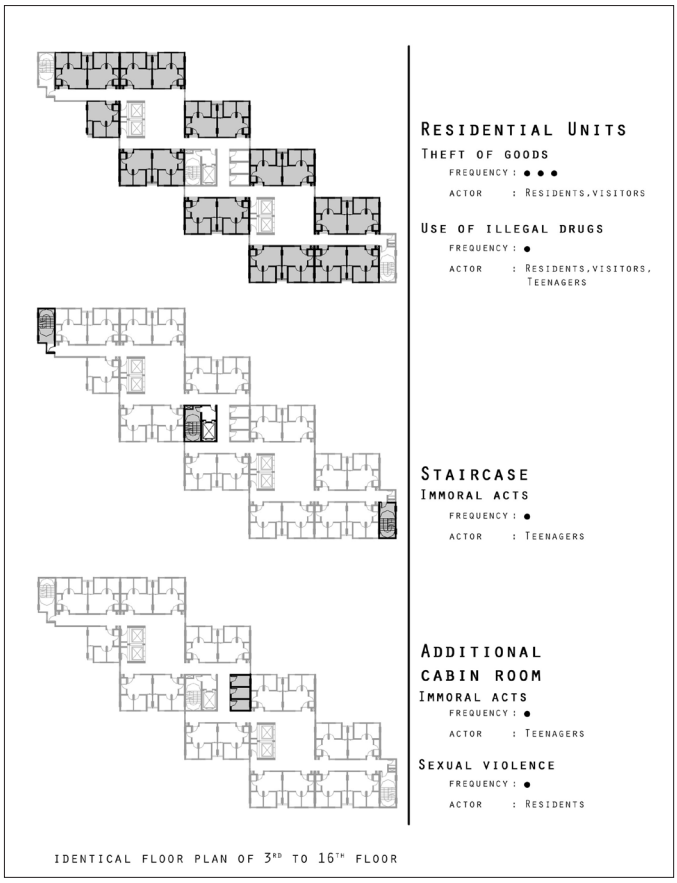

Figure 2. *Crime location inside building.*

on physical factors (Cozens and Love, 2015). CPTED then developed into its second generation, which extended its conceptual reach to focus on community participation to improve social control (Saville and Cleveland, 1997, quoted in Cozens and Love, 2015). These key concepts included social cohesion, community connectivity, community culture and neighbourhood capacity. A study by Kim et al. (2019), discussed the different effects of first-generation CPTED and second-generation CPTED. Second-generation CPTED emphasises the characteristics of the community and had a more significant impact on crime reduction (Kim, et al. 2019).

4. Findings

4.1. Crime occurrence in low income vertical rental-housing complex

On the basis of interviews with residents and the Community Association's annual report in 2018, we collected data regarding crime occurrence inside the building. Subsequently, we made a map of the locations and crimes throughout 2015–2018. Figure 2 below contains general locations of crime occurrence inside the building, because of the specific location, such as residential unit number and/ or floor where the crime occurred, remaining unknown.

The study found that crime inside the building occurred most frequently on the staircases, in housing units and in additional cabin rooms. Staircases and additional cabin rooms have relatively low visibility. The building layout played a role for this visibility level to come into being. The residential units were the scenes of several crimes, such as theft of goods and use of illegal drugs. We found out that theft was the most frequent crime in the area, while the others occurred much less often. Theft occurred in several different conditions.

First, it occurred when a housing unit was left empty by the owner. Second, it happened when the door was left open and the owner fell asleep. This condition indicated that many residents like to open their doors. This was a habit from their old way of living. Residents said that opening the door improved air circulation and also enabled them to observe other resident activities outside their units. Finally, theft also occurred when residents placed goods around the doorstep. The people who committed this crime were known to be a mix of insiders and outsiders. The other crime that occurred most frequently in residential units was illegal drug use. This crime was mostly committed by insiders and could also be considered to be juvenile delinquency.

The other locations prone to crime were the staircase area and additional cabin rooms. Staircase areas were the locations of immoral acts by teenagers because of the low visibility from the outside area. The area relies on artificial lighting because there are no windows available. Meanwhile, additional cabin rooms were a location of immoral acts, and sexual violence also has a similar physical association with the staircase area. We cannot directly see what goes on inside cabin rooms because there is only a single door to each room, which does not support visibility into the room. This room was used as a prayer

room for residents' guests and/or as a janitor's closet.

4.2. Visibility level inside building

In this section, we discuss visibility levels inside buildings on the basis of direct observation and VGA. The focus of the analysis centres on the residential floors, which consist of the 3rd floor until the 16th floor and which are represented by a single building plan, as the floors have an identical plan. The building's spatial configuration forms a zigzag circulation. The main circulation inside the building is a double-loaded corridor that is directly connected to residential units on its both sides. The corridor walls are windowless and offer no view outside the building, nor are the corridors visible from outside the building. There is one opening in the form of a louvre window at the end of each corridor, which allows sunlight to enter the building's interior and improves the air circulation.

Vertical access inside the building consists of stairs and elevators. Stairs inside residential floor consist of three sets of emergency stairs in each tower. These stairs have closed walls, and thus, they cannot be observed from the outside. The staircase area's lighting depends on artificial lights. The doors to these access stairs are always left open as the stairs are often used by the residents.

The other vertical access route is the elevators. Each tower has three elevator units, two of which are intended for residents' use, while the third is for cargo, which is located in the centre of the tower. The elevators for residents' use are located in a corridor with a wide front, which is also often used by residents for many activities. The presence of people using this space and the presence of people waiting for the elevator can be seen from the nearby corridor and from several residential units that face directly into the elevator area. Meanwhile, the elevator area in the residential floor cannot be seen from outside the building or from other floors.

The zoning changes of the public and private spaces in the interior of the building were found to have a role in changing visibility levels inside buildings. This is beyond its spatial configuration; besides, it is described in terms of the activities and behaviour in the corridor and residential units. Residential units are generally defined as private areas. However, in this building, these private areas can change their zoning to become semiprivate or semipublic. There is one window in each housing unit that offers a view of the corridor. However, these windows rarely function as intended. Rather, these windows are usually intentionally blocked with curtains and/or permanent covers such as gift wrapping as shown in figure 3. On the other hand, residents also have a habit of leaving their unit doors open. Based on our interviews, this habit came with many residents from their previous neighbourhood. According to residents, leaving the unit door open reduces stuffiness in the room, facilitates air circulation and makes it easier to see activities and/or people in the corridor. This situation introduced zoning into the residential units, which then became semiprivate. It was not only the residents who benefited from seeing the corridor but also outsiders, who could also see into the residential unit.

In other cases, some residents had

Figure 3. *Types of window covering.*

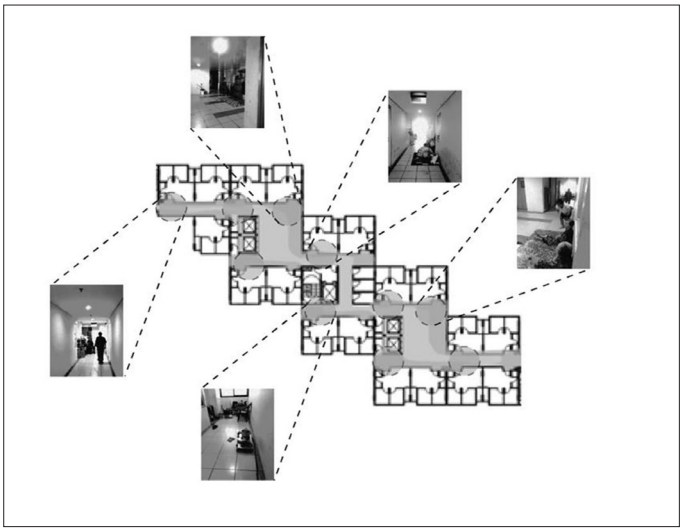

Figure 4. *Crowd location inside the building.*

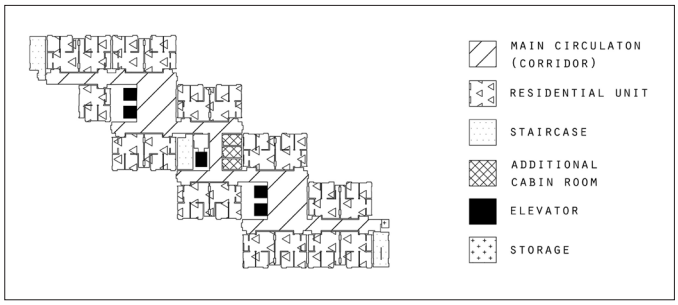

Figure 5. *Building layout.*

opened small shops to sell food inside their residential unit so that buyers could easily access (at least) their living room. This phenomenon changed residential unit territory to semipublic. Outsiders could easily see the interior from the corridor or even have access to their living room.

In the corridor area, there are also interesting activities that change the zoning of this semipublic area. Our observations and interviews show that the residents' activities often extend into corridor areas. Some residents seem to make the corridor as a reception room as shown by the presence of carpets and/or chairs and tables placed in front of some residential units as we see in figure 4. In addition, the corridor also functions as a space to store large items such as children's toys and work-related items. Corridors can also function as children's playrooms. Sometimes the corridor area is even used as an extension of the kitchen and a venue for shared activities. The existence of activities related to a household changed the area into a semiprivate space. In terms of visibility, this change in zoning gave the residents a sense of belonging to the corridor. The more they occupied the area the more they gained control over the area.

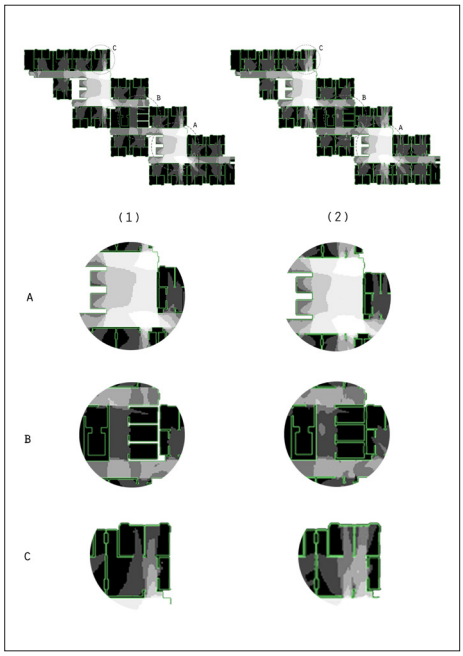

Figure 6. *Visibility Graph Analysis. (1) Set up layout without housing unit's corridor window function. (2) Set up of layout with housing unit's corridor window function.*

We turned a setup into a VGA in accordance with the observations above. The rooms named in the VGA layout are as shown in figure 5. Meanwhile, figure 6 shows a visibility graph of a residential floor of Jatinegara Barat Vertical Rental-Housing Complex. We developed the layout by ignoring the existence of a door to have the maximum visibility when the residential unit as a private area turned semiprivate/semipublic. Then, we created two-conditions; where the window of a residential unit that faced the corridor did not function at all (1) and one where it was functioning well (2).

This visibility graph was mapped using greyscale colour as its parameter, with the darker the colour the lower the area's visibility. According to the conditions in (1) and (2), several differences are important to be noticed. The zoom out graphs A(1) and A(2) consider a corridor with the widest area. Both areas have a brighter colour and so can be described as high-visibility areas. If the window functioned well in A(2), a wider area of bright colour was visible in the map of the corridor area.

Another circulation area shows differences in B(1) and B(2); this is the area in front of an additional cabin room. The dark grey of the corridor area indicates that the area has medium–low visibility. Meanwhile, the additional cabin room has an almost

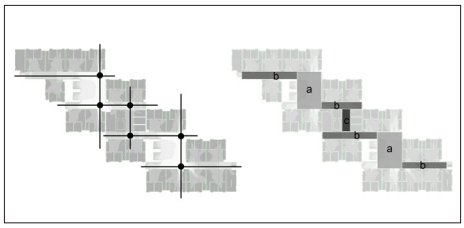

Figure 7. *(left) Intersection of corridor axis, (right) rhythmical visibility level in corridor.*

black colour indicating that this area has low visibility because it can only be seen from several points. This black colour in a public or semipublic zone was not only found in additional cabin rooms but also in almost all the staircase areas. A well-functioning window also made some difference to the graph; however, it mostly appeared to have a specific colour change in front of a residential unit.

Next, we noticed specific visibility changes inside each residential unit as drawn in C(1) and C(2). The well-functioning window, in this case, a barely transparent window, provided higher visibility not only in the corridor area but also in the residential unit itself. It provided visibility from the corridor into the housing unit.

From the visibility graph, the corridor as the main circulation area had the highest visibility level. However, the VGA mapping shows differences in visibility according to the rhythm b-a-b-c-b-a-b as shown in figure 7.

The 'a' area had the highest visibility level and also the widest corridor area connected to the elevator and several residential units. This area had become an extension of housing space and hosted several resident activities. Meanwhile, the 'b' area had medium visibility and was a small hallway that connected to several residential units. The 'b' areas could be observed from the 'a' areas, as in figure 4, which points out the crowd located around the intersection axis. The lowest corridor visibility levels were in the 'c' area hallways in front of additional cabin rooms. This 'c' corridor area only belonged to one additional cabin room that was not a resident extension space. This condition would change when there were activities around the intersection with the 'b' area. The visibility level during this rhythm changed every direction in axis circulation.

5. Discussion

On the basis of the VGA, the corridor had the highest average visibility inside the building. However, the visibility in the corridor area also differed, depending on its spatial configuration. Several areas prone to crime, such as the staircase and additional cabin room, had low visibility levels. The interior area of the staircase and additional cabin room could hardly be seen from outside the area (such as from the corridor or a residential unit). Meanwhile, the residential unit was one location that was prone to crime when the door was well-closed because it became a private area and could not be seen from the corridor.

Yet, spatial configuration is not the only thing that can influence the visibility level inside a building, because residents' activities also play a role in creating visibility levels. When there is a habitual preference, such as 'opening a door', visibility becomes a paradox. It provides surveillance of the corridor and improves safety. The VGA shows that opening the door increased visibility in almost every room inside the housing unit, particularly the living room.

Meanwhile, other habitual preferences, such as covering windows, also affect visibility. The lack of use of a window (such as using curtains) that directly faced the corridor decreased the visibility of the area. While the use of curtains can be considered to be a good thing because a resident can then control when they want it opened or closed; a fully open window without any covering increases outsiders' view of the residential unit. If these corridor windows were left uncovered, the view of the corridor in front of the cabin rooms from inside each unit would be well monitored. The use of windows has an impact not only on the corridor but also on several areas attached to it, such as additional cabin room areas or staircases.

Moreover, the location of the crowd around the corridor can be a potential subject to increase the natural surveillance. The extension of residents' living space to the corridor results in a higher sense of belonging to the corridor or in residents even spending their time in corridor. The presence of residents functions indirectly as an environmental control. When they used to gather around the corridor, they can barely see who passed the corridor. The presence of residents reduces the opportunities for potential criminals and engenders the fear of being caught, as people are

observing the area. The number of natural surveillance areas is higher when residents gather around an intersection axis because intersection areas provide wider visibility. This explanation indicates that the visibility level inside the building depends not only on its spatial configuration and physical appearance but also on how the residents interpret space and building elements in unique ways. Incidents are more likely to occur in low-visibility areas, when the area is not connected to resident activity and/or when the view is blocked due to the physical elements of the building such that the residents as natural surveillance agents cannot perform well.

6. Conclusion

Crime occurrence inside the Jatinegara Barat Vertical Rental-Housing Complex includes immoral acts, sexual violence, use of illegal drugs and theft of goods. The rates of these crimes are mainly influenced by variations in natural surveillance and territoriality at specific locations in the building due to their visibility. The physical characteristics of buildings influence the visibility of certain areas, such as staircases and additional cabin rooms, can be defined as low-visibility areas. Buildings' spatial configurations also determine whether visibility is good or poor. Certain socio-cultural characteristics of the residents, such as the habit of leaving doors open and/or blocking windows, as well as patterns of daily activities such as gathering in the corridor and lobby as opposed to remaining in the residential units can influence a building's security conditions as well. This means that the visibility configuration inside a building is not only formed by its physical appearance (whether it has openings, a door, or a wall), but the role of these elements can be affected by residents' behaviour.

The results of this study cannot be generalised. In particular, this study focused on a particular resident group living with their unique living habits inside housing for low-income people. However, this study may prove to be beneficial when considering the design or development of other low-income housing, particularly vertical constructions. The general design of such a building should consider not only physical elements but also the social aspects of spatial organisation. For more advanced and comprehensive results, further research is required that compares different kind of residents (social background) within similar building forms to investigate whether the results differ. Researchers could also consider broader environmental elements because in this study we only focused on the building's interior configuration.

Acknowledgements

The authors would like to express gratitude to Directorate of Research and Community Engagement Universitas Indonesia (DRPM UI) for administering the Hibah Publikasi International Terindeks 9 (Hibah PIT 9) Tahun Anggaran 2019 scheme under grant number NKB-0044/UN2.R3.1/HKP.05.00/2019, and Faculty of Engineering Universitas Indonesia (FTUI), Department of Architecture for their support in this research.

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ITU A|Z • Vol 17 No 3 • November 2020 • 89-101

Relation between urban form and heating energy consumption

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Received: November 2017 • Final Acceptance: December 2019

Abstract

The climate change and accompanying environmental problems have led different disciplines to think about that the natural resources soon start to run out. Rapid urbanization and industrialization and increasing pressure on natural resources have brought the concept of sustainability in urban planning discipline. Rapidly depleted energy sources threatened by uncontrolled growth have led to the emergence of new planning strategies and urbanization trends in urban energy efficiency and sustainable planning. There are many multidimensional studies in the context of urban parameters aims to provide sustainable settlements. One of those parameters is urban form, which comprises the spatial composition of buildings and open spaces in a physical texture. Theoretically, it is already known that there is a strong relation between urban form and energy consumption; but there is a lack of examination on existing settlements. This paper examines the relationship between urban form and heating energy consumption in different urban textures from Istanbul using the actual values of heating energy consumption to show up if the practical results are compatible with theoretical assumptions. It focuses on energy performance of urban textures and takes human behaviours and socioeconomic factors into account as another layer. Case study clearly underlines that the urban form of settlements creates a significant difference about the consumption of heating energy, while human behaviours and socioeconomic factors also have apparent impacts on it.

Keywords
Energy planning, Heating energy, Energy efficient urban form, Sustainable urban morphology.

doi: 10.5505/itujfa.2020.09787

1. Introduction

Irreversible damage of natural resources and global environmental problems has led to the emergence of the concept of sustainability especially in urban planning discipline, while the urbanization has been considered as the main responsible of energy consumption. The emergence of the concept of sustainability, which aims the balance between the economic, environmental and social dimensions of development is an important point that has led to changes in the form of modern cities after the industrial revolution.

In general meaning, sustainable urban planning refers to a mixed form of land use, aiming the efficient use of land in urban spaces, energy efficiency in residential areas, environmental facilities, transportation etc. (Mikaeili and Memlük, 2013). The management of the energy consumed in the urban area is the basis of sustainable urbanization and the effect of urban form on energy demand is a major challenge for achieving more sustainable urban environment.

As it is widely accepted that there is a direct relationship between urban morphology and energy consumption. Studies in the literature focusing on urban form and energy consumption are primarily from the perspective of individual buildings.

Olgyay's studies (1963) and Martin's studies (1967) as the first studies in literature, estimates the energy demand at micro scale by calibrating geometric approaches of building form and basic scientific principles with experimental results. Donovan and others (1976) attempts to identify and measure the factors that affect the energy consumed for residential heating energy in the UK using statistical models, examining the impact of price and analyzing behavioral changes. Gupta's study in 1984 is another macro scale study after Martin's as it shows that the distance between buildings, orientation and form are important factors in thermal performance. Newton et al. (2000) found that in terms of operational energy consumption, apartment buildings consume less energy than detached houses, according to a study based on the energy performance of two different types of dwellings, including detached houses and apartments throughout several climate zones in Australia.

Many of these studies take solar gain as an indicator of thermal performance and analyze a cluster of buildings using the simulation tools referring to hypothetical calculations and theoretical assumptions. Yet, there is no evident study derives from actual energy consumption values of an existing urban area that real human behaviors are effective.

In this study, relation between urban form and heating energy demand is examined by use of actual heating energy consumption values of existing settlements. The aim of this study, first of all to test the theoretical and practical assumptions of the relation between urban form and heating energy in residential areas using actual consumption values and to bring out the common morphological characters of similar heating energy consumption in living areas which have different morphologic and socioeconomic characters in neighborhood scale. It highlights the crucial morphological parameters of urban design to decrease the heating energy demand and provides spot benchmarks for urban design and management policies of new and existing settlements.

The method of this study bases on comparative analysis technique of a large amount of raw data set accumulated via surveys and computable inputs in order to explore the differences in heating energy consumptions in selected areas. Relational research methods are used in order to make the comparisons of parameters. Comparisons are visualized with matrixes and graphics. Relations of parameters were analyzed by use of non-parametric statistical methods.

The criteria for the selection of the cases is all of them are chosen from most settled residential regions of Istanbul that reflects the general housing typologies of Istanbul with homogenous urban forms. They have distinct morphologic parameters that are asserted in the literature as the most effective in heating energy performance

of settlements in macro scale.

Neighborhoods with similar typology have different social and economic conditions that widen the range of the study and help to explore how much other parameters affects the consumption values. The morphologic parameters that effect heating energy performance of settlements in macro scale are determined based on the literature.

This study is comprised of 3 parts. In section 2, relation between urban form and heating energy consumption is examined introducing the parameters of urban form affecting heating energy consumption in macro scale. In section 3, aim of case study is declared, method of data collection and processing are explained. Morphological parameters are analyzed in study areas and compared with actual natural gas consumption values. Conflicts and constraints of results are rendered while findings are discussed. In the last section, conclusions derived from this study are revealed.

2. Factors affecting energy consumption of settlements

In urban scale, different researchers have classified factors that play significant role in energy consumption of settlements in different ways. However, it is possible to group them under 3 main classes; natural factors, socioeconomic factors and physical factors.

Climate, topography and orientation are the main natural factors in macro scale. Climate is especially the key determinant of heating energy need in residential areas. However, the increase or decrease of energy consumption in residential areas is not directly related to climate conditions. Due to the changes in heating and cooling services, the effect of climate on energy consumption is negligible when compared to other variables.

The topographic settling and the orientation of buildings affects the impact of weather conditions, such as the amount of solar gain, wind etc. and it changes the need of energy. Sustainable urban design policies are the key of utilizing the weather conditions.

Social behaviors and economic situations are certainly effective on the use of residents and in parallel the consumption of energy in settlements. Household size, user behaviors and habits, life cycles, income rates etc. are socioeconomic factors that may affect the energy consumption trends.

The most significant physical factor that causes energy consumption in urban scale is undoubtedly the urban form. Studies show that the composition of buildings and open spaces in a physical texture can have serious changes in energy consumption.

2.1. Urban form and energy efficiency

The idea of creating sustainable cities where the urban energy is protected has led to many new urban morphology concepts in the literature and many of these concepts agree that a physically more intensive urban forms are more sustainable. The density of a settlement plays a crucial role in energy conservation and the physical density of a settlement appears with the concept of compactness.

There are numerous literatures describing the compact city concept, but the basic approaches are the same. According to the Green Paper (2005), the compact city strategy focuses on compact, mixed-use and dense settlement patterns that minimize the need for vehicles and mobility while enabling public transport to be used effectively, while focusing on the city's form and the effectiveness of the distribution of human activities within it.

Dumreicher et al. (2000) argues that a sustainable city must be compact, dense, diversified, and at a high level of integration.

According to Wheeler (2004), compactness also refers to the urban adjacency and connection that future urban development must take place alongside existing urban structures.

According to EU, the compact city approach aims to succeed these goals:

(1) Saving resources and energy (such as land use, transportation, pollutant emission, wastes etc.)

(2) Revitalization inner city, to control the expansion of city (KAJI at all, 2003)

As it is being a critical determinant of energy efficiency, sustainability and the cost of infrastructure; urban form has a strong effect on how people inter-

act, consume and create value within cities (www.urbanmorphologyinstitute.org).

2.2. Parameters of urban form affecting heating energy consumption

In today's cities, US Department of Energy (DOE) declares that almost 39% of the energy consumed in the urban area is spent by the residents. It is followed by transportation and industry, while the world's residential energy consumption is expected to increase by 48% from 2012 to 2040 (World Energy Demand and Economic Outlook, 2016). Besides, researches show that most consumed energy in residential areas is heating energy. This rate is 20% in Japan, 35% in China, 45% in the US and 70% in European cities (WBCSD, 2009). This shows that controlling the consumption of heat energy in residential areas is very crucial to achieve the sustainability in settlements.

The heat consumption in the residential areas has been covered in theory many times, the factors affecting the heat consumption are listed and many researchers, theorists and academicians have revealed the general bases that can be a reference to the design of the new settlement patterns. However, there is no macroscale study bases on the real consumption quantities that shows how these theories working in reality.

There are many natural, physical and socioeconomic factors mentioned in literature affecting the consumption of heating energy in residents. Urban form is the major physical factor including many aspects in different urban scales.

Components of urban form that affect the heating energy consumption depending on the urban scale; some of them creates major effects and some creates minor effects.

2.2.1. Typology of buildings

Studies on settlements have shown that there is a close relationship between typology of buildings and energy consumption for heating. Different configurations of buildings such as detached housing, high-rise apartments, slab housing and compact urban blocks etc. perform different when the heating energy consumptions are compared. They create different density of settlements and receives different number of inhabitants.

Geometrical characteristics of the buildings such as height, wall-to-volume ratio and the orientation of the buildings affect the solar gain and heating energy demand. According to the simulations based on experimental models shows that, height of buildings has a parabolic graphic when the heating energy demand is calculated in settlement; when low height buildings consume more heating energy compared to the middle height ones, very high buildings cause an over-shading effect on surrounding buildings and prevent the accessibility of sunlight (Shang et al., 2013). Type of dwellings changes the consequences of consumption of energy, materials, land for housing, transportation and urban infrastructure based on sustainability (Walker and Rees 1997).

2.2.2. Land use density of settlements

Density is a multidimensional concept in urban planning and design, and it refers to dwellings or people per unit area. Land use density of a settlement is the ratio of the total standing area of all buildings to the total area of the interest area (Pan et al, 2008). This ratio corresponds to the rate we accept as "building coverage ratio" (BCR) and shows the land use density ratio of total structured area. Since it is already accepted that, a more compact urban form provides a more efficient heating system (Owens, 1992), it is also critical that how dense should a settlement be, for an ideal life quality. A certain percentage of the available lot space need to be reserved for parking, setback and green area. However, sprawling on the land use means more soil pollution so the built environment has to be limited. According to Jabareen, (2006), high density and integrated land use not only conserve resources but also provide for compactness that encourages social interaction.

Building coverage ratio does not directly determine the density of the settlement; because it does not provide any information about the number of

people or amount of construction in a proper size of settlement. However, the density of land use allows the interpretation of the urban fabric as sprawled or compact in the settlements that have similar construction area and population.

2.2.3. Construction density and building height of settlements

Construction density is the common measurement that directly refers to the compactness of a settlement. It is generally calculated by "floor area ratio" (FAR) which means the ratio of the sum of the areas of all building floors. FAR is one of the most common measurement systems used to regulate the density of settlements and to control the bulk sizes.

In urban areas, construction density is very crucial for sustainable urban development policies. Low construction density that means lower height and larger urban area, while high construction density means higher buildings and denser urban form. Energy expenditure per square meter in multi-storey residential structures is much lower than discrete single-house dwellings (Næss et al., 1996). However, Doherty et all (no date), states that the high buildings do not always mean higher density or greater energy efficiency. High buildings may affect each other's accessibility to sun and may cause over-shading. When the vertical densities exceed the bearing capacity of the urban area, other energy consumptions per unit begin to increase. Here the point is what the ideal density of a settlement should be.

2.3. Socioeconomic factors affecting heating energy consumption

Income rates, lifestyles, life cycles, cultural habits, educational level, household size and other socioeconomic factors are also effective on the consumption of heating energy in settlements.

Herring and Roy, (2007) determine the socioeconomic effects in 3 different ways; first is the price effect that means more efficient energy usage reduces the costs. Second is indirect effect or income effect, which means the reduction of energy costs leads higher income share for other goods and services. And the third is economy wide effect (or macroeconomic effect) that leads energy consumption increase in other sectors, while the economic gains of energy consumption spend in other interests.

Educational level creates a general decrease in energy consumption habits since the awareness level is very high and the consciousness about environment and sustainability is highly developed.

Life cycle and household size is also effective on energy consumption. In the neighborhoods which larger families are living, consumption increases in parallel.

3. Case study

This study attempts to determine and quantify the factors affecting heating gas consumption. The report focuses on 20 neighborhoods selected from 6 neighborhoods in Istanbul were compared according to their forms and heating energy consumptions while evaluated with their socioeconomic status in order to understand the effect of human behavior. Selected neighborhoods reflect the typology of buildings where patterns are similar to those in all of İstanbul.

The major data series used in this study come from IGDAS natural gas consumption data. Consumption data on individual homes-gas delivery records for some 18000 building in 20 neighborhoods which are listed in Table 1.

Consumption amounts were degraded to unit consumption values and calculated per building, per square meter and per dwelling unit in order to explain the consumption differences of settlements with similar typologies. Comparisons have made by correlation analysis; scatter graphs, matrixes and column graphs inserted in tables have been used. All data

Table 1. *Case Study Areas.*

Beşiktaş	Sarıyer	Bakırköy	Üsküdar	Kadıköy	Ataşehir
Dikilitaş	Yeniköy	Ataköy 3-4-11	İcadiye	Osmanağa	Barbaros
Ulus	Reşitpaşa	Ataköy 2-5-6	Kuzguncuk	Caferağa	Kayışdağı
Levent	Emirgan	Ataköy 7-8-9-10	Salacak	Fenerbahçe	
Etiler	Pınar			Suadiye	

were evaluated over the same year so that the data can be compared fairly.

3.1. Morphologic parameters

Morphologic parameters that are considered in this study are calculated for every study area and categorized with their major values in order to draw some general rules in macro scale.

The morphologic parameters that effect heating energy performance of settlements in macro scale are considered as below:

- Building typology
- Land use density
- Building height
- Construction density

During the study, effects of orientation, green spaces, waterways etc. are not considered while non-morphological factors that have impact on heat energy demand kept constant.

3.1.1. Building typology

In the first stage, dominant building typologies of the selected neighborhoods were classified under 7 typologies in order to compare their thermal performance. Typologies are considered as the main building typologies of Istanbul emerged within years and have created the urban pattern of Istanbul over centuries. These are; detached, high rise, compact and row apartment blocks, villa type single residences, mansions and squatters. Aerial photos of urban textures in each neighborhood are showed in Figure 1.

General housing typology of Istanbul predominantly consists of apartment blocks. Apartment blocks are a group that warrants this study that over 80 percent of all housing units in Istanbul apartment blocks. However, there are different types of apartments that typologically behaves different from each other. In every neighborhood, homogeneity of building stock has calculated according to typological classifications as shown in Table 2.

Detached apartment blocks

It is a residential typology with a general character of discrete order, predominantly 3 to 6 storey building stock and multiple dwellings.

In this study, typology of Fenerbahçe, Dikilitaş, Pınar and Kayışdağı neighborhoods are considered as detached apartment blocks since more than %71 of building stock has detached character in average.

High-rise apartment blocks

It refers to single apartment blocks with 5 and more storeys and multiple dwellings. Typology of Ataköy 2-5-6 and Suadiye neighborhoods are considered as high-rise apartment blocks since more than %65 of building stock has 5 and more storeys.

Compact apartment blocks

Apartment type typology with a general character of adjacent order, predominantly having 3 to 6 storey building stock and multiple dwellings. Typology of Osmanağa, Caferağa, İcadiye and Salacak neighborhoods are considered as compact apartment blocks since more than %85 of building stock has adjacent order.

Row apartment blocks

It is an apartment type typology, which consists of several attached blocks with 5 and more storeys and multiple dwellings.

Typology of Ataköy 3-4-11 and

Figure 1. *Aerial Photos of Urban Textures in Each Neighborhood.*

Ataköy 7-8-9-10 are considered as row apartment blocks since more than %74,8 of building stock consists of row apartments.

Villa type single residences

This typology simply refers to single detached houses with 2-3 storey and single dwelling unit. Etiler, Levent and Emirgan neighborhoods are considered as villa type single residences since more than %65 of building stock consists of villas.

Mansions

Mansions are buildings with single or double dwelling units that has a high construction area than village type houses. Kuzguncuk, Yeniköy and Ulus neighborhoods are considered as mansion type housings since more than %50 of building stock consists of mansions.

Squatters

Squatters are 2-3 storey unlicensed buildings that has low quality construction and infrastructural conditions. Barbaros and Reşitpaşa neighborhoods are considered as squatters (slums) since %80 of building typology consists of squatters.

In each neighborhood, it is expected that there will be differences in natural gas consumption between the urban forms which assemble contiguously or discretely. Different building typologies are also expected to have different consumption values. Annual natural gas consumptions of all typologies were calculated as per square meter, per dwelling unit and per building.

In comparison of 20 selected neighborhood, it is seen that there is no dominant typology that has lower or higher natural gas consumption.

However, when average consumption values of typologies per square meter are examined, it is seen that the highest consumption values belong to villa type single residences while lowest values belong to squatters, row and compact apartment blocks.

All the areas that the consumption per dwelling unit and per square meter is lowest, building textures are adjacent; vice versa, highest consumptions belongs to discrete building textures. When we compared the dwelling unit consumptions, highest values belong to mansion types since they have highest dwelling unit size. Figure 2 shows the natural gas consumption values of selected building typologies.

As a general tendency, more compact and dense building typologies have lower consumption values such as compact apartment blocks, high rise apartment blocks and row apartment blocks, but it is not possible to claim that the specific building typologies have lower or higher consumption trends apparently since they have also have different building quality, usage, population, social and economic structure.

Table 2. *Typological Homogeneity Ratio.*

Building Typology	Neighborhoods	Typological Homogeneity Ratio
Detached Apartment	Kayişdağı Fenerbahçe Pinar Dikilitaş	71.0%
High Rise	Suadiye Ataköy 2-5-6	65.0%
Compact Apartment	Osmanağa Icadiye Caferağa Salacak	85.0%
Row Apartment	Ataköy 7-8-9-10 Ataköy 3-4-11	74.8%
Villa Type	Levent Emirgan Etiler	65.0%
Mansion Type	Yeniköy Kuzguncuk Ulus	50.0%
Squatters	Barbaros Reşitpaşa	80.0%

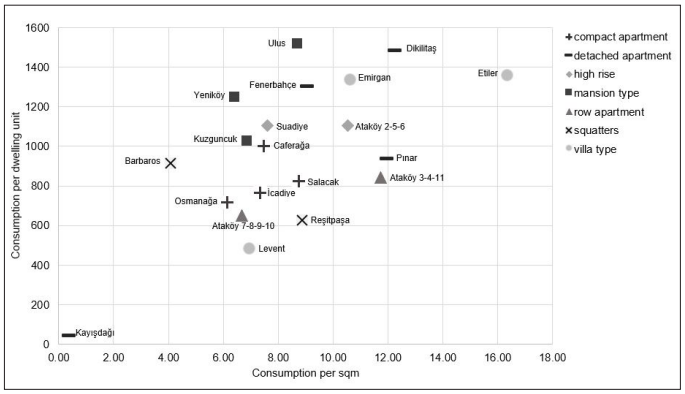

Figure 2. *Natural Gas Consumption Values of Selected Building Typologies.*

3.1.2. Land use density ratio

Land use density refers to the building coverage ratio (BCR) which means buildings' floor space covered in the land. BCR ratios in the area. At the neighborhood scale, the average occupancy rate was calculated for each neighborhood as land use ratio. Land use density does not have a decisive value directly related to the density of the settlement; because the unit does not provide information about the number of people in the settlement or the construction site. However, it enables the interpretation of the compactness of urban texture in settlements with similar land use density, construction site and population.

Differences in land use density can change the heating energy demand and cause less or more natural gas consumption in the settlements. The approach used in this section is formulated around spearman correlation method draws from two data series; building coverage ratio and consumption per sqm that attempts to determine whether there is a relation between heating energy consumption and land use density.

Since the variables are not normally distributed, spearman correlation test is applied to find out if there is any relation between variables as shown in Figure 3. Correlation value of these two variables is calculated as -0.45 that means there is a reasonable correlation between them; negative correlation value shows that there is an inverse relationship between them; while consumption per square meter increases, land use density (BCR) tends to decrease. This decreasing tendency is more evident in the neighborhoods where the building mass also increases vertically.

Neighborhoods that have same land use density levels have no similar consumption trends, however, in same typologies, it is clearly observed that while land use density increases, natural gas consumption tends to decrease.

3.1.3. Building height

Building height, that creates vertical density in urban form expected to affect heating energy consumption. Study areas are clustered according to their average heights to be able to compare in neighborhood scale. Four different height ranges are specified as 2-3 floors, 3-5 floors, 4-6 floors and 5-10 floors. Neighborhoods that have similar consumption per square meter do not properly have similar building heights. However, consumption difference of typologies, land use ratio or construction ratio in neighborhoods that have similar building heights can be easily noticed.

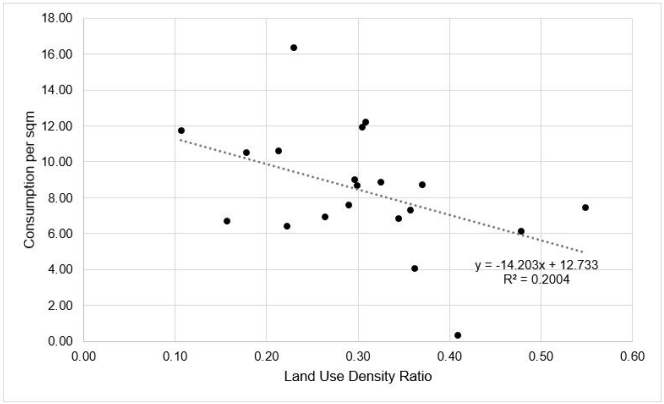

Figure 3. *Comparison of Consumption per sqm and Building Coverage Ratio.*

Except for the neighborhoods which have 2-3 floors, lowest consumptions in every height cluster belongs to adjacent building forms.

It is observed that neighborhoods that have less than average consumptions per square meter are villa types, mansions and detached houses that also have lower land use density.

In the neighborhoods that have 3-5 or 4-6 floors, population density is also in optimum levels when compared to the others. When study areas are

Table 3. *Morphologic Parameters of Selected Neighborhoods and Average Natural Gas Consumption Values per Sqm.*

Neighborhoods	Building Typology	Structural Layout	Number of Floors	Land Use Density Ratio	Construction Density Ratio	Average Consumption per m²
Barbaros	squatters	adjacent	2-3	0.36	2.68	4.07
Emirgan	villa type	discrete	2-3	0.21	2.95	10.62
Etiler	villa type	discrete	2-3	0.23	3.79	16.35
Kayışdağı	detached apartment	discrete	2-3	0.41	3.60	0.34
Kuzguncuk	mansion type	discrete	2-3	0.34	2.74	6.86
Levent	villa type	discrete	2-3	0.26	2.31	6.95
Reşitpaşa	squatters	adjacent	2-3	0.33	2.48	8.87
Yeniköy	mansion type	discrete	2-3	0.22	1.69	6.41
Fenerbahçe	detached apartment	discrete	3-5	0.30	5.34	9.02
İcadiye	compact apartment	adjacent	3-5	0.36	4.41	7.33
Pınar	detached apartment	discrete	3-5	0.30	2.48	11.93
Salacak	compact apartment	adjacent	3-5	0.37	3.66	8.74
Ataköy 3-4-11	row apartment	adjacent	4-6	0.11	5.32	11.73
Caferağa	compact apartment	adjacent	4-6	0.55	5.03	7.46
Dikilitaş	detached apartment	discrete	4-6	0.31	5.86	12.22
Osmanağa	compact apartment	adjacent	4-6	0.48	4.79	6.13
Ulus	mansion type	discrete	4-6	0.30	5.10	8.69
Ataköy 2-5-6	high rise	discrete	5-10	0.18	7.66	10.52
Ataköy 7-8-9-10	row apartment	adjacent	5-10	0.16	7.60	6.69
Suadiye	high rise	discrete	5-10	0.29	5.84	7.61

clustered according to their dominant number of floors and average consumptions per square meter are compared, in every height shows us that the highest consumption average belongs to 2-3 storey and lowest consumption average belongs to 3-5 storey neighborhoods as a general conclusion.

3.1.4. Construction density

Construction density indicates both horizontal and vertical density of a settlement. Common way to understand the construction density in that scale is to calculate the floor area ratio (FAR). This ratio gives us information about how many times the mass of the area of land used is building mass, but also refers to average building height in the settlement.

In the study, construction density is calculated in two different ways; first floor area ratios (FAR) of every neighborhood are calculated. Average construction area of the buildings in selected neighborhoods are also calculated in order to determine the building masses for each.

Average construction area of buildings in neighborhoods and the consumption values have a strong correlation value which is -0,53, means that while construction area per building increases, natural gas consumption decreases as shown in Figure 4.

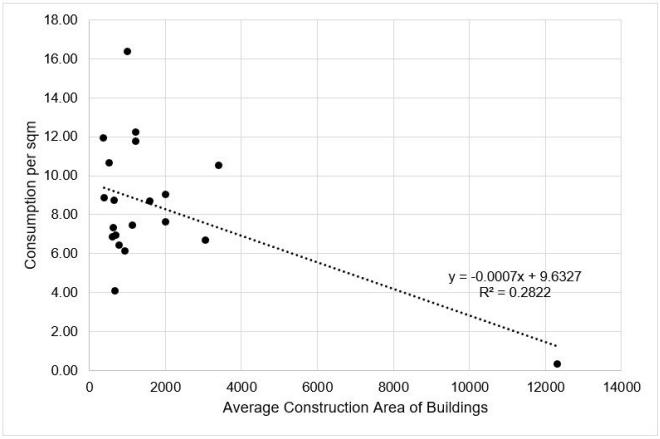

Figure 4. *Average Construction Area of Buildings in Each Neighborhood and Consumption Values.*

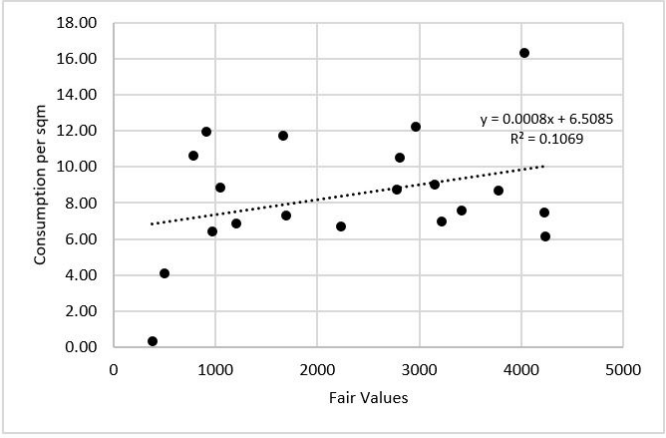

Figure 5. *Comparison of Consumption per sqm and Fair Values.*

3.2. Socioeconomic conditions

All case study areas have different socioeconomic levels that may affect heating energy demand. Although habits, life cycle, household size etc. are all effective on heating energy consumption. In order to measure that, fair values are taken as an indicator of income level. Correlation value between fair values and consumptions is calculated as 0.33 as shown in Figure 5. It means there is a medium level positive correlation showing that while income level increases, heating energy consumptions increases in parallel.

3.3. Comparisons and findings

The results of morphological comparisons are tried to be combined and meaningful similarities are tried to be interpreted Table 3 shows morphologic parameters of selected neighborhoods and average natural gas consumption values per sqm.

In the neighborhoods consists of compact apartment blocks, as a general tendency consumption per square meter is in medium levels.

In the typology of detached apartments, when land use density is high, consumption levels are observed medium, when land use density is medium, consumption levels observed high. This means in detached building texture; land use density affects the consumption tendency inversely. Similar situation is also observed in the neighborhoods that have high rise building typology.

In the neighborhoods consists of villa type houses, there is no low consumption tendency as expected. In squatters, income level seems to be effective on consumption values.

All morphological comparisons show that the physical dynamics af-

fecting heating energy consumption in settlements are dependent to each other's and needed to be evaluated together. Besides, unit consumption values help to explain different physical and social characteristics of related neighborhoods. Since every neighborhood has its physical and social dynamics, similar morphologies needed to be evaluated with all aspects of unit consumption values Table 4 shows natural gas consumption trends in similar morphologies.

The highest consumption per person belongs to Etiler, followed by Levent. Etiler and Levent neighborhoods are formed with villa type single residences with 2-3 floors and have lower population per building while income level is high. The neighborhood with the lowest consumption per person is Kayışdağı and it is also the most populated area among the selected neighborhoods. Plus, in Kayışdağı neighborhood, use of stove is still very common and natural gas consumption is calculated too lower than expected.

When the natural gas consumption per building is examined, it is seen that there is a high negative correlation coefficient between consumption per building and land use density which means while land use density gets higher, consumption per building decreases. Highest consumption per building is observed in Ataköy neighborhoods of Bakırköy, which has the highest number of floors and construction area per building. Ataköy neighborhoods are followed by Fenerbahçe, Suadiye and Dikilitaş respectively and those neighborhoods also have 4-6 number of floors. Although Etiler neighborhood consists of low-rise and villa type single residences, it has been ranked high according to the consumption values per building. This shows that the individual and relatively old residential texture of Etiler neighborhood needs more energy for heating while high income level is also a factor.

When the natural gas consumption per dwelling unit is compared, highest consumption value is calculated in Ulus and lowest is calculated in Kayışdağı. In terms of the size of households, highest consumption per dwelling unit in Ulus is a reasonable result since it has the largest dwelling size among neighborhoods. Following neighborhoods such as Etiler, Emirgan, Fenerbahçe and Yeniköy all have villa type or mansion type of buildings with large dwelling units. All the neighborhoods where the consumption per dwelling unit is highest, building textures are discrete. Figure 7 shows unit consumption values of neighborhoods.

In the neighborhoods that have same building typology and similar building heights, the neighborhood with higher

Table 4. *Natural Gas Consumption Trends in Similar Morphologies.*

Neighborhoods	Building Typology	Structural Layout	Number of Floors	Construction Density Ratio	Land Use Density Ratio	Average Consumption per building	Average Consumption per dwelling unit	Average Consumption per sqm
Levent	villa type	detached	2-3	2.31	0.26	4851.51	485.31	6.95
Emirgan	villa type	detached	2-3	2.95	0.21	5698.91	1337.65	10.62
Etiler	villa type	detached	2-3	3.79	0.23	16642.10	1360.33	16.35
Kuzguncuk	mansion type	detached	2-3	2.74	0.34	4244.25	1026.86	6.86
Ulus	mansion type	detached	4-6	5.10	0.30	13818.91	1517.89	8.69
Yeniköy	mansion type	detached	2-3	1.69	0.22	5129.42	1249.33	6.41
Reşitpaşa	squatters	attached	2-3	2.48	0.33	3456.75	624.82	8.87
Barbaros	squatters	attached	2-3	2.68	0.36	2802.16	916.28	4.07
İcadiye	compact apartment	attached	3-5	4.41	0.36	4744.30	765.64	7.33
Salacak	compact apartment	attached	3-5	3.66	0.37	5792.08	824.74	8.74
Fenerbahçe	detached apartment	detached	3-5	5.34	0.30	18127.85	1301.72	9.02
Dikilitaş	detached apartment	detached	4-6	5.86	0.31	14985.20	1482.90	12.22
Kayışdağı	detached apartment	detached	2-3	3.60	0.41	4172.36	42.00	0.34
Pınar	detached apartment	detached	3-5	2.48	0.30	4529.98	937.30	11.93
Caferağa	compact apartment	attached	4-6	5.03	0.55	8558.69	1001.40	7.46
Osmanağa	compact apartment	attached	4-6	4.79	0.48	5746.63	715.73	6.13
Ataköy 7-8-9-10	row apartment	attached	5-10	7.60	0.16	20468.78	652.06	6.69
Ataköy 3-4-11	row apartment	attached	4-6	5.32	0.11	14284.11	843.72	11.73
Ataköy 2-5-6	high rise	detached	5-10	7.66	0.18	35816.57	1103.28	10.52
Suadiye	high rise	detached	5-10	5.84	0.29	15371.93	1103.92	7.61

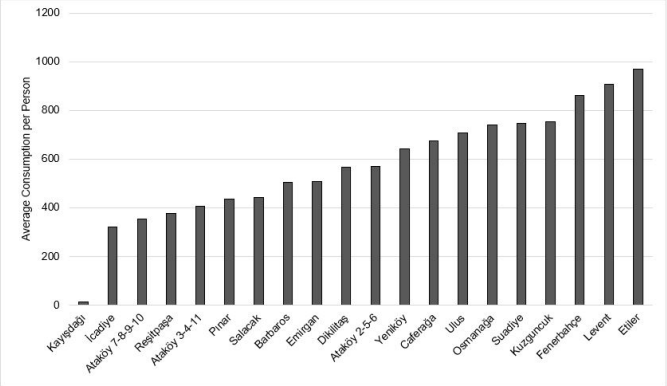

Figure 6. *Average Consumption Values per Person in Neighborhoods.*

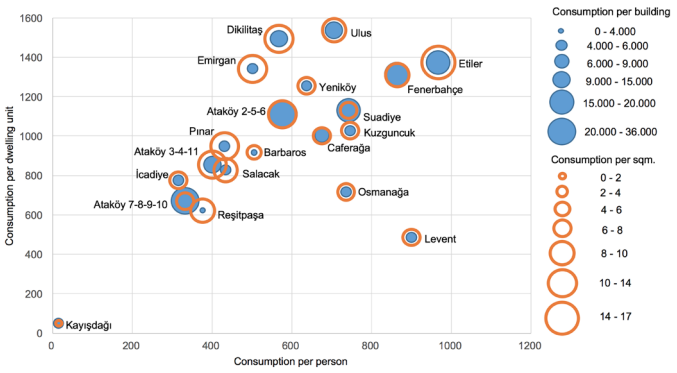

Figure 7. *Unit Consumption Values of Neighborhoods.*

construction density always consumes less than other. Barbaros and Reşitpaşa are squatters and their relatively lower consumption is caused by their socioeconomic structure. In 3-5 floors neighborhoods, İcadiye and Salacak has lower consumption in comparison with Pınar and Fenerbahçe neighborhoods. Although İcadiye and Salacak have same land use density and same socioeconomic conditions, İcadiye has higher construction density and as a result consumes less than Salacak.

Construction density ratios, land use ratios consumption per square meter and per dwelling unit are compared in settlements in order to observe the similarities of areal, volumatic and demographic densities at the same time.

According to this; it is seen that Suadiye and Fenerbahçe neighborhoods which have similar land use density and the number of people per square meter. In Fenerbahçe and Suadiye, while the amount of consumption per dwelling unit is close to each other, it is seen that the consumption amount per square meter is higher in Suadiye. Fenerbahçe, which has a lower amount of natural gas consumption, has a more compact settlement pattern than Suadiye, while Suadiye has higher income level.

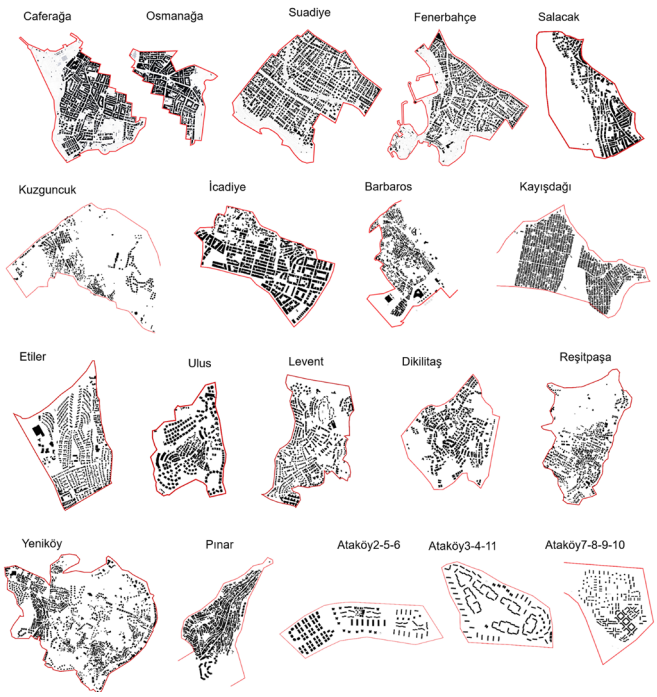

Figure 8. *Morphological Textures of Neighborhoods.*

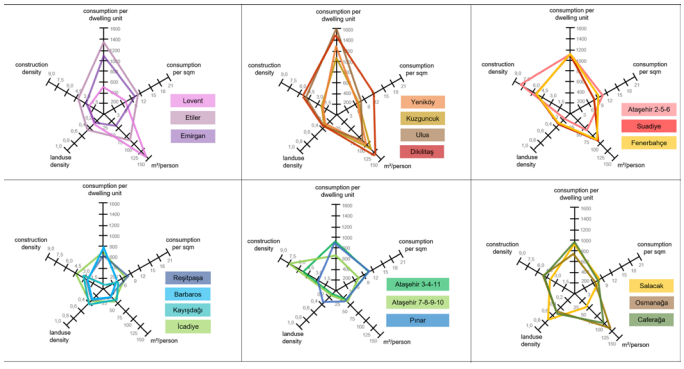

Figure 9. *Comparison of densities and consumptions.*

Among Etiler, Levent and Emirgan neighborhoods, Etiler has the highest consumption amount per square meter and per dwelling unit. Dwelling unit area per person is higher in Levent, which shows that the population is lower. While Emirgan and Levent have similar land use density and construction density, consumption per dwelling unit is higher in Emirgan, which means the dwelling units in Emirgan is higher among these neighborhoods. Consumption per sqm is also higher than Levent which proofs that, although both neighborhoods have villa type typologies, Emirgan has larger building sizes and population density than Levent. Figure 6 shows average consumption values per person in neighborhoods.

Kuzguncuk and Yeniköy have similar density in terms of land use, construction and population so their consumption values are calculated very similar. Osmanağa and Caferağa again have similar density in terms of land use and construction. Consumption per dwelling unit is lower in Osmanağa while sqm per person is higher; which means Osmanağa has a higher population density and lower size dwelling units. This difference makes them have similar consumption per sqm. Figure 9 shows the comparison of densities and consumptions.

Ataköy 7-8-9-10 and Ataköy 3-4-11 neighborhoods have similar typologies while construction density is higher in Ataköy 7-8-9-10 and consumption per sqm is lower in parallel.

The results of the study show that the morphologic parameters do not always causes the same energy demand in the settlements and have not similar effects on consumption values. Building

typology is not a single dominant factor for the settlements, however if the typology is more compact and denser, consumption per sqm and per dwelling unit is lower. Land use density has a reasonable effect on the heating energy consumption levels of settlements and in the neighborhoods that have more dense land use, natural gas consumption tends to decrease. Building height is not an independent parameter that can be measured and evaluated separately. It is highly related with the construction density. When settlements with same typology and similar building height are compared, consumption differences are generally caused by land use and construction density. Relation between construction density and the heating energy demand is calculated as the strongest relation compared to the other morphologic parameters discussed in this study. Since the social and economic structures are hard to measure and compare as quantitative values in such a study, different economic levels are tried to be compared over the fair values. However, results show that it is hard to mention about the effect of income levels to heating energy demand in this scale.

In brief, results indicate that dense settlements within case study areas have much higher energy efficiency lower heating energy consumption, which means the urban form has a significant impact on energy demand for space heating.

4. Conclusion

Energy consumption in settlements is a product of many interacting factors. Understanding the impacts of each component is key to determine the best urban planning and land use configuration.

In this study, the relationship between urban form and heating energy consumption is determined over the real heating energy consumption values in neighborhood scale. This relation is quite complex that there is no one certain formula that fits every kind of settlement but as a general tendency, it is observed that more compact urban forms means less heating energy consumption in macroscale although there are many micro and macro factors that change the consumptions individually. However, the social and qualitative factors also have quite strong effects.

By analysing the real values of heating energy consumptions in different urban forms, hypothesis of the study is proofed as there is a strong relation between urban form and energy consumption; different urban forms have distinct thermal performances and the practical results are compatible with theoretical assumptions.

Results of the study should be interpreted as observations of general trends rather than absolute conclusions. The current model needs further development to reduce uncertainties and include other urban energy components related to density. It is limited to chosen both morphological parameter values and number of study areas because of the scale of the study. However it helps to inferring general conclusions. The study can be expanded to evaluate the impacts of more study areas and a broader range of parameters in that scale. As a conclusion, this study is aimed to show the energy consumption trends of settlements with real consumption values to measure the potential for energy saving approaches of planning studies.

Findings of this study provide a possible way to develop new urban design criterias in new settlements for a more sustainable development. Urban planners, local authorities and policy makers of urban area could also benefit from this study while improving new housing development policies and urban plans. It is also a useful guide for natural gas providers for their macro scale projects.

Results of this study proves that urban form has a crucial position for energy efficiency and sustainability. However, the ideal housing pattern is still a question mark for academics and researchers since the city is a dynamic and living organism including many major and minor factors that causes difficulty in calculating the heating energy consumption of different urban forms in real life.

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ITU A|Z • Vol 17 No 3 • November 2020 • 103-114

A methodological debate on the measurement of the motorized passenger mobility in urban spaces: Towards a new methodological perspective

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Received: September 2019 • Final Acceptance: March 2020

Abstract
This paper discusses the methodological shortages in measurements of motorized urban mobility subsequent to a type of systematic literature review. In this sense, the research questions and the related methodologies of such studies have been criticized. According to the preliminary indications, firstly, it has been observed that in almost all these researches, the research question, which investigates the marginal effect of travel time on Vehicle Miles Traveled (VMT), has been adopted. Secondly, it has been asserted that such types of researches have not been able to isolate the generative part and redistributive part of the induced travel demand measurements up to now. Unlike any previous researches, dealing with the marginal effect of travel time on Vehicle Miles Traveled (VMT), this study firstly proposes a methodological focus specifically on the interrelation between the travel times of the individuals and the number of trips they exhibit in a day. For such a research question, the newest econometric model, namely, Generalized Simultaneous Equations Model (GSEM Path Analysis) will be convenient model structure, which refers to methodological contribution of this study for such similar future studies. The methodological proposal of this paper will be able to be integrated into a trip generation model, and will also be able to be used to assess the performance of any transportation project reference the discussions taking travel demand management policies into account.

Keywords
Induced motorized passenger mobility demand, Travel demand management policies, Urban mobility, Disaggregated travel demand models, Generalized simultaneous equations model.

doi: 10.5505/itujfa.2020.09582

1. Introduction

Unlike any other researches, this study firstly proposes a research focusing on the interrelationship between the daily motorized travel time of the individuals and the number of daily motorized trips of the related individuals. The outcome of this paper is the methodological proposal of such a research question. Herein, the generalized simulatenous equations model structure has been proposed as the most attractive model.

In the light of the research framework asserted in this paper, two main dependent variables have been defined: 'number of daily motorized trips' and 'daily motorized travel time for each individual'. In this context, firstly, the dependent variable called number of daily motorized trips is a candidate for the family of nonlinear count variable, while the daily motorized travel time will be the one of a gaussian distributed continious variable. Secondly, the first dependent variable called number of daily motorized trips will most probably involve excess amount of zero observations. In other words, there will occur so many individuals that have not carried out any trip in any stated day. This type of data deserves a careful treatment, coping with the potential problem of excess amount of zero observations. Thirdly, these two dependent variables tend theoretically to exhibit a kind of relationship, which is called simultaneity in econometrics. In other words, the daily travel time of an individual will affect the daily number of trips of this individual, then this daily number of trips will also affect the daily travel time of the related individual indeed. Such a type of reciprocal relationship is called simultaneity in econometrics. Lastly, the daily travel time of the individual will refer to a kind of endogeneous variable, affecting the daily number of trips of this individual. In the light of these views, any single equation model and/or any traditional simultaneous equations model structure will fall short in coping with all these four technical problems, which necessitate further modeling approach. From this point of view, this paper is designed as an instigator one for such related future studies, aiming to fill such methodological gaps in measuring induced motorized passenger mobility demand in urban spaces. To that end, the study has been structured by five sections in addition to this introduction part, namely, literature review, methodological debates, discussions, and concluding remarks.

2. Literature review

The notion called induced motorized passenger mobility demand in urban spaces refers to two main frameworks: diversion of the existing demand and newly generated traffic. In addition, the concept of newly generated traffic refers to two sub-forms, namely release of the suppressed demand and newly generated traffic with regards to the urban development effects.

The literature of measuring induced motorized passenger mobility demand mostly refers to the interrelationship between the Vehicle Miles Traveled (VMT) and the total travel time. In other words, the most of the empirical studies of induced motorized passenger mobility demand have focused on measuring the marginal effect of travel time on VMT. On the other hand, such these researches exhibit some weaknesses.

The first weakness comes from the differences between the spatial resolutions of the related studies. At this juncture, the ones conducting the facility based (a neighbourhood unit with its surrounding) or corridor based (along a highway route) analysis produce partial urban equilibrium marginal elasticities instead of the ones of system-wide urban equilibriums. The second is about the aggregation in data structures. That is to say, the travel survey data, which disregards the behavioral units (individuals or households level), will produce biased results that are far away from the reality.

The examples for the facility or corridor based studies are the ones conducted by Pells (1989), Hansen et al. (1993), Kroes et al. (1996), Luk & Chung (1997), and Mokhtarian et al. (2000), while the area-wide studies are Hansen & Huang (1997), Noland & Cowart (2000), Fulton et al. (2000), Cervero & Hansen (2002), Cervero (2003), Silva & Costa (2007), Ozuysal & Tanyel (2008),

Holcombe & Williams (2010), Hymel, Small & Dender (2010), Melo, Graham, & Canavan (2012), and Vos & Witlox (2013). The facility or corridor based studies generally adopt the methodological frameworks called growth comparison analysis and matched pair analysis so as to calculate the related marginal elasticities. On the other hand, the area-wide studies mostly involve the econometric models such as Ordinary Least Squares (OLS) regression models, auto-regressive models, and travel demand models so as to get the related marginal elasticity coefficients.

According to the results of facility or corridor based studies, the related marginal elasticity coefficients change between 0,15 and 0,30 for the four years time horizon; 0,30 and 0,40 for the ten years time horizon; 0,40 and 0,60 for the sixteen years time horizon (Pells ,1989; Hansen et al., 1993; Kroes et al., 1996; Luk & Chung, 1997; Mokhtarian et al., 2000). On the other hand, according to the findings of the area-wide studies, the related short-run marginal elasticity coefficient varies from 0,30 to 0,50 for the county level, while it falls between 0,54 and 0,61 for the metropolitan region scale (Cervero, 2002).

In addition to the differences in spatial resolution of the related studies, the related models of these studies are also grouped into two: aggregated models and disaggregated models. In this sense, the level of aggregation refers both to data gathering structure (household/individual scale field surveys or not) and to the related model structures. In almost all these studies, the VMT is defined as the main dependent variable. On the other hand, the related independent variables are defined as the lane-miles additions with several time lagged variables and geographical variables within the studies involving aggregated time-series econometric models, while within the disaggregated ones, the independent variables mostly refer to the total travel time and average travel speed in addition to the individuals based socio-economic variables. Besides, the functional form of log-linear model specification is generally selected. The findings of all the related studies with refers to both aggregated data and aggregated models will cause enourmously increasing aggregated estimation errors due to both data gathering processes and to generalized functional forms. In addition, such estimation errors will enormously increase as the study area expands. Thus, the behavioral units (individuals or households scale) based data gathering and modeling approaches are required to minimize the related estimation errors. In this respect, the study of Barr (2000) is an interesting example. In this study, the households based national scale field survey was conducted for the United States. The models of this study are designated via cross-sectional data analysis with refers to the logarithm of the VMT per household as the main dependent variable, while the households based socio-economic variables are defined as the independent variables (Barr, 2000). Furthermore, the related models are stratified according to the spatial sizes of the related metropolitan regions located in the United States. On the other hand, the related results of the study indicate that there is no statistically significant difference in the related marginal elasticity coefficient estimations with refers to these spatial size based stratifications (Barr, 2000).

In addition to the aggregated estimation errors of data & model structures, the third source of error is defined as disregard of the simultaneity effects between the dependent and main independent variables. In this sense, the main dependent variable called Vehicle Miles Traveled (VMT) will exhibit a kind of reciprocal relationship with one of the preliminary independent variables called lane miles additions. That is to say, an increase in the total length of lanes via the lane mile additions will make the measure of VMT increase and that increase in VMT will also induce the demand for the new lane miles additions indeed. Disregard of such a reciprocal relationship in formulation of the related models will make the level of estimation errors increase. Few studies -asserting such a related simultaneity effect- are exhibited by Noland & Cowart (2000) and Cervero & Hansen (2002). In the first example, the relat-

ed simultaneity effect is coped with by the addition of instrumental variables, which theoretically justify the interrelationship between VMT and lane miles additions. In the second example, the problem of simultaneity is coped with by the Two-Stages Least Squares (2SLS) simultaneous equations model structure (Noland & Cowart, 2000; Cervero & Hansen, 2002).

There are also other examples in literature tackling with the problems of endogeneity and simultaneity within a deeper manner. To illustrate, the study of Cervero (2003) asserts four simultaneous equations in the models with regards to the dependent variables called urban development, lane miles growth, VMT, and travel speed (Cervero, 2003). Lastly, in some further studies, it is investigated that whether the level of traffic congestion constitutes a statistically significant variance on the estimated marginal elasticity coefficients with regards to the measures of induced travel demand or not. In this context, according to the findings of the study of Hymel, Small & Dender (2010), the level of traffic congestion creates a statistically significant variance on the induced travel demand estimations in a negative direction (as it is theoretically expected), which increases as the level of income of the passengers increases (Hymel, Small & Dender, 2010). On the other hand, according to the empirical findings of the study carried out by Noland & Cowart (2000), the variance on induced travel demand estimations, which is created by the level of traffic congestion, does not exhibit statistically significant measures (Noland & Cowart, 2000).

According to these views, the literature of induced motorized passenger mobility demand measurements will refer to three different methodological approaches: ones adopting aggregated data collection procedure versus disaggregated data collection procedure, ones based on facility or corridor based studies versus area-wide studies, and ones asserting single index model structures versus simultaneous equations model structures. These three approaches will be re-phrased as data collection approach, spatial resolution approach, and model structure approach, respectively.

3. Methodological debates

It is required to define the term passenger for the investigation on the effect of change in daily motorized travel time of an individual on her number of daily motorized trips. Herein, the passenger is defined as the person, who is at least 16 years old. In accordance with this definition, the potential sample of the passengers within the study area is to be constructed randomly via the methodological framework called stratified simple random sampling. The more detailed methodological and contents based discussuions for such field travel survey design and sample selection procedure deserve an another research paper and so it is out of the scope of this article. The main intention of this paper is just to give the preliminary guidelines for such notions before beginning for such field research.

In this article, it is assumed that the researcher has succeeded the preliminary requirements in constituting a convenient sampling procedure and has conducted the field survey efficiently via gathering the convenient disaggregated data so as to begin the related modeling procedure. For this reason, this paper purely focuses on the detailed discussions based on modeling procedure of such future studies rather than focusing on the data collection processes. In this sense, with reference to the research question asserted in the paper, the theoretically justified dependent and independent variables will be defined as in the followings:

- Y1 = motor_y: total number of motorized trips of an individual (passenger) in a given day.
- Y2 = motor_s: total amount of time spent in minutes by the related individual (passenger) during all his/her daily motorized trips within a given day.
- X1 = motor_di: daily amount of total distance (in kilometer) traveled by the individual (passenger) with motorized vehicle(s).
- X2 =male_d: dummy variable asserting whether the individual (passenger) is male or not. If male, it takes value of 1; if female:0.
- X3 =h_head_d: dummy variable asserting that whether the related individual (passenger) is household

head or not. If he/she is household head:1, otherwise:0.

- X4=hh_inc: household disposable income per month (in Turkish Lira).
- X5 =oto_s: number of the private cars owned by the family.
- X6 =hhsize: household size (number of people in the family).
- X7 =age: age of the individual.
- X8 =hbw_d: dummy variable asserting that whether the stated daily trips of the individual (passenger) involve at least one home-based work (hbw) trip or not. If there exists at least one hbw trip among all the daily trips, it takes the value of 1, otherwise it takes 0.
- X9 =hbs_d: dummy variable asserting that whether the stated daily trips of the individual (passenger) involve at least one home-based school (hbs) trip or not. If there exists at least one hbs trip among all the daily trips, it takes the value of 1, otherwise it takes 0.
- X10 =tahsil_y: number of years of schooling that the individual has attended.
- Z1 = motorfft: motorized free flow time (motorfft) as a traffic congestion parameter for the daily trips of the individual (passenger). In other words, this measure refers to the average amount of free flow travel time (in minutes) of the indiviual in the case that the motorized vehicle of the trip is the unique one between the related origin and destination within given a day reference to each motorized trip.
- Z2 = mot_y_s: dummy variable indicating that whether the individual (passenger) carries out at least one motorized trip in a given da yor not. If he/she carries out at least one motorized trip in a given day, it takes the value 1, otherwise 0.

It is essential to highlight that the travel behavior (and so number of trips) of a passenger mostly refers to his/her socio-economic characteristics that are represented by her income, number of automobiles owned, household size, age and number of years of schooling. Besides, the explanatory variable called total motorized travel times spent by an individual in motorized trips is both independent and endogeneous variable affecting number of daily motorized trips (simultaneity). Herein, the travel time variables are the key variables, and their elasticities with respect to total number of motorized trips are assumed to reflect the willingness to travel more depending on a reduction in daily travel times. The other explanatory variables are dummy variables specifying sex (male_d), specifying whether the individual is household head (h_head_d), and indicating whether the individual is working (hbw_d) or student (hbs_d), respectively. Furthermore, the variable called motorized travel distance (motor_di) measures the total lenght of the motorized daily trips. In addition, free flow time of motorized trips (motorfft) and dummy variable indicating that whether the individual has realized at least one motorized trip in the day or not (mot_y_s) are two instrumental variables that are included in the related models. Herein, the latter variable is intuitively used so as to eliminate the potential excess zero observations in the number of daily motorized trips. Lastly, the variable called free motorized flow time is asserted in the list of variables, because within the disaggregated data level, any individual selects psychologically to travel between any pair of Origin (O) & Destination (D) if the free flow time of that individual (between the related O/D) refers to a value that is less than or equal to the his/her psychological treshold level. On the other hand, the variable called daily travel time is the daily sum of the motorized travel times, which is an outcome of the transportation network. That is why the disaggregated variable called free motorized flow time (instead of daily motorized travel time) is generally preferred in the classical travel demand forecasting models.

In the light of these views, a modeling framework, which can cope with the followings, will be required;

- i. Non-linear nature of number of daily trips of an individual.
- ii. Potential excess-zero observations in number of daily trips of an individual (motor_y = Y1).
- iii. Endogeneity of the daily motorized travel time of the related individual.

- iv. Simultaneity between number of daily trips of an individual (motor_y) and daily motorized travel time (motor_s = Y2).

To begin with, according to the first requirement (i), non-linear model structures come into agenda. In this sense, Poisson Regression Model (PRM) and Negative Binomial Regression Model (NBRM) are the leading model structures (Green, 2007; A.Colin Cameron & Pravin K. Trivedi, 2005). To begin with, the PRM (Poisson Regression Model) is the most basic form of the count models. According to the poisson model, the random variable that will be called yi shows a poisson distribution, and mean of this distribution is λi as revealed in equation 1:

$$f(Y_i = y_i) = \frac{(e^{-\lambda_i})(\lambda_i^{y_i})}{(yi)!} \quad y_i = 0, 1, 2, ..; f: \text{probability distribution function (pdf)} \quad (1)$$

The mean of the distribution is λi, which is explained by a set of variables called xi. The formulation to estimating model parameters is the log-linear model (equation 2):

$$\ln(\lambda_i) = \beta' x_i \quad (2)$$

The basic assumption of this model is the equidispersion (equation 3), which refers to that conditional mean and conditional variance are equal:

$$E[y_i|x_i] = Var[y_i|x_i] = \lambda_i = e^{(\beta' x_i)} \quad (3)$$

The elasticity with respect to any given variable is nonlinear, and it can either be estimated at the variable means or as the mean of individual elasticities in the sample (equation 4):

$$\frac{\partial E[y_i|x_i]}{\partial x_i} = \lambda_i \beta = \lambda_i e^{(\beta' x_i)} \quad (4)$$

The PRM is nonlinear and maximum likelihood can be used for parameter estimation as a mathematical simplicity as revealed in equation 5:

$$\ln(L) = \sum_{i=1}^{n} [-\lambda_i + y_i(\beta' x_i) - \ln(y_i)!] \quad (5)$$

Equidispersion implicitly assumes that "the formula for the probability of an occurrence is a deterministic function of the explanatory variables –it is not allowed to differ between otherwise- identical individuals" (Kennedy, 1998, p. 247). However, this assumption is relaxed by introducing an unobserved heterogeneity effect into the conditional mean called scale variable. This leads to a different model called NBRM, in which the conditional variance is larger than conditional mean (equation 6):

$$f(y_i|x_i) = \frac{\Gamma(\theta+y_i)}{\Gamma(\theta)\Gamma(y_i+1)} r_i^{y}(1-r_i)^{\theta}, \text{ where } r_i = \frac{\lambda_i}{\lambda_i+\theta_i} \quad (6)$$

Conditional mean of this distribution is λi and conditional variance is λi (1 + (1/θ) λi). The elasticities of the NBRM are still estimated as in equation 4 (Green, 2007).

This fact implies that it will be vital to test for overdispersion if you use the PRM. Even with the correct specification of the mean structure, estimates from the PRM -in the case that there is overdispersion- will be inefficient with standard errors that are biased downwards (Long, 1997, p.236). Several tests are suggested for overdispersion (Green, 2003; 2007) without estimating a NBRM. Since the PRM and the NBRM are nested, the log-likelihood of the NBRM needs to be improved over the PRM in case overdispersion is present, and this can be checked by a Log-likelihood Ratio (LR) test as indicated in equation 7:

$$LR = 2(\ln(L_{NBRM}) - \ln(L_{PRM})) \quad (7)$$

LR shows a chi-square distribution and any value larger than critical threshold with two degrees of freedom favors the NBRM. The case of overdispersion in count data will exist due to potential unobserved heterogeneity in that the events are thought to be seriously independent, and so the rate parameter, which refers to the conditional mean, will become to behave as a random variable itself. Such a case will necessitate further modeling approaches such as mixed modeling approach (A.Colin Cameron & Pravin K. Trivedi, 2005). At this juncture, Negative Binomial Regression Model (NBRM), which is taken into consideration as the specific kind of mixture modeling approach, will come into considerations (A.Colin Cameron & Pravin K. Trivedi, 2005). On the other hand, new modeling approaches (other than PRM & NBRM) will also come into considerations due to the potential case of

excess zero observations in daily number of motorized trips of an individual. Thus, the structures of zero censored models & zero truncated models will come into considerations. The selection among these models is purely based on the theoretical requirements depending on the research question & the related variables in that whether it is vital to involve the zero counts of the main dependent variable into the models or not. In the zero censored models, the zero counts for the main dependent variable and the remaining positive counts are modeled separately, while in the zero truncated models, the zero counts are directly eliminated from the model structure (A.Colin Cameron & Pravin K. Trivedi, 2005). In such a case, the research question is diverted to the induced motorized passenger mobility demand considerations, in which it is intuitively required to include the positive counts for the related variable. In other words, the zero truncated model structure will fit better when compared to the zero censored model structure in modeling the daily number of motorized trips. The basic mathemathical representation of that model structure is asserted as in equation 8 (A.Colin Cameron & Pravin K. Trivedi, 2005):

$$F(y|\theta, y>=1) = \frac{f(y|\theta)}{1-F(0|\theta)}, \quad y= 1, 2,.... \qquad (8)$$

, where f (y|θ): probability distribution function (pdf), F (y|θ) = Prob. [Y<=y]: cumulative distribution function (cdf) with relates to the random variable y, and θ is a parameter vector.

The indication of the zero truncated model structure, together with the negative binomially distributed variable called number of daily motorized trips (motor_y), will explicitly signal that the single index model for daily number of motorized trips will fit better especially within the structure called Zero Truncated Negative Binomial Regression Model.

It is needless to say that there are many variations of such models to improve the estimation efficiency (please refer to Green, 2007; Long, 1997; Cameron & Trivedi, 2005; and Winkelmann, 2008 for details). Application of these models takes place in many diversified areas: crime analysis, disease occurrence, doctor visits, occupational injuries, software faults, accident analysis and prevention, manufacturing defects to name the few. On the other hand, these models will only be capable of dealing with non-linear nature of the main dependent variable called number of daily motorized trips with refers to the potential excess zero observations. In other words, such these single index models will not be able to cope with the third (iii) and fourth (iv) requirements, which refer to the cases called endogeneity and simultaneity. Since, our model may have another important specification problem probably causing endogeneity bias: the dependent variable and the key independent variable (i.e. total of reported travel times in minutes spent in these motorized travels) may have causal relationship. The dependent variable is determined by an explanatory variable in a way as the explanatory variable is also determined by the dependent variable in turn. In such situations, since the error term is correlated with the dependent variable(s), the conventional methods will producebiased parameter estimates.

In principle, endogeneity bias is a form of omitted variables bias, and Mokhtarian and Cao (2008) summarizes seven different techniques to deal with endogenity problems: (a) direct questioning, (b) statistical control,(c) instrumental variables model, (d) sample selection model, (e) joint discrete choice model (f) cross-sectional structural equations, and (g) longitudinal models. Concerning our model, only three of them: instrumental variables; sample selection model; and structural equation models seem meaningful. On the other hand, non-linear nature of daily number of trips, potential excess zero observations in the number of daily trips, and potential simultaneity between the number of daily trips and daily travel times still wait to be coped with. Therefore, further modeling approaches, which have not been highlighted yet by the study of Mokhtarian and Cao (2008), will be required. In this context, the Simultaneous Equations Model (SEM) structure comes into agenda, which will overcome both endogeneity and simultaneity. On the

other hand, classical SEM structure will still fall short for the research asserted in this article. If both main dependent variables of our model were the types of gaussian distributed continious variables, it would be possible to assert the classical types of SEM with refers to Two Stages Least Squares (2SLS) or Three Stages Least Squares (3SLS) regression model structures. Herein, it will be possible to designate such a model structure via including the theoretically justifiable instrumental variables between the main dependent variables so as to eliminate the potential cases called endogeneity & simultaneity between daily number of motorized trips and daily motorized travel time. On the other hand, one variable (daily number of motorized trips) will be non-linear count variable, while the other (daily motorized travel time) will be gaussian distributed continious variable, which will make the classical SEM structure fail (please refer to Green, 2007; Cameron & Trivedi, 2005 for details). Therefore, the concept of newest methodological approach called path analysis, namely Generalized Simultaneous Equations Model (GSEM) structure, will come into considerations. Because, it will be possible to involve both linear and non-linear equations together within the same equations system by such this GSEM structure.

In fact, the intuitive effort that is exhibited here stand for the justification of the final model selection, namely path analysis called GSEM. In these models, the dependent variable will be the total number of motorized trips realized by an individual within 24 hours. The main explanatory variable will be the negative of total motorized travel time spent in minutes for these daily trips, since travel time defines a disutility. The remaining explanatory variables will be the personal and family characteristics, as it is explained in the data section. Furthermore, there is also one more dependent dummy variable, asserting that whether the individual selects to travel at least once in a day or not (mot_y_s). Herein, since the dummy dependent variable called mot_y_s will refer to the binary variable, it will refer to a probability structure as a dependent variable. In the light of these views, the related GSEM structure will seem to be in the form as asserted in the following table and figure (see Table 1 and Figure 1).

Table 1. *Designation of GSEM structure (*).*

Dependent Variable	Function	Function Family	Function Link
motor_y	f (motor_s, X_i)	Negative binomial mean distribution	Logarithm
motor_s	g (estimated_motor_y , motorfft , mot_y_s X_i)	Normal distribution (Gaussian Family)	Identitiy Link
mot_y_s	Φ (X_i)	Probit function family	

(*) where
f: [Negative Binomial Distribution Function | Conditional mean function: exp(Xeβe)] Here, in Xeβe, the abbreviation "e" refers to the "exponential" form.

g: [Gaussian Linear Function | Conditional mean function: g(XLβL)]. Here, in XLβL, the abbreviation "L" refers to the "linear" function form.

Φ: [Probit Function | Conditional mean function : Φ(Xpβp)]. Here, in Xpβp, the abbreviation "p" refers to the "probit" function form.

Xi: vector of covariates defining individual based socio-economic variables in the GSEM system, in that; Xi :c (male_d , h_head_d , hh_inc , oto_s , hhsize , age , tahsil_y , hbw_d , hbs_d).

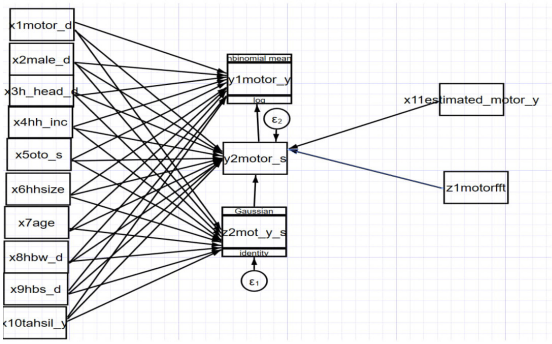

Figure 1. *GSEM Path Structure.*

Furthermore, subsequent to the designation of model structure, the calculation of the related marginal elasticities will come into minds. In this regard, three main methodological frameworks will be asserted in calculating the marginal elasticities after the related non-linear models:

a) Estimating averages of Marginal Elasticity (ME) per each individuals,

b) Calculating ME at means, that computer programs generally carry out this,

c) Marginal Elasticity estimation at $X = X^*$, where X^* is a specific value

that is theoretically meaningful (Cameron & Trivedi, 2005).

The intuitive explanation with refers to the marginal elasticity calculation in nonlinear models is explained by equation 9:

$$ME = \frac{\partial E[Y|X]}{\partial (Xj)} \quad (9)$$

By equation 9, the function g(.) will have a non-linear mean functional form. Then, the single index model will take the form as in the equation 10:

$$E[Y \mid X] = g(X'\beta)$$

$$\frac{\partial E[Y|X]}{\partial (Xj)} = g'(X'\beta)\beta j \quad (10)$$

Afterwards, the relative effects of changes in regressors will take the form (equation 11) :

$$\frac{\partial (E[Y|X]/\partial Xj)}{\partial (E[Y|X]/\partial Xk)} = \frac{\beta j}{\beta k} * \frac{g'(X'\beta)}{g'(X'\beta)} = \frac{\beta j}{\beta k} \quad (11)$$

On the other hand, for the side of finite difference method concept, the logic will transform to equation 12:

$$\frac{\Delta (E[Y|X])}{\Delta (Xj)} = g(X+e_j, \beta) - g(X, \beta) \quad (12)$$

, where ej is the vector of jth entry, when other entries are zero.

Lastly, for the cases of exponential conditional mean distributions, the function will take the form as revealed in equation 13 (Cameron & Trivedi, 2005):

$$E[Y|X] = \exp(X'\beta)$$

$$\frac{\partial E[Y|X]}{\partial (Xj)} = E[Y|X]*\beta j \quad (13)$$

In the light of these indications, the marginal elasticty calculations will intuitively get the form as equation 14:

$$\frac{1}{N} * \sum_{i=1}^{i=N} \frac{\partial (\hat{E}(motor_{yi}|Xi, motor_s i))}{\partial (motor\_s\ i)} \quad (14)$$

Average Marginal Effect of motor_s on motor_y for an individual ‘i’ :

Average Marginal Effect of any Xi on motor_y for an individual ‘i’ (equation 15):

$$\frac{1}{N} * \sum_{i=1}^{i=N} \frac{\partial (\hat{E}(motor_{yi}|Xi, motor_s i))}{\partial (Xi)} \quad (15)$$

To summarize, the expected conditional mean calculation (with regards to the marginal elasticity estimation) within such a stochastic nature will mathematically be explained as revealed in the equation 16:

$$\frac{\frac{1}{N} * \left(\sum_{i=1}^{i=N} \frac{\partial \hat{E}(motor\_yi|Xi, motor\_si)}{\partial (motor\_si)} * \sum_{i=1}^{i=N} \frac{\partial \hat{E}(motor\_si|Xi,\ motor\_yi,\ motorfft)}{\partial (Xi)} \right)}{\frac{1}{N} * \left(\sum_{i=1}^{i=N} \frac{\partial \hat{E}(motor\_si|Xi, motor\_si, motorfft)}{\partial (motor\_yi)} * \sum_{i=1}^{i=N} \frac{\partial \hat{E}(motor\_yi|Xi,\ motor\_si)}{\partial (Xi)} \right)} \frac{\partial (\text{motor\_y})}{\partial (\text{motor\_s})} \quad (16)$$

To conclude, the GSEM model structure seems to be able to cope with all the technical obstacles, namely non-linearity of daily number of motorized trips, potential excess zero problem in daily number of motorized trips, potential endogeneity of daily motorized travel time, and potential simultaneity between daily number of motorized trips and daily motorized travel time. Firstly, this model structure will deal with the non-linear nature of number of daily motorized trips (motor_y) with the indication of the NBRM structure into the GSEM design. Secondly, the GSEM concept will cope with the potential problem of excess zero observations for the variable called number of daily motorized trips. Herein, it will be guaranteed that the potential zero counts in daily number of trips are automatically eliminated via the indication of the condition asserting that the individual exhibits at least one motorized trips in the day (mot_y_s=1). Thirdly, the related GSEM structure will be able to tackle with the potential endogeneity of daily motorized travel time of an individual (motor_s) in modeling the number of daily motorized trips (motor_y) with helps of the indication of free motorized flow time (motorfft) as the theoretically justified instrumental variable (Figure 1). In this context, the number of daily motorized trips (motor_y) will be modelled with helps of the related socio-economic characteristics & the related dummy variables, and this derived estimated value of the number of daily motorized trips (estimated_motor_y) will then be used in modeling the dependent variable called daily motorized travel time (motor_s). This will make the model structure satisfactory in dealing with the cases called endogeneity and simultaneity between number of daily motorized trips (motor_y) and daily motorized travel time (motor_s).

Table 2. *Comparison of the Models (*).*

MODEL	Copes with the non-linear nature of "motor_y"	Copes with the "excess zero problem" for "motor_y"	Copes with the "endogeneity" of "motor_s" in modeling "motor_y"	Able to deal with the case of "simultaneity" between "motor_y" & "motor_s"
Poisson Regression Model (PRM)	✔	x	x	x
Negative Binomial Regression Model (NBRM)	✔	x	x	x
Zero Truncated Models	✔	✔	x	x
Classical SEM structures, such as 2SLS & 3SLS	x	x	✔	✔
Generalized Simultaneous Equations Model (GSEM)	✔	✔	✔	✔

(*) ✔ : the asserted property is satisfied; (X): the asserted property is not satisfied.

4. Discussions

For decades, it has been realized that the efforts of satisfying all the requirements -with refers to the unendingly increasing travel demand of the individuals- constitute such a kind of vicious circle. In this sense, the new policy concept called travel demand management policies have been adopted. This policy framework will be defined as a paradigm shift in transportation planning. On the other hand, the operational sides of such considerations fall short in the developing countries. In an other words, it is required further empirical studies, highlighting the practical sides of the monitoring such travel demand management policies. In this context, the notion called induced motorized passenger mobility demand comes into considerations. Herein, the efforts of exploring the leading factors of daily motorized trip makings constitute the operational baselines for travel demand management policies. In other words, an explicit measurement for induced motorized passenger mobility demand is required to carry out such a concrete empricial baseline, which highlights the prominent performance indicators of the travel demand management policies. In this sense, unlike any previous research, this study has fisrtly asserted the hypothesis called " the less travel time that the individual spends in a day, the more number of trips he/she will exhibit in that day". In addition, a new methodological proposal has been developed in this paper so as to test such a new hypothesis for the future studies. In the light of these views, a new methodological proposal -subsequent to the methodological discussions- has been exhibited.

In accordance with the new research question, firstly, the variable called daily number of motorized trips refers to a type of non-linear count variable, while the variable called daily motorized travel time exhibits a kind of gaussian distributed continious variable. Secondly, the number of daily motorized trips of an individual (motor_y) will probably involve excess amounts of zero observations. Thirdly, the cases called endogeneity & simultaneity between the variables called daily motorized travel time of an individual and number of daily motorized trips of this individual will probably be the case in such researches. That is to say, daily number of motorized trips will be determined by the variable called daily motorized travel time in a way as this variable (daily motorized travel time) will also be determined by the dependent variable (daily number of motorized trips) in turn. So as to cope with all these technical obstacles, the path analysis called Generalized Simultaneous Equations Model (GSEM) structure has been asserted in this paper.

5. Concluding remarks

In the lights of the views of this article, four main guidelines for future researches will be as in the followings;

1. Instead of the classical investigations on the marginal effect of change in travel time on Vehicle Miles Traveled (VMT), the new researches -taking the marginal effect of travel time on specifically the number of trips into account- will be adopted.

2. The disaggregated type of approaches should be adopted with refers to the behavioral units, namely household and individuals. Such kind of data collection approach will be expected to make the aggregated estimation errors dramatically decrease.

3. A type of convenient simultaneous equations model structure is to be developed with refers to the potential research question of such future studies, taking the number daily motorized trips and daily motorized travel time in the core as the main dependent

variables. In this respect, as it is discussed in the part of Methodological Discussions in detail, one of the main dependent variables (number of daily motorized trips) will be a non-linear count variable, while the other (daily motorized travel time) will be a kind of gaussian distributed continious variable. Furthermore, such related variables will exhibit a kind of simultaneous relationship, all of which will make the classical Simultaneous Equations Model (SEM) structure fall short.

4. The spatial resolutions of the related studies should refer to area-wide approach instead of the ones called facility or corridor based approaches so as to grasp system-wide marginal elasticity coefficients between number of daily motorized trips and daily motorized travel time. Otherwise, the related estimated marginal elasticity coefficients will refer to the concept of partial urban equilibrium, which will explicitly fall short in highlighting the practical sides of urban scale travel demand management policies.

This article proposes a research focusing on the interrelationship between the daily motorized travel time of the individuals and the number of daily motorized trips of the related individuals for the first time in literature. In the light of this effort, a methodological proposal for such a research question has been asserted with refers to the generalized simulatenous equations model structure. Subsequent to this contribution, it is aimed to construct a methodological baseline for monitoring and assessing the performance of any transportation project with refers to ongoing discussions for travel demand management policies for the related future studies.

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ITU A|Z • Vol 17 No 3 • November 2020 • 115-125

Identification of central business district (CBD) boundaries by Space Syntax analysis and the case of Elazığ (Turkey)

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Received: September 2019 • Final Acceptance: May 2020

Abstract

The central business district is a phenomenon used in many sciences, especially in geography. Various techniques have been developed to define the boundaries of this area. While the boundaries of CBD generally depend on the observation and experiences of the researcher conducting the study, individuals working in different fields of science try to determine the boundaries with various simple calculations. This situation may cause researchers to identify different CBDs in the same area. In this research study, the integration calculation provided by the Space Syntax Analysis method was used to determine the specific locations of the Central Business Districts. The city's global integration analysis (Segment / Integration HH), local integration analysis (Segment / Integration R800) were conducted using the DeptmapX program. As a result of the study process, it was observed that it is possible to determine the location, size and potential expansion of the central business area with the integration analysis of the Space syntax analysis method. Although it was possible to determine CBD boundaries of a city with this method, it is necessary to evaluate the study's analysis results by comparing them with field studies in order to reach the most accurate result.

Keywords

Central business district, Central business area, Elazığ city, Space Syntax analysis, Spatial analysis, Urban geography.

doi: 10.5505/itujfa.2020.90277

1. Introduction

Cities are one of the most significant places where humans and nature intertwine and where people try to establish dominance over nature. For this reason, these places attract the attention of different branches of science and a variety of studies about the urban areas have been carried out by different disciplines. Cities have an important role to serve their environment and people living in them. One of the most basic characteristics that distinguish urban places from rural areas is the service they provide to their environment. Some studies conducted in this context focus on determining the service characteristics of cities.

The CBD map is one of the basic maps used in the geographical city studies aiming at determining the qualities and limits of the service provided in a city. However, the boundaries of CBD are usually based on the field observations of the person who conducts the study. For this reason, it is possible to see that there are different boundaries of the very same specific area determined by different observers.

Although there have been some attempts to identify CBD boundaries by special methods in previous periods, these initiatives have been limited to the areas studied. Namely, it was possible to apply a specifically created method to a different city.

2. Concepts of central business district and centralisation in geographical studies

Centralization has emerged as a very important factor in understanding a complex network structure. It is also related to various spatial factors affecting social activity in cities. Centralization, in other words, central and perimeter levels, represents the topological hierarchy scale of the access within a system. Namely, the number of streets in a place indicates the level of access; the higher the level of access, the more central the place is.

The etymological origin of the word central is"centrum" in Latin or "kentron" in Greek which means thorn. It also means the tip of a compass and the middle point of a circle. In other words, the peak point of a city is the space where socio-space units are stacked the most. There are different types of centralization in the areas of urban agglomeration. It is important to distinguish spatial and social notions (concepts). Therefore, the topological centrality applied in space syntax theory implies a spatial integration of a field. It can also be described as the configurational structure of the street network (Czerkauer-Yamu,2010:24).

The Central Business Area issue was first discussed by American geographers Murphy and Vance (1959) and the Swiss geographer Carol (1960) (Uğur, Aliğaoğlu, 2015:157). Several definitions have been made by different scientists on the Central Business Site:

Real central business site functions are the retail sales of goods and services for profit and the fulfillment of different bureau services (Murphy and Vance, 1959:429).

The centralized workplaces of the cities have been described with the terms like Citè or City by the writers in Europe for a long time; according to Schwartz, although there may be some exceptions, these places are usually formed in cities with populations over 100,000 (Schwarz, 1966:451).

In general, the CBD is a place where informing, managing and profit-making activities are brought together. Central Business District can be defined as the central part of the cities, which have a collective shape, where commercial activities reach high density and increase in a vertical direction (Beaujeu-Garnier and Delobez, 1983:325-6).

The most important functional area of all small or large urban centers is the so-called "commercial core" or the Central Business District (CBD). This section is located in or near the geographical center of the cities, except those on the coast. In coastal cities, it is definitely close to the shore and mainly developed on the basis of recreation. The central business areas in the cities can range from small groups of four to five shops, and they can be in different scales, including shopping centers without traffic and with free parking lots (Tümertekin, Özgüç,2002:475).

The Central Business Site is a phe-

nomenon that needs to be determined only in thestudies on urban areas as cities are commercially much more developed than rural areas. In addition, as CBDs serve the surrounding settlements, they have significant functional positions.

Cities are the commercial service centers of the settlements in there are of influence. For this reason, the trade function is one of the most important ones that ensure the continuity of cities (Özçörekçi, 1944:71). CBD is analyzed under the title of trade function in most studies. In this context, the most intensive trade area of the city is determined and the map is accordingly produced; the commercial shops or places in the CBD are then classified into daily, periodic and long-term maps. The greater the variety of these qualities, the greater the attractiveness of that area is. For example, while the pedestrian traffic is more intense in the area that serves the daily needs, the pedestrian traffic is less intense in areas that servethe periodic needs. For this reason, the level of attractiveness at the centerdecreases towards the surrounding areas.

The solution to various infrastructure problems in regional planning and the identification of economic centers accordingly is the most important step. The developed centers distribute services to theirsurroundings: they thus need to have a variety of functions. The demands of people living in a region ranging from daily necessities to luxury consumption needs, cannot be fully equally satisfiedeverywhere. The most necessary services for the population in a settlement are provided in the economic center, which is specifically formed in a central location. This central location undertakes the specific functions of other settlements around it; in addition to responding to the needs of its local population, such locations are important in terms of providing services to its surroundings. The centralityis made of the plurality and a variety of central functions gathered in an urban location and based on one or several transportation systems in that location (Karaboran, 1989:94-5-7).

In urban settlements, the land becomes useful for different purposes. Shops, houses, and factories in cities are placed in the order; there is a spatial differentiation. As the population of the settlement increases and evolves in such settlements, the “commercial sites” and “residential areas” are firstly separated. An increase in the business activities in a specific area leads to the creation of a Commercial Core.

Commercial sites are one of the most significant types of usage in urban lands. There are generally four types of commercial sites in cities:

1. Centralized Trade Areas or Central Business Sites.
2. Commercial Lanes.
3. Scattered Workplaces.
4. Shopping Centers (Tümertekin, 1967:18).

Trade is one of the traditional functions of city settlements. In fact, one of the reasons for the creation of the first city settlements is short or long-distance commercial relations. Cities are the trade centers of their people and surroundings. Some of the essential functions that cities have performed throughout history are to market agricultural products of a certain region and sell goods and urban services to the same region (Akçura, 1971:192). The main reason for manufacturing in cities is not the ease in production in the city, but the advantages of the city in terms of trade (Jacobs, 2011:354-5).

3. Methods used in determining central business district (CBD)

Different methods have been used to determine the CBD boundaries. The first of these methods is the classification of Zurich by Carol. In the first phase of this method, activities with and without central business site functions are distinguished. The building scale is evaluated in the second stage. According to the system, if an activity serves the city or a wider area, it is considered as a central business site function; on the other hand, if it serves a small area, it is out of this scope.

If three or more floors in a building are occupied by facilities with CBD function, then the building is considered to be a construction with a CBD function. If one or two floors of a building are occupied by the CBD function, then it is considered to be a semi-CBD function building.If less than one floor

of the building has a CBD function, it is considered to be a non-CBD function building (Carol, 1960:431-2).

Murphy and Vance had a different methodology about the issue. The method employed by the researchers is based on the use of two different indexes. These are the Central Business Elevation Index (CBI) and the Central Business Intensity Index (CBII).

CBI is obtained when the total area used in profitable activities in a building is divided by the square measure of that building. If this index is greater than 1, then the building is considered as a part of the CBD. CBII, on the other hand, is obtained when the sum of the areas used in profitable activities in a building is divided by the total area of all floors of that building. If this value is more than 50%, then the building is considered as a part of the CBD. However, researchers emphasize that this method is not applicable to all cities (Uğur and Aliağaoğlu, 2015:158).

In another study, the Central Business Site is examined in several ways: The intensity of some highly valuable functions such as jewelers, boutiques, banks, insurance companies, law firms, accounting offices, architectural offices, doctors, chambers of commerce are taken into consideration (Battino et al., 2012:624). The ratio of the number of core activities to the path length (activity / 10m) and the ratio between the housing area and core activities (housing/activity) are the other two indexes used in the same study.

D. Hywel DAVİES in his work titled "The Hard Core of Cape Town's Central Business District: An Attempt At Delimitation" revealed the difference between the Central Business Site and the Main Core within. He showed this difference by conducting a case study on Cape Town. The study was based on the Central Business Elevation Index and Central Business Intensity Indexes, which were introduced by Murphy and Vance. Apart from these indexes, the land values, human and vehicle movements within the Main Core were calculated (Davies, 1960:53-59).

Besides the aforementioned publications, the most recent study on the limitation of the Central Business Site has been carried out by H. Taubenböck et.al. A remote sensing method was used in the study. The city of Le Defense in Paris was chosen as the area of field study. In the method, only the physical parameters of the city were obtained. The maximum floor height, the maximum building volume, the density of the building, the density of high buildings and the densities of these buildings were the physical parameters of the study (Taubenböck and etc.,2013:18).

4. Methodology

The goal of this research study is to determine CBD boundaries more clearly and accurately by using the Space Syntax Analysis method. As this area is determined according to a specific method and system, the disadvantage of selecting different borders in the studies will be prevented; it is believed that the process employed in this research study will ensure a consensus in terms of the borders of CBD in the studies.

There might be more than one CBD in some major cities. It is thought that, with the Space Syntax analysis, not only the borders of the central business areas in cities but also the number of these areas can be determined.

It is possible to use the method of this study in other cities analyzed in different studies. This fact increases the validity and reliability of this method.

The study was based on the Space Syntax Analysis method. In this context, an axial map of Elazig city was created by using the DeptmapX program. The axial map was accordingly revised. At the beginning of these ar-

Figure 1. *The name of some streets and avenues in West of Elazığ.*

rangements, the D260 highway passing through the city was removed from the system. D260 highway was specifically removed from the system until the point that the area intertwined with the city (until Elazığ, Tofaş junction) (Figure 1);as such long roads are located over a wide and long plane, they cause errors in urban integration.

Another arrangement was the removing settlements, non-residential polygons, and routes from the parcels within the zoning border in the system. If the parcels and routes that have not become settlements yet are removed from the system, they lead to a calculation error.

After the arrangements, the global integration analysis (Segment / Integration HH) of the city was conducted by using the DeptmapX program; the local integration analysis (Segment / Integration R800) was performed after this analysisprocess. The R800 value was used after a series of analyses (R200, 400, 600, 800, 1000, 1200) as it was determined that it gave the most accurate result regarding the integration of the workplace.CBD maps were generated from local integration analysis. Field studies were conducted to test the accuracy of the obtained maps and the routes were photographed (Figure 5-6-7-8).

5. Assessment of centrality in space syntax analysis

Urban integration can be understood and analyzed by following the transportation networks in the cities. Space syntax is a method that analyzes how micro and macro spatial layers are shaped, how they work, develop and change (Hillier, 2005: 10).Today, this theory that connects space with social life is one of the most effective scientific approaches in architecture and urban design (Kubat et al., 2007:1).

Hillier argues that the concept of density center in a city means the combination of land uses and activities at an important center (Hillier, 2007:127). The concept of being central can also be defined by the intensive flow of pedestrians. Movement economics is a component of "live Centralization", which is one of the key ingredients of Centralization; this means the socio-spatial effect. Live centralization is an element of centralization managed by the activities that bring unexpected benefits resulting from retailing, shopping, entertainment and mobility. Life centers that manage living centers also necessitate spatial requirements of other central functions such as management, office employment or religion. The theory of motion economics is based on investigations of the flow of motion in a street network, which affects the mobility of the street, the spatial configuration of the network itself.

The highest density of motion in a city system exists in urban centers. Low and high motion intensities occur through mobility and this process is in a hierarchy. Generally, different centers can host different functions. For example, while there are many more shops and offices in a historic area, there can be more residences in a residential area which is far from the city center (Czerkauer-Yamu, 2010:25).

In fact, the centralization structure becomes functional through the spatial configuration of the route selection within a street network. This has an effect on the selection of the area to be used. These elements seen in the whole city plan are called "attractors". Understanding Centralization is not very problematic because, for example, if we think of living centers in historical centers, we can see that the concept is very clear and stable.

In conclusion, where there is a center, there is also centrality. The topological center is linked to the urban fabric and its accessibility. Space Syntax Analysis provides a tool called "integration" to examine centralization in cities.Integration is a highly important factor in the space syntax method (Özbek, 2007:47,49,51).

The axial map is the representation of a space drawn according to certain rules, where the legibility, accessibility and street systems of a space can be classified as hierarchical. The integration contains several measuressuch as "step", "depth", and "radius". These measures represent "movement from one axial line to another line", "steps to go from any area to all other areas" (Klarqvist,1993:11-2) and "maximum number of accessible steps". If the

whole map included in the calculation, it is called "global integration" or Radius "n" (Rn). if steps from aksiyel line is smaller than the total number of axial lines, this limited calculation is called "local integration" (Turner,2007:540-5).

Integration: The degree of accessibility from the whole system. "It describes the average depth of space to all other spaces in the system" (Klarqvist,1993). Integration can be calculated as a global or local measure. Global measures(Rn: global integration)calculate integration for the whole system whereas a local measure(local integration) is restricted tofinite syntactic steps and therefore a specific spatial neighbourhood. Basically, Integration is used for a syntactic analysis. Integration enables measurements of the relative accessibility of a space within a system.

The first step of integration is to calculate the depth of each axial line,

$$D_i = \sum_{j=1}^{N} d_{ij}$$

D: Total depth for the given node i
dij: depth between two spaces of i and j
(Volchenkov and Blanchard,2008)
N is the total number of nodes in the axial map

The average number of syntactic steps from a given node i to any other node is called "mean depth" (MD):

MD=D_i/(N-1)

Mean depth can be defined as the minimum number of syntactic stages that will be required when moving from one place to another on the chart, however, since the size of the axial map effects the MD value, it is not possible to compare different networks thoroughly which have unequal number of nodes. To solve this problem, two concepts have been developed: Relative asymmetry (RA) and Real Relative Asymmetry (RRA).

The relative asymmetry or relative mean depth expressed as a "fraction of the maximum possible range of depth values for any node in a graph with the same number of nodes as the system" (Bafna,2003):

$$\mathrm{RA} = 2\frac{\mathrm{MD}-1}{(\mathrm{N}-2)}$$

Real Relative Asymmetry is calculated by adding a normalization parameter (DN) to the formula of RA for each node i (Volchenkov and Blanchard,2008):

$$\mathrm{RRA} = 2\frac{\mathrm{MD}-1}{D_N(\mathrm{N}-2)}$$

Basically, DN in this formula is the RA values of the central node of a diamond graph (or the normal distribution of nodes) with the same number of nodes as the system and it is extended as(Volchenkov and Blanchard,2008):

$$D_N = 2\frac{N\left(\log_2\left(\frac{N+2}{3}\right)-1\right)+1}{(N-1)(N-2)}$$

Integration is a measure of depth and focuses on the correlation of movement and mean depth. It has to be noted, that researchers assume the integration measure with regard to centrality as an indicator of how people move around. In the urban system, some space may be more accessible or have higher integration than other areas. The syntax that connection and structural features of the transportation systems in the cities greatly affect the spatial integration. The diversity in integration calculations gives ideas about variations on the integrity of settlements. Therefore, the spatial integration map can also be assumed to represent the topological configuration and location of the CBD. As a result, the usability of global analysis, which is one of the integration accounts in the case of Elazığ, was tested in determining the central business area.

Hillier and Hanson describe integration as a global measure of depth and think that systems with different sizes can be directly compared with another; formulated as "Integration = 1 / RRA" (Hillier, Hanson, 1984:1089)

In terms of space syntax, centrality is defined as the accessibility which is appropriate for the minimum possible change in local and global urban settlements. Therefore, the integration of central locations is much higher than the whole system (Czerkauer-Yamu, 2010:25).

The most important concept of the Space Syntax method is the "integra-

tion" phenomenon. Integration is a method that is formed by overlapping the smallest and largest potential movement lines in the structure island system, which is transformed into the grid form of cities. By calculating the integration of each line into the local system and into the whole system, an urban grid system can be analyzed, mobility can be predicted, and data can be produced to explain its current mobility. This relationship will be effective in many areas of urban functions as it constitutes the most fundamental subject of design (Autors, 2015: 13).

Integration is used in syntactic analyses. It allows relative accessibility measurements of space within a system.

6. Identification of boundaries of central business district in Elazığ

The city of Elazığ stretches out from the east towards the west. Today, the development of the city is mostly in a west-northwest direction. For this reason, Elazığ has a linear structure, especially towards the west. The linear structure of the city caused the integration value to increase more in the middle of the settlement area (Figure 2).

In the global integration analysis, the most prominent routes were mostly boulevards in the city. Ahmet Kabaklı Boulevard, which connects the roads in the central part of the city to the north, and Atatürk-Cahit Dalokay Boulevard, which provide transportation to the east side of the city, are among the leading systems. In addition to the aforementioned boulevards, Zübeyde Hanım Street, Elazığ Street, and the following Governor Fahribey Street are the routes with the highest integration values in the city.

Figure 2. *Analysis of Global Integration in Elazığ (Integration HH).*

Figure 3. *Cluster Areas in Elazığ (Local Integration R800).*

When the local integration analysis is examined, two clustering areas attract attention. This proves that the city has two different central business districts. However, the area identified as the second cluster corresponds to the area where the city's auto industrial site is located (Figure 3). Auto industry sites are not considered as CBD. For this reason, the second cluster area should be considered as a space used when necessary, not as a CBD.

The area identified as the first cluster area shows the most intense area of integration at the local scale. This area is also part of the city's CBD.

The CBD boundaries of the study area are the spaces between Muammer Çorbacıoğlu Street in the north, Şehit Polis Kamil Gökçeer Street in the south, Bahçeli Street in the west, Şire Square and the Covered Bazaar in the east. When Figure 4 is analyzed, it can be seen that Şire Square and the Grand Bazaar form a small cluster area within the boundaries of the CBD.

The CBD area in Elazığ was classified according to a hierarchy according to the level of significance. The first-order important routes indicate the most intensive part of the economic activities in CBD.The other routes are the secondary parts of the CBD.

The aforementioned secondary parts are not often included in the studies. However, as a result of the field observations, it was concluded that the location of these streets and avenues in the economic cycle is important. In addition, these secondary routes fulfill the task of connecting the first-order routes. In this context, secondary and third-order routes should be studied within the boundaries of CBD.

Important first-order routes in CBD in Elazığ are; Gazi and Hürriyet streets in the north, Yakup Şevki Street which

is the follow-up of these streets, Şehit Polis Kamil Gökçeer in the South and General Abdullah Alpdoğan streets which cut CBD in the northeast-southwest direction. In the area where Şire Square and the Grand Bazaar are located, the east-west direction Atatürk School Street and the north-south direction Aksaray Street are the first degree CBD routes of Elazığ. The route with the highest integration value is Gazi Street (Figure 4-5).

At the beginning of the second order of CBD routes is Muammer Çorbacıoğlu Street, which intersects with Gazi Street in the west, extends parallel to Gazi Street and Vali Fahribey Street, located at the south of the street. The proximity to Gazi Street, which has the highest integration value, has a big share of the increase in the importance of these two avenues. Thisimportance of these routesis followed by General Hakay Talay Street, which extends in the east-west direction (Figure 6-7).

There are three basic routes in the study field that have the second-degree integration value. They connect the first-degree integration routes to either one another or to the other streets and avenues. The first route is Akın Street that connects Gazi and Vali Fahribey Streets and extends towards north-south direction. The second is İstasyon Street that starts at the intersection of Hürriyet and Gazi Streets and extends towards the north. İnönü Street, starting from the intersection of Hürriyet and Yakup Şevki Streets extending towards the north (Figure 7).

There is a common point of the third degree important routes; all of these routes are made of lines that cut the other avenues in the north-south direction. Yenice Street, Tuncay Street, Şire Square and Sakarya Street in the Grand Bazaar are the third-order important routes (Figure 3-8).

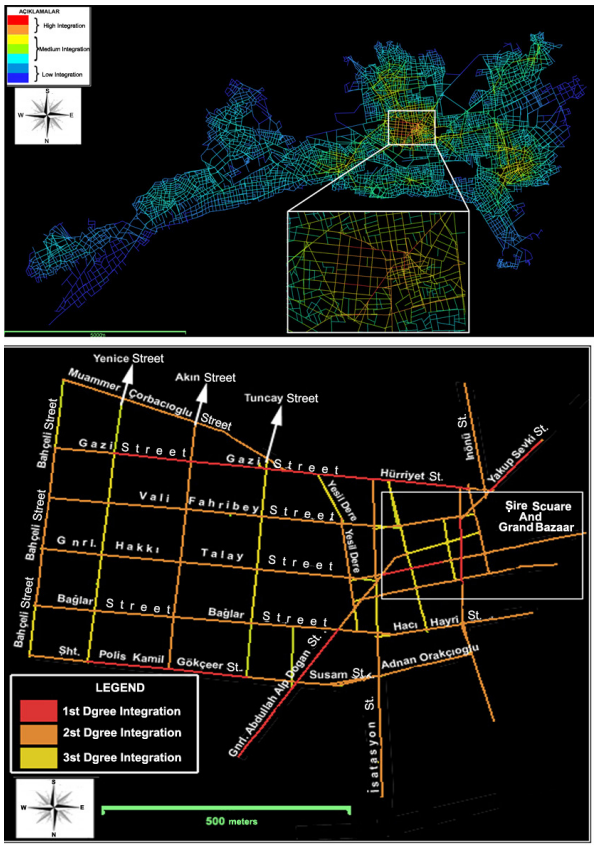

Figure 4. *Routes of Central Business District (CBD) in Elazığ.*

Figure 5. *a) Gazi Street, b) Yakup Şevki Street, c) Hürriyet Street.*

7. Conclusion and findings

SpaceSyntax Analysis provides the identification of the most integrated axes of a city's transportation network in a specific space or in the whole urban area. An area where axes with high integration values, located at the center of the city, attracts commercial functions as it provides the advantages of being together in terms of trade; such areas with high trade activity and capacity form the main trade area of the city called CBD. In this context, it is possible to determine the position, size and potential span of the central business area by integration analysis of the space syntax method. The analyses conducted in the city of Elazığ indicate that the spatial alignment method can be used as a tool for determining CBD.

Figure 6. *a) Vali Fahribey Street, b) Muammer Çorbacıoğlu Avenue, c-d) Bahçeli Avenue.*

Figure 7. *a) İstasyon Street, b) İnönü Street, c) Akın Avenue, d) General Hakkı Talay Street.*

Figure 8. *a-b) Şire Square, c) Bankalar Street (going down from Gazi Street to Şire Square), d) Nalburcular Avenue, e) The Grand Bazaar (West Entrance), f) The Grand Bazaar (South Entrance).*

Although there are two clustering areas in Elazığ, there is only one CBD. Although there is a rapid urban development towards the west due to the continuity of the linear structure of the city, and despite the fact that some of the official institutions have been moved to the west of the city, no CBD has been developed in this area yet.

A second CBD is likely to develop in this area if the western part of the linear structure of the city is changed in the future. Considering the situation in the global integration map and the current development process of the city, it is possible to say that due to its proximity to the center, Hazardağlı Intersection (Beyzade Efendi and İmam Efendi Boulevard), could become the intersection point of Sürsürü-Ataşehir and Cumhuriyet neighborhoods.

Most of the CBD routes with first and second-degree integration in the city are in the east-west direction, while all of the third-degree integration routes are in the north-south direction. This shows that the integration value of the roads in the direction of the general extension of the city is higher. Therefore, in the future, if a new CBD is formed in the future, we can foresee that the route will be on an east-west direction which is suitable for the city's development route.

Although the CBD boundaries of a city have been determined by the Space Syntax Analysis Method, it is useful to evaluate the results of the analyses by comparing them with the field studies in order to reach the most accurate results.

As a result of the field studies, it is determined that although Bağlar Street followed by Haci Hayri Street, Martyr Police Kamil Gökçeer Street, and then Adnan Orakçıoğlu Street iswithin the boundaries of CBD, the ground floors of the buildings constructed on these streets are not allocated to any businessfirms. In other words, as all of the buildings are used as dwellings, there are no commercial shops or places on the streets. Therefore, these streets in Elazığ's CBD boundaries should be ignored in studies.

There are surely some streets and neighborhoods with business firms outside the CBD boundaries (Şehit İlhanlar Street, Şehit İdris Doğan Street, etc.); however, as they are not defined as specific fields that integrate with the other streets, they are not included in the system. As a matter of fact, the high number of business firms in an axis doesn't mean that it has the characteristics of CBD.

Elazığ's CBD boundaries start at Bahçeli street in the west and end at Şire Square in the east, while the northern part starts with Muammer Çorbacıoğlu street and extends until

General Hakkı Talay street in the south (General Hakkı Talay street is included in CBD). Within the system, General Abdullah Alpdoğan Street and İstasyon Street constitute the linear routes connected with the CBD area within the system.

In cases where it is not possible to obtain detailed land-use data in terms of time and cost, it can be possible to understand the city by analyzing the central business area via the transport network. It is also possible to analyze the changes in the location of the city's central business area over time by examining the change in the city's transport network.

Streets in the boundaries of the CBD including residences in terms of function should be carefully determined in the studies. On the other hand, the residential areas can be re-planned and CBD areas can be rearranged on this basis. It can thus be possible to transform such areas in the cities with increasing population into more proper locations for the people living in them. SpaceSyntax analysismay includeresidences in the axes within the boundaries of the CBD area. Similar to Elazığ example, although some streets in the area with central business activities have high integration values due to the transportation network, these locations have only housing functions. These areas, as Burgess points out, are extremely important for CBD which is the focus of commercial, social and urban life. The arrangement of these streets, which can be called as the transition area, is also important for the planning and harmonization of the CBD functions with the CBD development as well as for the residential areas and urban life in the center.

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ITU A|Z • Vol 17 No 3 • November 2020 • 127-139

Tracing paper as a site for "taking the mind for a walk"[1]

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Received: April 2019 • Final Acceptance: May 2020

Abstract

This article concentrates on the tactility of a mind-walk that is realized by writing on tracing paper. The mind becomes a terrain as it is being walked on while writing, and writing is both making traces on a surface and opening a path in the mind. As the writing continues, lines match with time, and the path that has already been visited becomes distant. A methodology has been researched to see the previously visited path and the upcoming path simultaneously. The need for seeing both past and present has turned into an initiator idea of seeing depth on the paper surface that has employed tracing paper as a site for this experimental work. Generally used as an architectural drawing medium, tracing paper is used both as a surface and a design environment. As the tracing paper is a translucent plane that makes seeing the superposed lines altogether possible, resorting to the papers diversifies the mind-path created by a single line. Thus, a thought becomes not an extending line that drifts away, but a visual experience of visiting superposed writings simultaneously. The totality and wayfare of thought unfold in and through the frame by its size A4 (21x29.7 cm). In this article, the possibilities of a medium are presented through tracing individual experiences. Also a path narrative is employed to delineate the understanding of the case of being on a continuous walk. Both the path narrative and the tracing paper have been tools for experiencing a surface with depth.

Keywords
Walking, Mind-walking, Tactile experience, Line, Tracing paper.

doi: 10.5505/itujfa.2020.55822

1. Introduction

Mind-walk is an imaginary walk carried out with a body. As Solnit (2000) describes, the mind is a landscape of sorts. And while the mind becomes a terrain when it starts to be walked, paths appear while the walking continues. Writing, drawing, reading, painting and walking are some of the ways that open the paths through the mind terrain. All the continuous intentions and productions constitute these paths. Walking through the mind means visiting specific places that consist of ideas and images. As Ingold (2010) points out, to walk is to journey in the mind as much as on the land, and to read is to journey on the page as much as in the mind. Some thoughts can only occur at 6,000 feet above the plains and while following a route a thousand bifurcations swarm in one's mind (Gros, 2014). When writing and creating a path on the mind terrain, images and thoughts are gleaned. However, there are also elements such as decisions, bifurcated ideas, selections, dead ends that constitute the mind terrain. One might encounter differentiating paths, forget the places passed by and stray away but still be on the path.

As Careri (2007) states, the songlines of Australian Aborigines tell path-stories that map their continent. Each path has its own song and the complex of the songlines constitutes a network of erratic, symbolic paths that cross and describe the space (Careri, 2007). A song continues as the walk continues, the length of a song is as long as a walk (Solnit, 2000). As a songline makes a path imaginable, unlike a map, the song merges with the path and tells stories about encounters at the body level. What a songline contains is what the writing is made up of: The body, the time and the surface.

As to write is to walk through the mind terrain, from the body to the writing surface and from the surface to the body there is a flow of continuous lines either in the form of a path or a text. While writing, encountering ideas and visiting images transform into a kinesthetic experience of the body that draws lines onto a surface. Writing becomes the correlation of time, the writing surface and the body. As the writing continues and the time passes by, the written text, the encounters and decision moments recede into the distance and fade away. Eventually, the problem of *the trackability of an imaginable path* occurs. In order to image the path as a whole and also continue writing at the same time, a methodology is needed.

According to Deleuze (2006), the creative act is realized through mediums. For the filmmakers, blocks of movement-duration are mediums to tell stories with (Deleuze, 2006). In an interview, artist Kimsooja tells the story of her relationship with the surface, "I had this exhilarating moment when I was trying to push the needlepoint into the fabric…So that was the moment that this is it, this is the methodology I would experiment to investigate to dig into the depth of the surface" (Bloomberg, 2017). The surface was the two-dimension that she broke free from but was the space where she was still working. Through the possibilities of the medium, which was the needle for Kimsooja, the depth of the surface was discovered. As the needle was the medium to discover the depth of the surface for Kimsooja, by problematizing seeing the mind-walk as a path without becoming distant, the surface itself has been the medium to discover the depth for this work. The valid writing surface was shifted to tracing paper to create a writing surface with a depth that starts to reveal its possibilities as it is experienced. A series of successive surfaces folding the unfolding thought in an unchanging frame has been the site for taking the mind for a walk. The continuous flow of time, between the body and the surface, was interfered and folded by changing the only changeable element of this correlation, the surface.

1.1. Methodology

In this phenomenological in-depth research, that comprises first-person lived experience, a specific experiment practiced by the author has been taken as the basis. The phenomenological method is solely concerned with the description of an event or object (Crust, Keegan, Piggott, & Swann, 2011). It studies the structures of consciousness as experienced from the first

person point-of-view (Smith, 2018). This method, necessitating the individual experimentation, reveals and enables discovering unspoken relations between body and object through experience narratives. The fundamentals of the practice have been set by defining the problem of *the trackability of an imaginable path* and bracketed as discovering the *depth* of the writing surface. In this regard, this article is structured retrospectively by examining the theoretical background of the elements that constitute the problem, the relation between the experienced medium and the problem, the background of the practice, and analysis of the experiments. The analysis is dependent on the interrelations between the bodily movements and differentiating layouts of the medium.

The phenomenological method is employed to track the relations between the body and the writing surface. The tracing paper as a design environment has worked as a site that unblocks the path that had a desire to unfold. For this work, it is taken as the site where the ideas are probed, attached, resorted, accumulated and folded. The tracing paper, as the site, is discovered through tracing the somatic motions transformed into movement sequences that create the layouts of the medium. The experiments of the author are tracked and the traces of depth through these experiments are pursued. The tension of searching for a methodology to reach a trackable path constituted the background of this site experimentation and, revealing the possibilities of a rediscovered medium, constituted the practice of the site. The narrative of working with tracing paper is formed by using photographs of the experiments, and the experiments have been narrated from the first person to unfold the unconscious discovery of depth. The photographs used in the fourth part have been the references to investigate the movement sequences and meanings of the differentiating layouts. Therefore, these photographs are not illustrative for the text, but the text is a reading and the analysis of the photographs.

Eventually, as the body and the medium, as the object, are the main elements of the traced interretaions, the focus has been on creating a narrative of being at the body level and revealing the tactility of working with a medium while thinking through the medium.

2. Elements of writing: Lines, surfaces and tactility

The work of the three elements, tracing papers, writings, and the body, is more than an interaction. While writing, thoughts and images transform into lines. The translucent surfaces of tracing paper create encounters in depth. Lines and superposed surfaces work as signifiers of movement and resorted thoughts. The body is the connective tissue between lines, rearranged surfaces and thoughts. This work of the threefold, on a broader scale, is the work of lines, surfaces and *tactile experience*. In the following, these elements are examined both with their expansions at the broader scale and with their situation that is specific to this work.

2.1. Lines

A line is a continuous movement. It does not flash into view, it emerges or is experienced in a period. Line, as a movement, indicates a flow, and tracking a line is a temporal activity: drawing a line, connecting places, sewing, singing a song, walking, telling a story, living… They all occupy a period. Depending on the fact that the lines are related to time, they have metaphorical connections with and translations to other things that are temporal. Thus, while occupying time, they also connect, collect and project things. As they work as ever-extending placeholders, which are signifiers of intentionality and movement, lines build paths that expand and collect infinitely many images, places and temporalities. As continuity indicates connection and movement indicates time, lines connect and collect whatever they touch or signify. What is collected on a line differs according to experiences and projections realized throughout the line.

By means of the great variety of experiences and projections, lines appear in different forms and meanings, such as a walk being a line is a trace on the earth and the air. It makes visible and

invisible traces. Casey & Davies (2015) approach the line as both a physical and temporal phenomenon and also a connection that links events and places in one's mind. As they have it, a walked line is the unfolding of an event. The line becomes a space where people meet and dialogue takes place (Casey & Davies, 2015). On the other hand, a line might be a walked and embodied path as in Richard Long's works that he calls sculptures (Url-1). And as Solnit (2000) states, each walk moves through space like a thread through fabric, sewing it together into a continuous experience. Throughout a walk, the body, places and time get connected and merged as if a thread. Therefore, it is possible to talk about the versatility of different lines. According to Ingold (2007), lines can be sorted as threads, traces, ghostly lines, cuts, cracks, creases, and lines that do not fit this taxonomy. The appearance of lines is differentiated both by their relations with surfaces and by their relations within themselves. Ingold (2007) specifies this approach by stating that the history of lines is about the history of the ever-changing relations between lines and surfaces. The relation of a line within itself is an in-between relation as for being both a line and a surface at the same time.

2.1.1. Text as the trace

The experiments between tracing paper and lines were possible depending on the two aspects of writing. These are that the writing is a line on a surface and hence an image, and it is the conveyor of meaning and thought.

According to Ingold's taxonomy, the text is a tracing where a line is in a relationship with a surface. It might be formed by surface cuts, hewing out, engraving or it can be painted or sewn on a surface. The layout of text changes according to which surface it is written on, the writing medium and the material of the surface. The visual experience of a text depends on the correlation between lines and surfaces. When looking at a text, one is engaged in visual practices (Ingold, 2010). Writing and the surface both create an environment that surrounds the writer and the reader, and the environment is a path that can be tracked. Although the texts are images, they are not grasped at one glance. To track the writing, one needs to follow lines. As Solnit (2000) states, to write is to carve a new path through the terrain of imagination and to read is to travel through that terrain in the guidance of the author. However, it is possible to be surrounded by the writings as an environment. As Pallasmaa (2005) has put it, two types of vision are focused and peripheral visions. While the text works as a peripheral image as a whole, reading is related to a focused image, and writing is a focused imagination that calls in peripheral images.

Besides the visuality of a line, a line is a form for writing that the thought is transformed into [Figure 1]. Thus, experiencing a text is grasping a thought via an image that is the extension of thought. The flow of writing is bidirectional: thought transforming into an image and the image transforming into thought. The inner space, the body, embraces images, thoughts and movements, and a path starts to open when a flow is allowed. Images, thoughts and movements get caught in this path as writing.

2.2. Surfaces

Surfaces are layers that make the tactile experiences possible. The body is a surface of sorts, and everything that the body can touch, including air, are surfaces. According to Ingold (2014), air is the very medium that makes perception possible. As densities are variable, such

Figure 1. *The materiality of thought as lines and surfaces: A handful text (H. I. Uysal, 2020).*

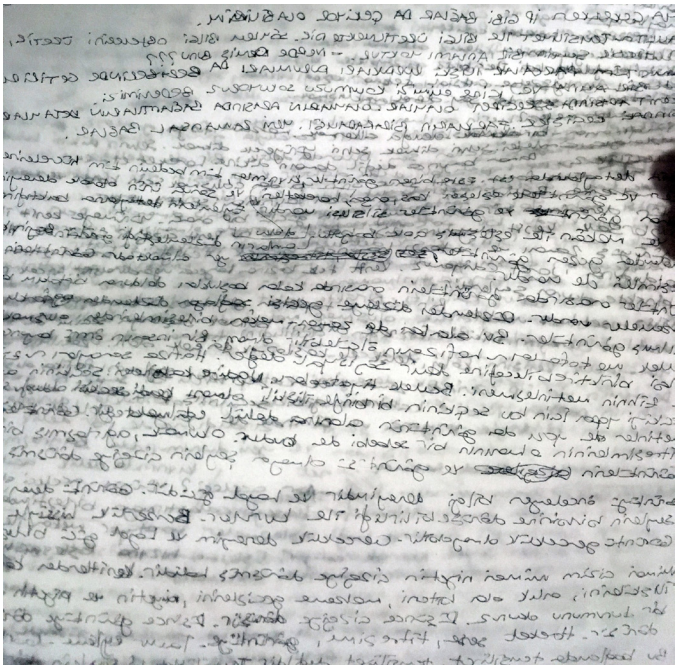

Figure 2. *A random image of superposed layers of tracing paper (H. I. Uysal, 2019).*

as a paper, air or water surface, not all the surfaces are experienced as planes. However, surfaces work as mediums and via all surfaces, tactile experiences are engaged.

The transparency feature of a surface ensures that all the senses work. Focusing on transparency, for example, the experience of walking on glass creates a feeling of falling into the image even though it is a solid surface. Claid (2017) describes her experience of walking on glass as follows: The visual sights below warp and distort, their lower backs tingle as if vertebrae have clashed together, legs become fuzzy and have a life of their own. In this case, experiencing the image works with kinesthetic. Even though the contacted surface is a solid floor, as it is transparent, it offers a visual experience, and the encountered image changes the whole bodily experience. In terms of transparency, image and experience, the relationship between writer/painter and tracing paper works very similar to walking on glass.

2.2.1. Tracing paper as the site

Tracing paper has a surface that can be drawn on, but also is a translucent layer that makes possible seeing and encountering the already drawn underneath. It is a design environment that is commonly used for sketching and making technical drawings. By using tracing paper, it is possible to see underlying surfaces, to trace, copy, reproduce, revise, design, etc. Tracing paper also protects the original. Therefore, without changing the original, alternatives can be produced, notes can be taken. Its use is based on seeing, remembering and referencing the underlayers. There are various types of tracing paper that vary in density, color, size, texture and opacity.

Although they are neither transparent nor opaque, tracing paper offers a surface that can work as both. Since they are not transparent like glass surfaces, one does not have the feeling of writing on an already written surface or falling into the underlying writings. Hence, it is possible to be aware of underlayers; the writer/ designer would be surrounded by the environment that is created through underlying images. Using tracing paper makes it possible to focus on the surface and work similar to working on an opaque surface or focusing on the depth and creating visual connections with the underlying surfaces. Therefore, tracing paper works as both a frame and a blurred surface. As the figure shows, the superposed layers of tracing paper are full of writings [Figure 2]. The topmost paper is the most dominant layer where the words on the underlying papers get connected. Even if the topmost paper is blank, the writings on the underlaying papers are blurred to create an environment of words, expressions and thoughts. This environment is used for recalling or not leaving the thoughts and making possible to see all the lines altogether. Thus, the thought is preserved in between the surfaces and the temporal thought is not lost.

2.3. Tactile experience

> "Thought is molecular. Molecular speeds make up the slow beings that we are."
>
> *Gilles Deleuze, 2000*

Bohm (1985) addresses a bidirectional flow of wholeness that is between "soma", meaning body, and "significance", related with meaning. Soma-significance means that the soma is significant to the higher or

more subtle level, and signa-somatic means that significance acts somatically toward a more manifest level (Bohm, 1985). In any case, soma and significance act together. As Bohm (1985) states, there is only one flow, and a change of meaning is a change in that flow. Therefore, any change of meaning is a change of soma, and any change of soma is a change of meaning (Bohm, 1985). According to Bohm (1895), "meaning is conveyed from one person to another and back through sound waves, through gestures carried by light, through books and newspapers, through telephone, radio, television and so on, linking up the whole society in one vast web of some-significant and signa-somatic activity". As Talbot (2015) quotes Bohm, vibrations of meaning are conveyed from the mind to the object. By focusing on Deleuze's (2000) phrase, it can be stated that molecular thoughts make up the writing that has a different haste of movement. The thought is pulled into the line and transformed into writing. The writing is not a conveyor of an image, it is the image with cavities, curves following each other.

Thoughts and images that create writing become conveyable via the environment of lines and surfaces. The conveyance takes place between people and the environment. Depending on the selection and the correlation of surface and lines, the experience with the image of lines and surfaces may have differentiating paths of soma-significant and signa-somatic flows. Depending on those flows, if the body is the center, one can see that there is a tactile flow in two directions. The body-centered flow is called experience, and the experience is tactile depending on two situations: With Pallasmaa's (2005) words, the body is projected onto the world, and the eye is the specialization of the skin tissue.

According to Merleau-Ponty (1964), the world is made of the very material of the body. Things are an annex or prolongation of the body (Merleau-Ponty, 1964). The idea of the world as bodily flesh is on the same axis of thought that the body is projected onto the world. Building an environment where one is surrounded by the extensions of its thoughts has the meaning of being surrounded by bodily projections that work as interfaces. The body encounters its prolongations via those interfaces. As the body is in continuous relation with the environment, touching the world always becomes touching oneself. Jacks (2004) uses the word merging for the integration of the body to the environment and the action of both as a whole. He associates merging with the Japanese word for body, *shintai*, which refers to the physicality of the body in dynamic relation to the physical properties of the world. The body is merged with the world due to its nature and structure. Touching is followed by merging, and merging is not getting flattened but getting intertwined with the possibilities of bodily connective tissues. Touching and merging create the lived space and time that is called tactile experience.

The second aspect is the visual experience. The visual experience is a tactile experience as the eye is the skin. Pallasmaa (2005) states that "All the senses, including vision, are extensions of the tactile sense; the senses are specializations of skin tissue, and all sensory experiences are modes of touching and thus related to tactility." Thus the visual experience is not an encounter with a flattened surface or a frozen moment but is a dynamic process that is realized among the surface and the haptic eye. Body touching the surface, inhaling the image and exhaling the lines builds up the invisible connections. Between the writing surfaces and the body, invisible thought lines emerge. The air between the surface, and the body is full of bonds that carry and project the thoughts and the images.

The images of thoughts, facts and emotions are created and experienced via imagination. According to Corbin (1972), there is a world of images created with imagination, which is a world that is ontologically as real as the world of the senses and the intellect. He uses the term *mundus imaginalis* instead of imaginary as the term imaginary is equated with the unreal and the things that do not exist. To delineate what imaginary leads to,

mundus imaginalis describes the image movement in this world, which consists of images and where the images are in suspense (Corbin, 1972). We experience space in the same way we experience the interior of the body. According to Corbin (1972), the five senses in the outer world, which are related to a specific organ in the body, synthesize into one sense in the inner world, which opens up to the world of images. As the body moves in the world of images, the muscles, organs, cells join the move and make the imaged movement. The whole body gets involved in the movement of images. Image is preceded by experience, and imagination realizes experience through images. The relation of image, experience and imagination is based on the interchangeability and comprehensiveness of all. Imagination is the creation of the inner world that calls in the world of images and, as it is delineated above as tactile experience, is projected from the inner world to the surface via invisible connective tissue.

3. Mind-walking with tracing paper: Walking and writing

Walking is the displacement of the body over time at the body level. A mind-walk is a walk through the terrain of the mind. While walking, we walk our experience plane, ramble through images and places that are all viscosities of time. According to Zevi (1993), walking within a building and studying it from successive points of view is to create the fourth dimension and give the space an integrated reality. When the walk within the building is translated into walking through resorted surfaces of tracing paper, the whole image becomes the thought that had been transcribed onto those surfaces. The experience plane of a walker is an extending line that the images are attached to. Ways that unflatten the experience, transform it into other forms. These forms can be listed as writing, drawing, photographing, repeating, recording, thinking, expressing and telling. Yet other forms can be added to this list, and some forms would be formless. For example, an architectural drawing is a form of architectural intention that is transformed into lines. Line transforms into movement, the movement to image, image to the manner, manner to action. Throughout the transformation process, the content can be expanded or narrowed; matter can become lineal, a line can be spatialized. However, all the forms are lineal in a way since they are temporal and experienced at the level of the body.

Writing is a slow unfolding. It is a walk that forms a unique path in the mind. As the speeds of writing and thinking differ, the transcribed line is a slow unfolding of the bodily experience. Thought unfolds and extends toward a line, and the line transforms into a text by taking a path drawn from the body to the surface. As the writing continues, the line becomes charged with meanings, thoughts, images and bodily movements. Sometimes the thought in the mind is in the form of a skein (Solnit, 2000). To walk in the mind is to unwind the skein, unfold the thought and visit the places of thought on the line. Saville (2008) describes the movement as the harmony between kinesthetic and visual experience. Where the kinesthetic and visual experience is combined, movement is flattened as a line. However, as writing is a movement that is realized between the inner body and surface, between the path in the mind and the text on the surface there are invisible embodied lineal connections. On the other hand, writing, which is the slow opening of the mind, is to leave the pre-written behind in time and at a distance. As writing continues, the former text becomes distant and temporal, the lineal connections between the body and the surface start to attenuate. In order to recall the former thoughts, the page should be turned backward.

As the written text becomes distant and the connections start to attenuate, there emerges the need to see all the writings at one glance to keep the thought on the path and let new paths to be blazed. However, this need is quite unlike the visual experience of looking at a map or a satellite image, as the encountered surfaces create different image qualities. The visual quality of this need is similar to looking back to see the descents and ascents of the path that is passed by while walking.

De Certeau (1988) distinguishes the narratives of the path and the map and calls the spatial practices of being on the path as spatial stories. Being on the level of the body is being on the path, and the view that the observer sees is not an overview of the path but the track of it. Using a translucent paper instead of an opaque paper and superposing all the written pages has been a way to see the walked path and the oncoming path simultaneously.

Through the usage of tracing paper, the invisible embodied lineal connections between the body and the surface continue to extend and fill the atmosphere between the superposed papers. As it has been called a tactile experience previously, all the layers of the translucent surfaces and their order are included in this bodily experience. Changing the order of the written pages is a way of sorting a thought differently and creating new connections. Resorting the translucent surfaces changes the distances of thoughts and as the body is involved in the resorting activity, not only by writing but also by rearranging, the whole experience becomes a kinesthetic mind-walk.

4. An individual experience flow of experiments with tracing paper

Tracing paper was used during the ongoing thesis study of the author. It was used as a medium to pursue the flowing ideas about the unstructured work. Before starting to use tracing paper, the initial intention was to be aware of unconnected issues, intentions, thought particles, images in the mind. There were pathless intentions and words, and as the unconnected issues were being written, they were wandering away as separate pages. Thoughts were becoming connected as they were written, but the connections were moving away as they were left behind. The need to see all the connections together without distances had appeared.

Tracing paper is a familiar medium as it is a tool used for architectural sketching. The tracing paper appeared to be appropriate for creating an environment for continuous writing and thinking. Depending on the rediscovery of the medium as an experimental environment, without quitting writing, the writing surface was changed. Accordingly, this section consists of a close look at the experiments with tracing paper via individual experiences. The method used for examining the process was tracking the movements made while working, connections that emerged during the resorting of the tracing papers, and photographs that were taken during or after the process.

4.1. Initial determinants

Before the surface shift, from the opaque to the translucent, making a nonhierarchical and unsorted list that consists of intensions, words, images and thoughts was an earthly path to start on. Writing the words equidistantly would keep all the issues unsorted. First, all the words, concepts and statements were written on an opaque piece of cardboard. Although the locations of the words on the cardboard surface, while being side by side created connections and sorting spontaneously, the expressions were to be seen loose and unsorted. While using the cardboard as a base plane, tracing paper was taped onto the cardboard to keep all the written issues in their initial state. The cardboard surface worked as a reminder and while being worked on via another surface, it kept its raw state [Figure 3]. Despite the tracing paper layers being processed, the initial surface of the inscribed equidistant expressions stayed unconnected. On the other hand, each new layer of the tracing paper became connected. Depending on reaching connections created on the upper layers of the tracing paper, keeping the layers untouched and undisturbed has been the first determinant. To continue working on an idea, layers were added either by taping or by simply placing one onto another.

The first attempt at working with the tracing paper was drawing lines onto it to correlate with the words on the cardboard. The first surface drawn on became the front side, and the other surface became the back side. It was noticed that the tracing paper did not have two neutral surfaces as white paper has. It was not possible to treat equally the surfaces of the paper. The back surface would turn into an area of interference to the front surface. In addition to the

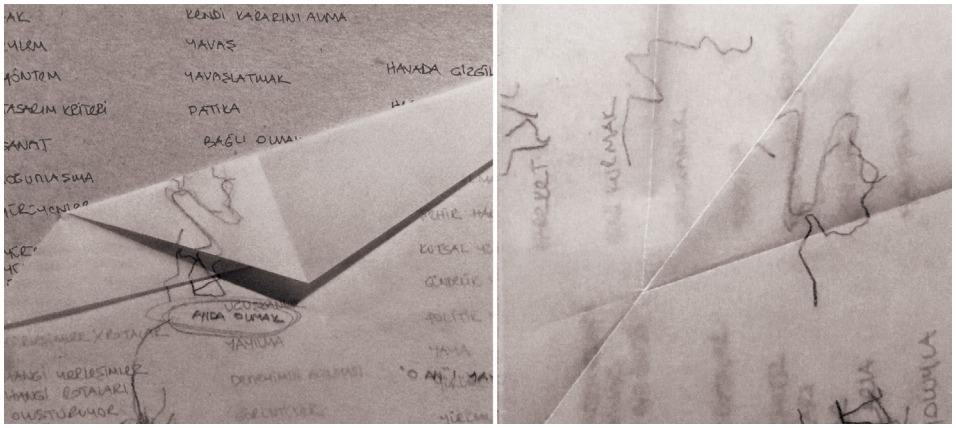

Figure 3. *The work of the cardboard and translucent paper surfaces. The words encountered through the tracing paper layer and folding (H. I. Uysal, 2017).*

front and back side relationship, folding the paper was experimented to see how the surfaces differed while drawing lines. Folding helped to create more than two surfaces, augmenting the fronts and backs [Figure 3]. Noticing the differentiating sides of the tracing paper was the second determinant for getting engaged with the medium and investigating via it.

As the third determinant, seeing and focusing solely onto the surface of the topmost tracing paper, an opaque layer was placed between the upper tracing paper and the underlayers [Figure 4]. All these initial practices were the determinants for the relationship with the medium, enabling examining the possibilities of the medium by experiencing it. By associating the tracing paper with the words below it, and moving the tracing paper on the cardboard surface, the possibilities of relationships between the lines and words have been revealed.

4.2. Selection of the medium qualities

While executing these experiments, tracing paper of different sizes and types was used. By experiencing different types, eventually tracing paper of the size A4 was selected. It was adequate for enabling viewing the whole surface and focusing comfortably. Paper weighing 112 g/m² was strong enough and suitable for conserving and archiving. Also, the surface behavior was not too slippery nor too textured. In terms of their relationship with the surface, an 0.4 mm needle tip or 0.2 mm plastic tip pen was used.

4.3. Tactile movements

After working with both cardboard and tracing paper, the cardboard was removed and only the tracing paper was used. The written and drawn tracing papers were placed under the one in use. But the underlayers did not always work as a reference or reminder. Sometimes they were only background working as peripheral images. On the other hand, if the focus was on the background, they seemed to become explicit images. If the underlayers were associated with the content of the topmost surface, they were drawn into the ongoing work. By slightly sliding the top paper, the image of a former thought was encountered and pulled into the present. By reordering the surfaces, new connections and other pos. sibilities appeared. Reordering surfaces

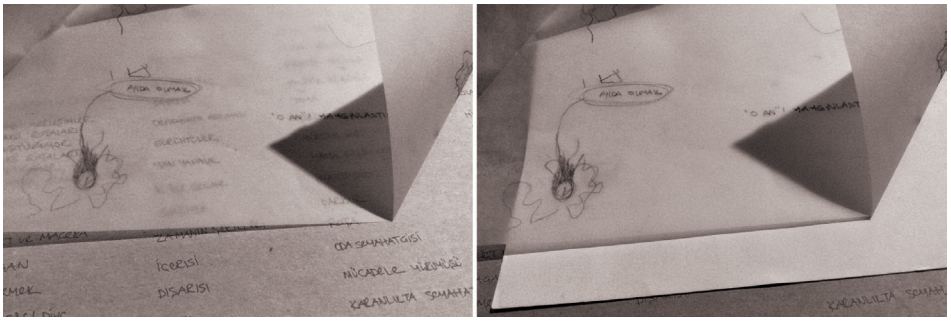

Figure 4. *Placing an opaque layer in-between (H. I. Uysal, 2017)*

worked as resorting ideas to create a new thought path. If the top paper was removed or shifted, other diverse lines would be visible [Figure 5]. To reach a thought on a particular place of the mind-path, a walk was started through all the other surfaces, passing by other thoughts and images, and revisiting places, finally arriving at the targeted thought. This walk corresponded to resorting, removing, shifting or adding previously transcribed surfaces. All the movements were for following the path of thought by playing with distances, orders, and zooming in and out. However, the movement was not random. It was controlled by the need to see more clearly, more blurrily or not to see at all. To edit the thought on the same plane, it was assured that all the thoughts unfolded into the same frame, and the path in mind was framed with superposed A4 tracing papers where it was folded.

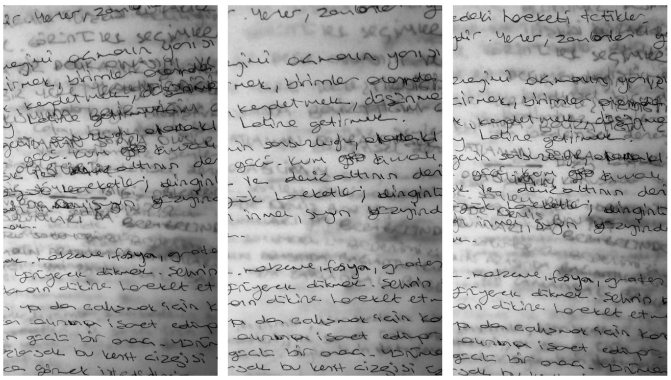

Figure 5. *Encounters with different images depending on the slight shifts of tracing papers (H. I. Uysal, 2019).*

4.4. Layouts

The initial experiment that created the layouts consisted of some attempts to cut the A4 papers. These attempts were finalized by taping cut pieces onto other A4 paper. To be able to archive and resort the papers, the size A4 was kept in the future works. Keeping the size as it is, formed the layouts of the paper.

The layout of a surface changed according to the scope of the thought it conveyed. Having some writing on a surface allowed it to keep its semantic context. The first writing attempt was to write separate subjects on separate pieces of paper. If anything was needed to be added onto a specific paper, another paper was placed onto the written paper to keep it untouched. Sometimes there were only a few sentences that could belong to one specific surface [Figure 6]. Sometimes, although it had space, one surface was not enough. If the thought needed to continue, it leaped to another surface that was always removable. Thus, if the recently created connection caused by the addition was not appropriate, the taped addition would simply be removed. The first idea, if necessary, would remain in its initial form without an additional note, and the note could be visible as the least visible writing trace at the bottom to create other possibilities of a path. The main reference writing would be placed at the top, and the other writings that were essential to see would be under it to provide the following of the thought. The reason for adding a translucent surface by taping it to the finished surface was to edit the writing, but also to see the way it was before it was edited. This was also done to deepen and expand the text [Figure 7]. In no circumstances were there made any changes or corrections on the front surface of the original paper, because all the visual connections that create the path and the process needed to be kept as they were. The only permanent intervention made onto the original tracing paper was drawing lines onto the backside to highlight selected specific expressions on the front side. Even though the line on the back surface seemed to be blurred as it was on another paper surface, it moved with the surface it belonged to.

If instead of seeing everything, not seeing things became crucial, white paper was taped to the backside of the tracing paper [Figure 8]. Or an A6 sized white paper was taped, in order to focus on the writing in process and still be surrounded by peripheral image of the under layers. As the A6 paper was placed as a separator, the flow of some thoughts were stopped, surrounding image of the under layers was kept and the focus on the specific idea continued. Besides, when the surface to focus on became smaller, the thought would accumulate onto the surface; it would fold and deepen. When the A6 paper was removed, the path continued to

extend and become connected with other layers. As the tracing paper surface worked for following and unfolding thought, the path created through bonded thoughts had been visible via layouts produced during the work in process.

4.5. Other experiments

Throughout the working process, in addition to the specified movements and layouts above, ways of combining writing with two-dimensional images and of experiencing the new connections due to their superpositions were experimented with [Figure 9]. The writings, drawings or photographs were superposed within the context of a shared subject. As the texts had been peripheral images, in a similar way, photographs and drawings worked as textual elements. The image, above or below, was an atmospheric element that set the tone for the ongoing writing.

5. Conclusion

Before being transcribed, thoughts are in the form of a skein that waits to be transformed into lines. There are no trails of a path on the terrain of the mind, but there is an image of possible paths. Throughout the process of experiencing the tracing paper, writing and mind-walking have been a translation of the skein into forms of tactile movements. Bringing the materials together, rambling on different paper surfaces and writing have been bodily processes. Unfolding thoughts became connected to time and place through writing. The speed of thinking has been aligned with writing speed. An imaginable path is created. All the experiments were done with tracing paper with the movement sequences of superposing, shifting, taping, resorting, adding papers with different opacities have been between seeing or not seeing the underlying layers. These movement sequences have formed the tactile experience, and while the papers were revisited, the traces of the movements have worked as signifiers of the mind-walk process. Seeing the written pages below had the meaning of visiting the place where thought has risen, and being there unfolded other paths of thought. Depending on the experiences of thinking through tracing paper, various ways of thought tracing, mind-walking types have emerged. While tracing the layouts of the surfaces and the tactile movements, intertwining of the body and the surface have become explicit.

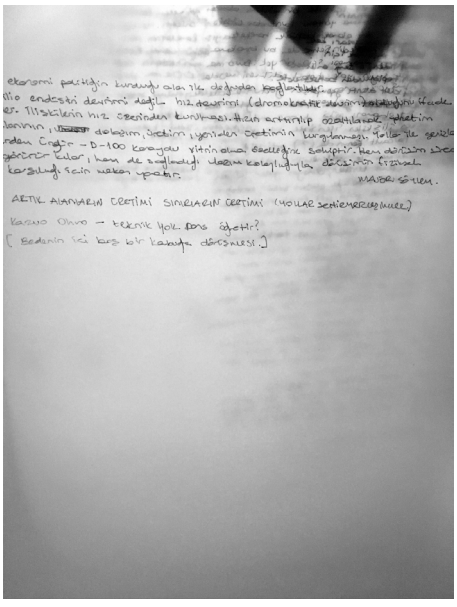

Figure 6. *Not using the entire tracing paper surface. Creating a paper with spaces to keep the writing within its meaningful context (H. I. Uysal, 2019).*

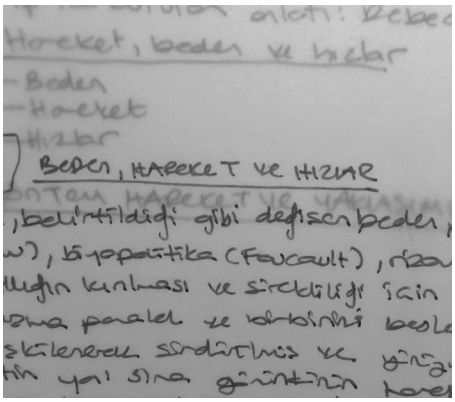

Figure 7. *Underlying surface contains an outline, and the top surface follows the outline by expanding it; the overview and the detail working together (H. I. Uysal, 2018).*

In a broader perspective, writing is a tactile act already. It is a visual and kinesthetic experience. However, the change in the opacity of the medium, breaking free from the opaque surface, has changed the experience as a whole. Going beyond the act of writing, working with translucent layers has become a tactile visuality that draws the paper

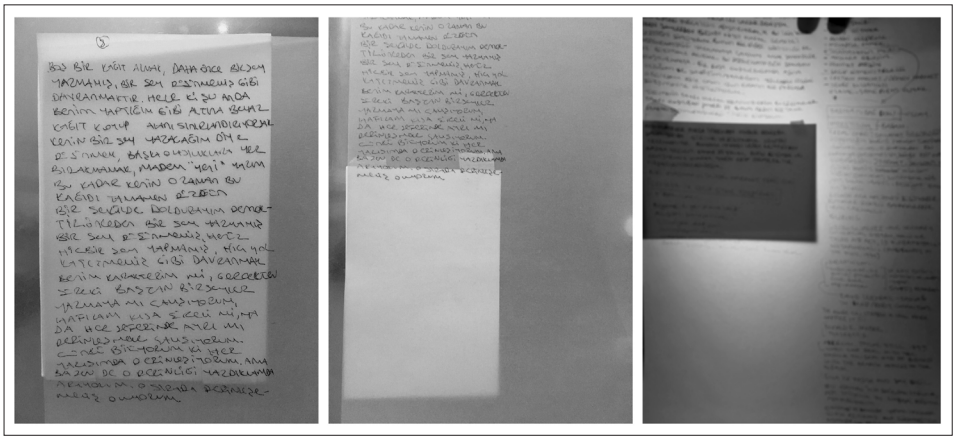

Figure 8. *A6 papers being used to provide focusing; the layouts created by these papers (H.I. Uysal, 2018).*

space into the experience as depth in situ. The depth provides accumulation of writings instead of distal writings. The surface has become an active place with changing views and depths. Continuing to walk the path while looking both backward and forward is the definition that makes this need specific. Using the tracing paper was the medium to continue working. The experiments with it have revealed the possibilities of the medium. For a mind-walk, the tracing paper has been the site with a depth that enables the thoughts to accumulate.

This work asserts the challenge of keeping a nomadic experience as it is. However, it does not research the representation but the actualization of the experience. As this work is charged with and has a background of bodily walks, it continues to search for a methodology of keeping walking through the topography, the surfaces, and the mind-terrain. Becoming aware of connectiveness of the time and line has been the first step for questing the accumulation of lines that would create a depth where one can see the time. The differences between map and path narratives create the quality of seeing and tracing. Seeing has become encounters on a path that show the traces of the troddened path. Writing has become an act of sewing the images, lines, and surfaces around a thought. In conclusion, this work consists of the interrelation of two separate research issues: the exploration of the unfamiliar meanings and usage possibilities of a familiar

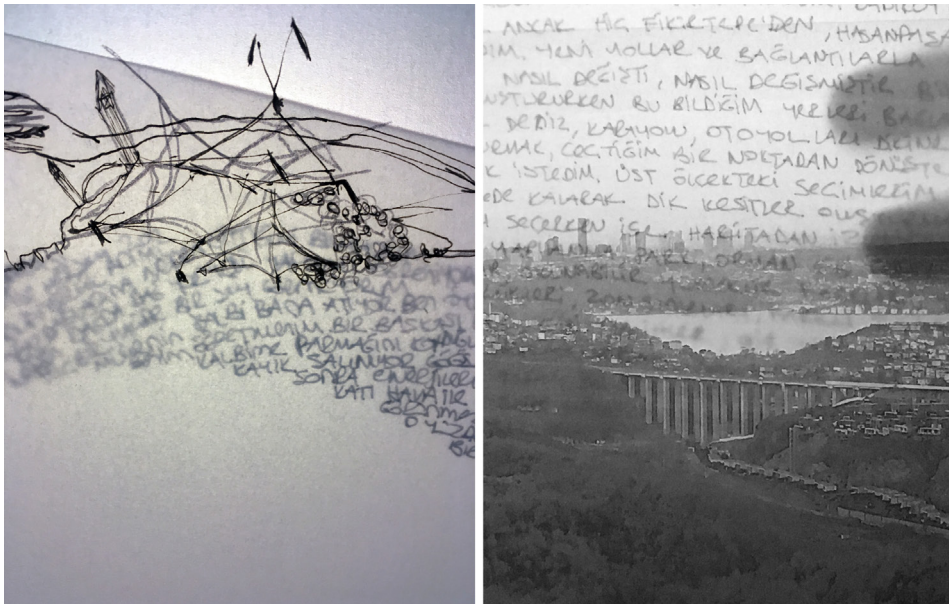

Figure 9. *Correlation between other images and writing (H.I. Uysal, 2018).*

design tool through experiences, and the path narrative of being at the body level. The interrelation has revealed a methodology for a tactile mind-walk through an imagined surface depth.

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Endnotes

[1] Paul Klee's Pedagogical Sketchbook (1925) begins with the phrase "An active line on a walk, moving freely, without goal", and the emphasis is on his mostly cited phrase "drawing is taking a line for a walk".

ITU A|Z • Vol 17 No 3 • November 2020 • 141-153

Layering in representation: Rethinking architectural representation through Perry Kulper's works

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Received: December 2019 • Final Acceptance: February 2020

Abstract

"Layered representations" in architecture create a 'personal' language with their complex structures and can be accepted as creative tools for thinking and designing architectural space in a performative way. These kinds of multiple/interwoven representations that are produced by the overlapping and manipulation of both design tools and ideas are valuable in the context of their original narratives and present an alternative approach in the dialog with space by expanding the boundaries of architectural representations. This study aims to focus on these new forms of architectural representation and discusses them through "personal-knowledge theory". Within the scope of the study, some of Perry Kulper's works are chosen and examined as case-studies. Dual readings, which are discussed through the concepts of 'design thinking and designing act', as well as 'explicit and tacit knowledge', constitute the methodology of this study. Selected works and their architectural narratives are then discussed based on these dual readings. Depending on outcomes, it can be suggested that although layered representations produce singularities through personal knowledge, these singularities include/carry the possibility of creating alternative spatial worlds and atmospheres in architecture.

Keywords

Architectural design, Layered representations, Personal know(ing)ledge.

doi: 10.5505/itujfa.2020.27879

1. Introduction

(Architectural) thoughts become debatable through representations. For this, architectural representations have analogue or digital design tools that have their own rules. But today, architectural representation is seen as a language that covers/includes hybrid multiple situations (depending on their medium, tools and techniques) and multidisciplinary approaches. As the discussion of architectural representation has changed synchronously with the ideation of architecture, the search for alternatives has acquired a greater degree of visibility and has come to be seen as possessing increased potential for architectural practice. Therefore, greater attention needs to be paid to the relationship between design thinking and designing act. Drawings on this perspective, in this study, representations that lead and contribute to these hybrid multiplicities and those which bring personal approaches together with more specific forms of representation, are discussed and designated as layered representations.. These representations are those that are informed by both analog and digital tools, but "there is no direct definition for these types of representations. But they have a dynamic structure that exhibits performatively different layers of knowledge and their relationships, produced in-action, and grasped by the resolution of this moment of action" (Asar & Dursun Çebi, 2018, p. 201)[1]. Layered representations can also be defined as productive design tools as they generate and reveal creative situations while designing that, which will serve to uncover alternative approaches to and relationships between thinking and action. In order to decipher this relationship (thinking and action), personal knowledge theory, discussed through the relationship between explicit and tacit knowledge in the context of this study, has been utilized as the situation includes an individualized process.

Personal knowledge, as set forth by Polanyi, draws on Gestalt psychology, and he treats it as "an alternative ideal of knowledge" (Polanyi, 2005, p. preface). It is an internalized type of knowledge that is reshaped each time in conjunction with a series and/or variety of several actions. Thus, it is composed of one's experiences, as well as cultural and social accumulations depending on a variety of intuitive or perceptual 'things'. Although it is not possible to decode personal knowledge in all its dimensions - due to the abstract elements it encompasses, it is believed that some of this knowledge can be discussed in the context of space-making. In order to do so, some dual readings through 'thinking and action' and 'explicit knowledge and tacit knowledge' are formed. These dualities are in a continuous relationship both within themselves and between each other. Taking this relational network into consideration, these dual readings are used in order to analyze selected representation samples.

In its broadest sense, architectural representations emerge from mutual interactions between design thinking and designing act. These interactions take place through the varying forms of relationships between explicit and tacit knowledge, which draw on personal knowledge theory. Through representations, the main idea of the designer and the tools and tactics used to express these ideas become visible. In this regard, based on his alternative engagement with architectural drawing and representation, Perry Kulper and his works were chosen for analysis; his use of divergent techniques for representation was also noteworthy.

The structure of the study can, therefore, be expressed as follows: In the first part of the study, explicit and tacit knowledge theories and layering in representation are discussed through the relationship between design thinking and designing act. Following this, an assessment is made of the selected works of Perry Kulper based on these theoretical relationships. A final assessment and evaluation are then provided in the conclusion. Depending on the interpretation, layered representations as a means of expressing an idea in architectural practice can be viewed as having an interpenetrating relationship between designer/architect and representation object. Therefore, this paper argues that layering in architectural representation can be conceptualized as an expression of the designer in

the context of their personal approach to both thinking and action.

2. Layering of architectural representation through design thinking and designing act

The complex networks established between "things" (as per Heidegger's (1971) expression) refer to the multiple structures that have the potential to be implemented in different ways, specific to each design problem. These structures might be between multiple situations involving thinking and acting, thus facilitating hybrid interpretations. The visibility or disputability of these relations is ensured through architectural representations. In this sense, architectural representations can be seen as "… a hybrid product of an idea and properties of the representational medium" (Scheer, 2014, p. 52). If we approach architectural representation through the idea of hybridity, we need to rethink the use of design tools and their meanings. This raises a number of questions including: How do we interpret the architectural representation? How do we internalize it? And therefore, how do we personalize it? In this study, these questions help us to rethink the creative tools, tactics as well as information used in the representation of spatial narratives. These types of 'hybrid' representations have been discussed by various researchers. Gürer (2004), for instance, used the expression 'mixed structured representations', and Oxman (1997) and Lawson (2005) used the expression 'multiple representations'. Within the scope of this paper, however, they are referred to as 'layered representations'. Accordingly, the layering forms of architectural representation and the way in which they reveal the relationship between design thinking and designing act are taken into consideration. Based on the idea that architectural representation is "not an outcome, but rather a mode of thinking and a relation to the world…" (Bolt, 2004, p. 17), the design processes in which these relations are established and, in particular, the moments of action that create these processes are taken into consideration.

Layering in architectural representation focuses on moments of action. Disciplines such as painting, photography and architecture were able to express activity only by freezing and creating contradictory situations in the context of the action-expression relationship. Therefore, there have been various attempts to create a sense of action through visualization. One such attempt was chronophotographic records starting with the art of Futurism. The works of Etienne-Jules Marey and Manuel-Cafini (Miklós, 2015) focused on how the movement of the body can be expressed in painting or photography. These images created by multiple exposures, and thus, overlapping (this can also be considered a type of layering) succeeded in conveying presence or sense of motion on static paper. However, these attempts can express not only a sense of overlapping, but also the perception of action.' Proun' works produced by El Lissitzky between 1919 and1927, for example, can be considered in this context. "The two-dimensional Prouns meant to Lissitzky the temporary transfer station between painting and architecture..." (Van de Ven, 1987, p. 214). This *in-between* or intermediate, transitory situation can be seen as an attempt to deliver a form of performative act.

In the case of architecture, Tschumi's work creates a performative situation both on a representative and structural scale. For example, in the Parc de la Villette (Paris, 1982-98) project, Tschumi uses the concepts of 'the event', 'the movement' and 'the space' together, and "he defines three overlapping autonomous, and non-hierarchical layers (with grids, lines and surfaces, which contain various functions) of the park" (Stapenhorst, 2016, p. 187). Here, Tschumi tries to reinterpret the representation by drawing on action-oriented relations, and utilizing the relationship of the event-movement and space concepts.

The inclusion of movement in architectural drawing can also be considered from the standpoint that "architecture has been liberated from the straightjacket of the orthogonal thought process of plan, section and elevation" (Edwards, 2008, p. 233). Various concepts of architectural drawing resulting from such efforts have been

derived and used many times. For example, Nathali Frankowski and Cruz Garcia of the WAI Architecture Think Tank group use the concept of 'action drawing' for architectural drawings (drawings, which are formed by lines, planes, volumes, images and typography and are used side by side to explore the complex universe of architecture). It is said that drawing is a means of communication and thought between the architect and the world by utilizing this approach as well (Salgado de la Rosa et al., 2016, pp. 247-248). In this manner, designing act involves a partnership that evinces a variety of forms of expression depending on the designer's concept and approach. However, this is a performative relationship.

Indeed, when Schechner looks at the concept of performance from Erving Goffman's perspective, he delivers it through action and defines "performing as a mode of behavior that may characterize any activity. Thus, performance is a 'quality' that can occur in any situation rather than in a fenced-off genre" (Schechner, 2005, p. 29). Such an attribute helps us to associate the concept of performance with architecture, because architectural design becomes subjective through the forms of performative relationships established between thinking and making. The visibility of this relationship and spatial experience is, thus, provided by architectural representations. However, from a traditionalist point of view, such relationships are implicitly revealed in architectural representations because of their prescriptive and reductionist attitudes. For this reason, depending on this relational network, the discussion is conducted by means of layered representations, which involve different layers of knowledge and are shaped through performative narratives (containing actions such as deterioration, re-establishment, and production at that moment, which trigger the next production).

In layered representations, the multiplicity of meanings expressed by different techniques, their associations, and the new spatial situations that arise from them are considered important. Layered representations, which can also be expressed as a kind of practice of thinking in action, can be used in multiplicity of ways in different stages of design. Mixed techniques such as sketches, and collages, as well as the combined, simultaneous use of digital and analog tools can be regarded as both suitable examples or as giving rise to them. The important point, here, is how 'things' turn into each other in the act of designing. This transformation process is a way of manipulating design tools by means of action. This manipulation, while maintaining a position against the reductionist attitude of representation, not only produces knowledge about the object of design by layering, but also begins to say something about the act of designing.

The discussion of layering in architectural representation can be expressed as an attempt to bring together what can and cannot be represented (explicit and tacit things) in design. Therefore, layering in architectural representation can be seen as a first step in the approach to this nebular world, which exists in the space between design thought and the act of designing. It is affected both by our past experiences and the ongoing thinking-acting relationship based on constantly changing and transformative dynamics. All in all, it results in the formation of a variety of representations each time throughout the process of design.

According to Scheer, "representation entails an endless revision of our knowledge of the world based on our experience of it" (Scheer, 2014, p. 42). On the basis that our personal knowledge can be revised and transformed in such a process, then architectural representation can also be transformed by means of changing knowledge and therefore our way of thinking. Furthermore, in architectural practice, the relationship between thinking and acting takes place in the context of our personal knowing, and the multiple constructions of this situation constitute layered representations.

Personal knowledge theory was first discussed by Polanyi (2009) in the mid-20th century. While discussing personal knowledge by questioning the nature and rationale of scientific knowledge, Polanyi intended to develop an alternative theory about knowl-

edge. According to Polanyi "we can know more than we can tell" (Polanyi, 2009, p. 4). The conclusion to be drawn from this is that what we say is what we can express explicitly, but what we know and cannot say can be referred to as tacit things. For this reason, personal knowledge discussions can be held to benefit from the relationship between explicit and tacit knowledge.

The theories of explicit and tacit knowledge have been discussed by many researchers (Nonaka (2007), Takeuchi (2006), Howells (1996), Grant (2007), Smith (2001), Toom (2012) etc.) after Polanyi. Some of these researchers have argued that these types of knowledge have turned into each other, while others have claimed that they affect each other. For example, Cook and Brown (1999) argue that tacit knowledge is used to create explicit knowledge, but explicit knowledge is not a transformed form of tacit knowledge, rather it is a kind of knowledge that receives support from it. The same applies to tacit knowledge. In a discussion of these points, they take Polanyi's example of cycling. However, they note that the essential element in this example resides in the action of the riding of the bicycle. From here, they claim that "the act of riding a bicycle does distinct epistemic work of its own" (p.386). According to them, this is not something that people have, but an integral part of the action itself. For this reason, they prefer to use the word 'knowing' rather than 'knowledge' (Cook & Brown, 1999, pp. 384-386).

Within the scope of this paper, the relationship between explicit and tacit knowledge is considered through a similar argument. The revealed moments of 'knowing' are considered important because they are related to action. Indeed, 'knowledge' is generally related to a de facto thing: 'knowing' is about a process of dynamic performance that can be differentiated for everyone. Aydınlı and Kürtüncü expresses this situation through the word 'understanding' as follows: "While the word 'understand' defines an action that is over and done with; the word 'understanding' defines the ability to internalize knowledge, to carry it to different contexts, and to reproduce knowledge, which is an endless action" (Aydınlı & Kürtüncü, 2014).

Personal knowing, which is discussed through the interactions (in action) between explicit and tacit knowledge, constitutes the theoretical structure that contributes to the layering of architectural representation. Architectural representations have a kind of linguistic structure defined by certain rules through their technical expression. However, the use of tools in the architectural design process can be reinterpreted in conjunction with design thought. Personalizing and layering design tools in this context help to reveal the relationship between design thinking and designing act, and contain clues as to the designer's explicit and tacit knowledge. Therefore, layered representations developed through forms of personal knowing vary each time and for each designer. Such representations can be seen as one of the important design tools in the development of alternative approaches to the design process.

3. Analysis of architectural representations: Some drawings of Perry Kulper

"Drawings become the 'windows' through which we see things created in someone's mind…" (Muller, 1988, p. 5). These windows help us to analyze what the designer thinks and what he/she wants to express at each and every stage of the design process. In this sense, many drawing types - windows- can be referenced. For example, what Lawson refers to as *presentation drawings* include 'drawings by which the designer transfers his work to others' (p.34); while *calculation drawings* include 'drawings that can also be seen as a special case of proposal drawings and are effectively made as an alternative to doing some calculations' (p.49) (Lawson, 2004). By way of further example, Herbert describes drawings in two ways - public and private drawings. According to him, *public drawings* are a common convention and symbol system for ensuring communication between people; and *private drawings* include personal conventions, unfinished graphics and sketches that address the purely abstract characteristics of the

design idea. He treats public drawings as presentation drawings and private drawings as study drawings (Herbert, 1988, pp. 26-27).

All these interpretations regarding drawings are shaped according to the personal point of view and therefore may vary. The designer can go beyond such generalizations in line with the design idea; produce drawing types that express his/her own design approach, and use different tools together by transforming existing ones. Thus, as the drawings (or their genres) become more authentic, the 'windows' that Muller speaks of will begin to differentiate, and become personal. This is also directly related to the logic of the generation of layered representations. For this reason, Perry Kulper's drawings[2], which can be regarded as the combined visible product of such manipulation and layering, have been chosen for the case study.

Kulper basically explores the potential of drawing. His drawings are unusual; they are not simple; but rather hybrid, multiple, transformed, and in this sense, evince a very unique form. Accordingly, *Bleched Out: De-Commissioning Domesticity, Metaspheric Zoo* and *Speculative House, Garden + Landscape* were selected for consideration within the scope of the study, as Kulper uses different drawing types for each of the different stages in these projects. Each of the selected samples contains different types of drawings that Kulper has both named and used. As the main aim of this study is to uncover the type of layering that might occur depending on the relationship between design thinking and designing act, further benefit can also be derived from Kulper's design texts and drawing types in the analysis of his selected works.

According to Kulper, relational drawings can be regarded as "simply work on specific relationships" (Kulper, 2015, p. 21), and "they are neither purely figural or abstract, … focus on a particular area of study- not architectural or formal, yet, … these particular drawings explore erasure as a representational activity" (Kulper, 2016, pp. 40-22). His *Bleched Out: De-Commissioning Domesticity* project serves as an example of this relational drawing technique (Figure 1). Kulper demonstrates spatial relationships using blocks, lines and colors through this drawing technique, which is a kind of relational diagram. For Kulper, the relationship between the type of drawing and the way of making is held to be as follows: "Within a very limited framework, or set of ambitions this drawing studies erasure, censoring and recoding. It is a pre-cursor to an architectural proposal a relational drawing with no particular scale, orientation or direct spatial implications" (Kulper, 2015, p. 23).

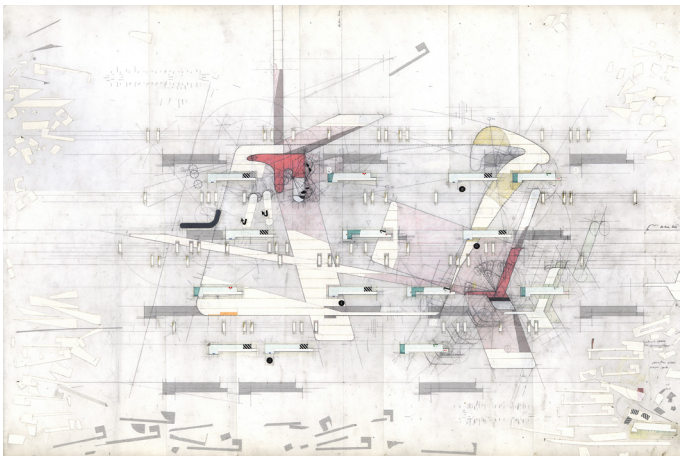

Figure 1. *Bleched Out. De-Commissioning Domesticity, v.01, 2003 (P. Kulper private archive).*

At this point, it can be said that design tactics and approaches have been developed in tandem and inform each other and that the intention of the study can be expressed as follows: "This speculative project attempts to rethink conditions of a domestic world through the literal and figurative acts of editing, censoring, or 'bleaching out' of the elements that typically comprise domestic settings. At the same time, it challenges the additive, or accretive practices of the architect" (Kulper, 2017). This situation tends to express open-ended relationships that are inherent in that thought not the sequential or agglutinative thinking that occurs in conventional space thought and expression.

The intention in question can also be considered through two images that inspired Kulper in his work. The first of these is "a series of large 'edge' paintings by the American painter Sam Francis", the other is "the de-commissioned military aircraft occupying the

desert floor at the Davis-Monthan Air Force Base Aircraft Boneyard near Tucson, Arizona'" (Kulper, 2017). The 'edge' painting is combined with the connotation of military aircraft occupying the desert floor. In the edge painting, the edges of the canvas are painted, the center is not painted, but left as a vast space, and the boundaries of the defined canvas are questioned. The planes in the desert were grouped according to their size and were also ordered. Based on the relationship and the internalization of the painting and the order of the planes, Kulper tried to create relational thinking and thus a relational drawing technique for this piece. For this, he sought alternative ways to represent non-representational things by working on a kind of sign sequence. The generated sign sequences can also be considered a kind of subtraction for spatial organizations. But, on the other hand, the drawing has acquired a systematic aspect as a result (Asar & Dursun Çebi, 2018).

The systematic and abstract language created within the drawing itself can be considered through the lens of '*explicit knowledge*', while the manner in which the relations come together to establish this language can be evaluated through that of '*tacit knowledge*'. Expressions about '*Kulper's tacit knowledge*' can be partly analyzed in conjunction with how he thinks and which paths he follows while he is designing. Kulper describes this process as follows:

> "An initial series of 'marks' are established in the space of the drawings- they are ciphers for probable, or expected, domestic characteristics. These 'marks' are then systematically qualified through additional 'marks' to do with 'bleaching out', or editing the original marks. This operational volley of censoring and qualifying is followed by a series of notations which attempt to 'recode' the now censored origins- the recoding, a kind of mimetic and material rhetoric, to do with virtually presenting the now 'evacuated' marks. A pair of hybrid reflexive objects occupies the 'edge' of the 'bleached out' field, metaphorically providing a new respiratory impetus for the now 'suffocated' proto-architectural characteristics" (Kulper, 2017).

In this context, it is possible to say that '*Kulper's design action*' practiced through the combination of marks, encodings, and drawings has succeeded in establishing a multi-relationship network, as a performative relationship between *thinking* and *action* is realized. Coding is used where the expression of the marks is insufficient, whereas drawings are used at the point where the coding highlighted the spatial connotations. However, what brings these technical layers together is the expression of affected and imagined things in the context of design discourse and relational drawing techniques. Thus, the logic of the drawing through the generated string of marks is established through the generated string of marks. This, in turn, constituted 'his explicit knowledge' that could be analyzed. However, the architectural characteristic is designed in such a way that it cannot be grasped at first glance and always includes a 'tacit' side due to the hybridization of the used objects and the feeding from metaphorical thinking. Therefore, on the one hand, this situation has personalized the drawing, and on the other hand, the drawing becomes layered due to the knowledge, technique and experience it contains. It can be suggested that this form of layering, while involving a systematic primitive mind, has also acquired an abstract feature through relational additions.

The Metaspheric Zoo project (Figure 2), which is taken as the second sample, was a proposal prepared by Kulper for the Prague Biennale in 2005. The word *Metasphoric* is a cross between "metaphor" and "atmosphere". According to Kulper, "it is the first in a series of preparatory drawings to discover and theorize the zoo" (Kulper, 2005, p. 18).

Kulper expressed the project's description as follows:

> "Its primary topical, relational, and programmatic attitudes were established through an image combining characteristics of a puzzle, a geographic matrix, and a taxonomic inventory. Ambient surfaces tease coded and indexical marks. Instrumental practices are crossed with language and invented 'characters' toward the creation of a synthetic, incomplete, and strangely

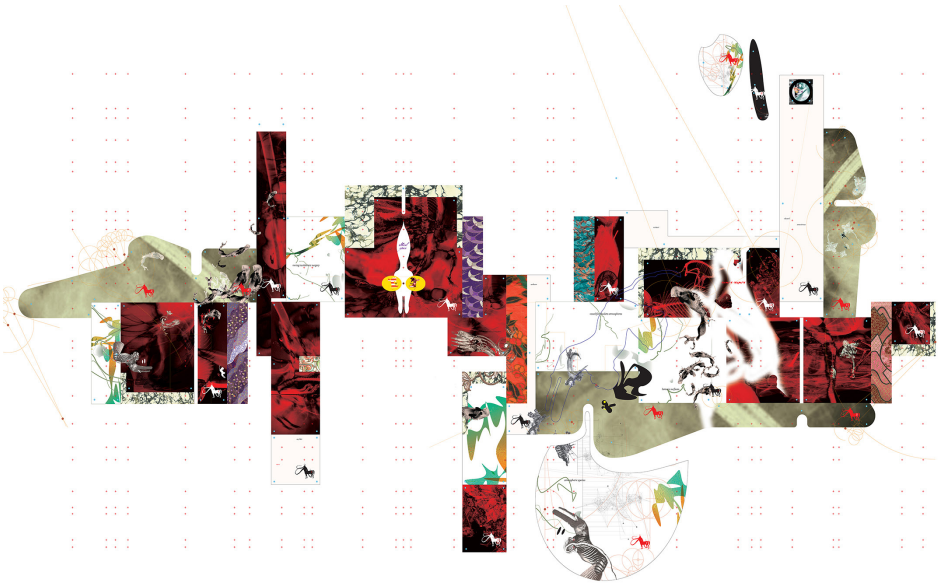

Figure 2. *Metaspheric Zoo, 2005 (P. Kulper private archive).*

> familiar whole. From this beginning, programmatic interests in botanic surfacing, a roving taxidermy, and a vessel for obsolete atmospheres emerge, confronting the disparate impulses of instinct and desire which are all but eradicated from our over-programmed society" (Kulper, 2005, p. 19).

According to this discourse, drawing can be viewed as a practice in which many behaviors and characteristics need to be handled together and re-invented each time through language. Therefore, the immanent context of the project enabled the production of its characteristics. This situation affected the use of design tools. Here, Kulper used the type of drawing which he called *thematic strategic plot:* "Strategic plots that plot conceptual frameworks, objects and events over and through time…" (Kulper, 2015, p. 21). Similarly, Kanekar declares that strategic plot "… is quite telling in that the plot signifies the manner in which the story is constructed and planned. It marks, lays out, and locates the underlying story but there is also another side to this meaning, that of intrigue and secrecy" (Kanekar, 2015, p. 117). Therefore, drawing, which is referred to as a *thematic strategic plot*, can be viewed as having a relational and creative fiction with respect to its own story.

When the *Metaspheric Zoo* project is examined in detail, it can be seen that some kind of grid structure is used and that on top of that each spatial organization is produced relational with both itself and inter se. When these grid boxes, which can also be referred to as atmospheric sections, come together, the design story begins to become visible. However, it should be noted that these drawings have an abstract side. This openness (abstract thing) allows us to interpret things that we know are explicitly associated with our experience. This openness can also be expressed as a partial externalization of *'Kulper's tacit knowledge'.*

The concept of atmosphere implies that the things that trigger intuition can also be represented. This situation led to the emergence of alternative spatial relations and personalized drawings. Indeed, according to Kulper:

> "Although culturally grounded, drawing is a kind of personal cartography in which circumstance and creative identity coalesce toward spatial configurations. Drawing is a risk, and confronting the white surface, or black screen, is an act of violation. It is an assault on whiteness and abstraction" (Kulper, 2005, p. 19).

Therefore, if we consider this sample with respect to design thinking and designing act, it can be claimed that

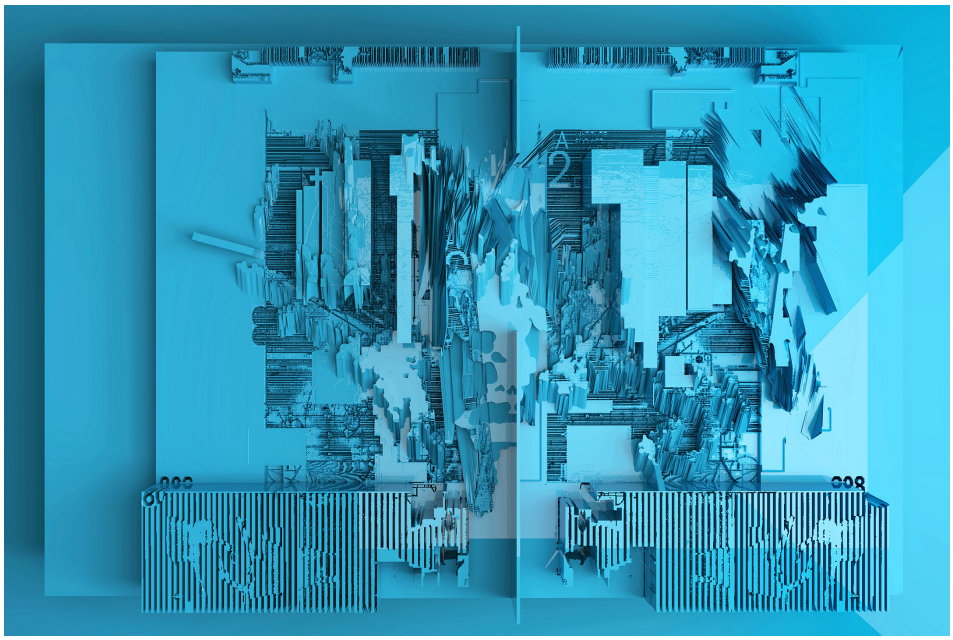

Figure 3. *Speculative House, Garden + Landscape, v.95-Blue, 2018 (P. Kulper private archive).*

the intertwining of both thinking and action has made the representation layered. Layering was carried out on thematic (similar to Kulper's expression for the drawing type) fragments /sections. The basic approach of design has been determined 'through an image combining characteristics of a puzzle' (in Kulper's statement), and the grid structure was then created via this approach. A 'crossover' was performed by means of indexical marks and codes added to the resulting surfaces. This approach can be categorized methodically as a kind of mapping. Thanks to this mapping, some things have been 'explicitly' expressed, while others have been 'tacit' in the context of the atmosphere (although being 'strangely familiar') created by the relational tension. For this reason, the layering of this drawing is fragmentally formed.

Last, but not least, v.95 (which is a collaborative work with Jeff Halstead), found among his *Speculative House, Garden+ Landscape* series of drawings, is chosen because of its three-dimensional expression technique (Figure 3). The reason Kulper regards this drawing as speculative and the inspiration behind it can be explained in his own words as follows:

> "The visual speculations of the design studio Archizoom, the architects Archigram, the architecture, design and media arts-based Ant Farm and the architects Superstudio gave me room to go out on a limb – many limbs in fact – in the making of 140 collage-like images" (Kulper, 2019, p.65).

Such alternative forms of thinking and making coming from the 60s are always open to new speculations both in terms of architectural thought and the use of design tools. In the case of Kulper's works, this gap in today's multi-representation environment is discussed. In this drawing, Kulper focused on a tool (the Quick Selection tool in Photoshop) (Kulper, 2019, p. 65), and using this tool in a creative way by making the representation layered. He designates his making-style for this project *proto-digital collages* by using the Quick Selection Tool in Photoshop. He explains the potential and use of the tool as:

> "Motivated by an interest to learn the 'Quick Selection' tool, these proto-digital images unravel the potential of a few simple Photoshop® operations. Under the rubric of simple programmatic elements – that of domestic, garden and landscape realms – this work rethinks programmatic typologies. By appropriating images – much like the aforementioned practices, but using the Quick Selection tool rather

> than scissors, to snatch and reassemble some image fragments – a number of interesting things evolved in these very quick visual speculations. An increased range of formal and material possibilities emerged: the generative potential of the history panel – turning layers on and off – offered generative spatial and representational potential; the agency of file sizes, degrees of resolution and scaling opportunities opened things up; and discovering ideas rather than proving them came front and center" (Kulper, 2019, p. 65).

Research on the potential of the tool also generates the discourse of the study and is expressed as follows: "… this work is interested in challenging norms, and opening domestic default assumptions towards probing alternative models for living in relation to natural, synthetic and fictional spatial worlds" (Kulper, 2019, p. 65). The three-dimensionalization of the drawing through this avant-garde-based discourse is also reminiscent of the traditional home-garden arrangements. This situation makes the relationship between 'explicit and tacit knowledge' visible, and it "representationally spatialized" (Kulper, 2019: 65) those things either explicitly or not explicitly expressed.

Fictional thoughts about the garden and landscape also affect how the chosen design tool is used to express that idea. Although each tool has its own limits, it is still in the hands of the designer to expand those limits as alternative thoughts or options arise. It can be seen that the layering in the *Speculative House, Garden + Landscape* drawing has been carried over into three dimensions in a digital environment. This includes both intellectual and physical layering, but it also gives the observer a perceptual hierarchy of positive and negative spaces. Thanks to this hierarchy, the physical layers become visible, and as an audience we are able to understand or at least make interpretations about the project as the layering of the drawing is shaped volumetrically.

According to the Wai Think Tank group, Kulper's drawings are a cosmos of information and possibilities, an architecture of ideas that don't remain static and always evolve (Wai Think Tank , 2012). "He is fluid in his uses of techniques and design methods... in the quest for a 'relational synthesis'" (Kulper, 2013, p. 58). For this reason, his drawings can be seen as a kind of "personal cartography" (Kulper, 2005, p. 19). These cartographies are only one of the infinite possibilities of the relationship between 'design thinking and designing act'. They also reflect the designer's relationship with the world. This will be perceived and interpreted differently by each observer just like the differentiation of interpretations of people, who read the same literary text, as "experiences through the image of thought are the source of the formation of a new thought" (Özgencil Yıldırım, 2003, p. 38). Kulper's drawings are thus seen as fostering discussion of the forms and narratives of layering in architectural representation, because his drawings evince the multiple, complex and performative relationships between design thinking and action.

While each of the examined samples has a personal language, they are also different from each other due to the form of tool using (making) employed. The commonalities in the samples can be considered through the combined use of different layers of knowledge (signs, drawings, affected images, experiences, intuitions, the way of making, tools used, etc.). Differences are directly related to what each drawing is trying to say. For example, when we look at *Bleched Out: De-Commissioning Domesticity* and Metaspheric Zoo drawings for the first time, we see expressions that are complex and difficult to interpret. However, when we examine in detail the combined use of the drawings' texts, affected images or tools, we begin to understand the logic of the drawings. This can be evaluated through the affected images in *Bleched Out: De-Commissioning Domesticity* and the fragmental structure in *Metaspheric Zoo*. However, the drawings also contain metaphoric, atmospheric and relational layers. Such layers are considered important because they can reveal different relationships. This is visible in positive-negative space perception in the *Speculative House, Garden + Landscape* drawing.

While the complexity in other samples became more speculative due to their two-dimensional situation, the perception of three dimensions created there approaches the relationship between the layers of the house-garden images we know. Therefore, making the layering volumetric triggers a different narrative.

When selected drawings of Kulper are considered together, it can be concluded that he has developed his own language, which he uses in different ways and forms each and every time. This provides an openness in which different positions can be taken during the designing act. This openness is believed to make the layering of the representation possible. In this context, it can be said that Kulper builds his design process through provocative, intriguing and performative narratives.

4. In lieu of conclusion

Architectural representation is considered important as it includes both the creation of an idea and the expression of that idea. It encompasses the dual relation between thinking and action. Therefore, this study focuses on the relationship between design thinking and designing act, and discusses architectural representation through the argument that this relationship is multiple and personal, as it is claimed that architectural representation derives from the multiple, and thus, becomes layered.

The relationships established through layering in architectural representation will differ for each design problem and for each designer. For this reason, Perry Kulper's drawings, as provocative samples, are chosen as they consist of different and alternative layering types. All of the samples are personalized in the context of the tools, thoughts and ways of making. These drawings, which can be read as a kind of drawing research, create an alternative gap in the discussion of the relationship between thinking and action in terms of the multiple layers (as either intellectual or physical) they contain. Thanks to this gap, the possibilities for action increase, and the language used becomes performative. In this context, the combined use of both analog and digital tools as well as environments has taken them out of their knowledge frameworks. The types of drawing used by Kulper can be considered within the scope of studies where this frame is exceeded.

The layering in the selected samples is considered important as it reveals alternative relationships in which we can discover new things by thinking together about things that will never come together. The expressions of the layers in the drawings vary with the narratives triggered by these layers. This change originates from a dynamic network of relationships that arises from both the explicit and tacit knowledge of the designer. Therefore, it can be said that such drawings are more than just objects that are finished and to be agreed upon. They are also things that try to express the forms of reflection of the practice of thinking (instant cross-sections through which an idea travels through an infinite network of possibilities) and the act of designing.

Similarly, Castle cites Kulper's approach to drawing as follows: "… all of the drawings are design worksheets to develop things and are not intended to 'be in the world'" (Castle, 2014, p. 18). At this point, it can be suggested that, Kulper proposes an alternative idea of architecture that oscillates between 'design thinking and action', 'explicit knowledge and tacit knowledge'. These interactions are set up in different ways in each design. For the relationship between design thought and action, Kulper interprets the futuristic thought by using different design tools. He is influenced by many different images and hence re-evaluates the residues of this influence in different contexts to produce new meanings. At this point, the relationship between *his explicit and tacit knowledge* begins to intertwine. One of these reflections can be seen in the variety of drawing types he uses in the different stages of design. These relationalities provide the generation of the layering. Thus, they produce a visionary and alternative way for his architecture.

For him, "alternative architecture is relational, not hermetic" (Kulper, 2009, p. 63), takes place in the context of thought, and is speculative. In this

sense, when the selected samples designed by Kulper are reevaluated, it can be claimed that each drawing forms a narrative through a layering of its own generative logic, with the result that the layering is of different densities. However, in all samples, the relationship between layering is often expressed as intertwined. Therefore, they are neither fully defined nor legible because the attempt to place things that cannot be expressed (action and therefore intuition, emotion-oriented things) in drawing between these layers leads to a narrative form known only to the designer. At this point, personal knowing occurs and the means by which the designer interprets thought tacitly takes place in the drawing.

In the context of layered representations, the point of interest is that such representations have the potential to enable us to determine a course that will allow us to express ourselves in a world of design possibilities. For this, we must pursue the forms of expression that we can integrate with our own world without being trapped within the limits of the known discipline. As a result of this reading of layered representations, it can be said that although representation has an inherently reductionist structure, if we can find a personal way of encountering the boundless structure of thought; the act of designing can become a practice in which we can express our explicit and tacit knowledge together, and, representations can become layered narratives and performative forms of expression that together contain such knowledge. Thus, representation is not only a generic language that expresses what is occurring at the end of the design process; it can also become a productive and creative environment that the designer can personalize, and really communicate and think with during the design process.

Funding

This work has been supported by The Scientific and Technological Research Council of Turkey [TUBITAK] under [grant number 1059B141800388]. It has been produced within the 12-month research visit by the corresponding author in RWTH Aachen University.

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Endnotes

[1] In this study, the so-called representations were named as "mixed structured representations". However, as the study became deeper, it seemed out to be that these types of representations are not only complex but also multi-layered. So, in order to avoid any misleading, the naming given has been changed accordingly.

[2] The types of drawings which are used and named by Kulper: Aspectival drawing, Thematic drawing, Proto-strategic plot, Strategic plot, Cryptic drawing, Proto-formal drawing, Relational drawing, Composite drawing, Analogous drawing (Kulper, 2018: 19.19 min.).

ITU A|Z • Vol 17 No 3 • November 2020 • 155-167

Designing for spatial narration in children's playscapes

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Received: March 2019 • Final Acceptance: March 2020

Abstract
Today, digital technology is very much present in the everyday settings children live, learn, and play in. Focusing on supporting children's use of body-movement and senses in narrative play, we offer a theoretical framework and guiding design principles for digitally-enhanced physical play environments. Probing how children construct spatial narrative through interaction with tangible objects, we argue that blended environments which combine digital and physical media may contribute to the versatility of such spatial activity. With reference to an overview of related work in human-computer interaction, we discuss the intermediary capacities of objects, whether they are designed as toys for child-play or not. We identify different forms of interaction that children have with objects, and position blended environments within this classification. Also offering a repertoire of roles children take on in play, we outline four design principles for a prototype of a digitally-enhanced environment that enables children to articulate spatial narrations.

Keywords
Design for play, Interactive narrative, Playscape, Spatial experience.

doi: 10.5505/itujfa.2020.25932

1. Introduction

Children intuitively use their environments for play and are generally adept in creating their own materials within it. While inherent features of places and objects may constrain how one engages with them, children use their imagination and intellect to see the environment and the objects in their own way: they utilize signals, construct their own rules and manipulate everyday objects according to the physical scenes they create (Piaget & Inhelder, 1967; Garvey, 1990). For example, they can turn a nook into a hiding place, or step on the pavement for immunity. Children can transform a place and create their own narrative world. A playscape is a space for "magical thinking" (Talbot and Frost, 1989) that children interpret and reinterpret in play. Today, playscapes are changing as digital technology becomes ever more present in the everyday environment children live, learn and play in. From here on, environments that possess digital technologies in support of the physical world are referred to in this text as digitally-enhanced.

In the field of human-computer interaction (HCI), there are several ongoing efforts for creating digitally-enhanced play environments that incorporate the body and space in the interactive experience. Many studies focus on augmenting objects of play with digital features that support spontaneous, imaginative and tangible interaction (Price et al., 2003; Follmer & Ishii, 2012; Van Beukering, 2014). Tangible features may prompt children to be physically active. Some other studies, grounded in the constructivist paradigm, encourage children to be physically active in a spatial context (Back et al., 2016; Shapira et.al, 2016; Boon et al., 2016; Valk et al., 2013). Even though these works do not focus on spatial narration, the novel interactions they offer activate more body movement than with just the fingers and eyes. There are yet other studies that support physical activity by providing digital augmentation through pervasive technologies (Price et.al, 2004; Ryokai et. al, 2011). These invite children to be physically active and explore their physical environment by moving around and looking. Yet, each consists of a unique configuration of activities, material resources, and relationships, as well as the interactions that emerge from these. They are structured, rule-bound, and goal-directed. They follow educational concerns but do not support children's own playful spatial narration.

This paper contributes to the existing body of research exemplified above with a framework of digitally-enhanced settings for small children of 4-8 years to create alternative play scenarios. The premise is to support children's spatial narrations as much as possible in their daily environments such as homes, schools and gardens as well as creating a bridge between children's spatial experience and their construction of meaning with an awareness of the role of their bodies. Our study delineates guidelines for designing environments that blend physical and digital objects for children to control in narrative play. The term narration throughout this study refers to story construction, not only as a process of meaning-making with symbols, but also as place-making via spatial transformation using objects. The theoretical groundwork given below concentrates on objects and their intermediary capacities to instigate narration with bodily movement in space.

We first give an overview of the relevant literature on child development to establish how physical objects can enhance children's spatial narration through bodily experience. Then we deliver four different interaction forms for classifying children's active engagement with their surroundings as well as the constitutive and intermediary role of everyday objects during play. Later, referring to key examples with a particular focus on children-object engagement implicit in spatial interactions, we delineate the terms self, avatar and reflection as different roles in narrative play. In the last section prior to conclusions, we synthesize design principles for digitally-enhanced narrative play scenarios of spatial experience.

2. Background

In developmental theory, children primarily construct knowledge through interacting with the environment and its components (Bruner, 1990; Piaget, 1962; Singer et al., 2006).

Accordingly, the physical environment and objects have key roles in a child's cognitive development and children have their own views of the world. Building on this, Papert's constructionism (1993) advocates that children learn more effectively when they are actively engaged in the making of tangible objects. Different than instructionism with technical methods for an educational agenda, constructionism is concerned with the nature of knowing (Papert & Harel, 1991) and how ideas "form and transform" in hands-on engagement in various contexts and media (Ackermann, 2004).

Research in developmental psychology (Piaget, 1962; Winnicott, 1971) and pretend-play in childhood (Garvey, 1990; Brosterman, 1997) shows that physical objects have a central role in children's exploration of their environment during play. Engagement with objects can support the construction of play narratives with both the real and transformed identities of the object (Fein, 1980). Several studies attest to how children use objects in play. According to Garvey (1990), objects mediate an open-ended place where children can represent their imagination. And Rossie (2001) demonstrates that children transform objects into toys, whether the object is designed specifically for child-play or not. The capacity for play that an object holds is linked to affordance, as coined by first Gibson (1966) then Norman (1988), the key facility of an environment or an object to convey its potential uses. Built-in features and embedded qualities of artifacts are suggestive in the meaning-making process through objects (Ackermann, 2007). Affordance is an essential issue to consider in the design of digitally-enhanced environments and the physical objects contained within. Children's engaged experience in an environment is defined by the materiality and the interactive potential of that environment (Crawford, 2009).

These fundamental relations between objects, space and narration in play are key in the design of digitally-enhanced play environments. It is essential to consider the intermediary role of children's everyday objects for mediating spatial narration.

3. A repertoire of forms of interaction in embodied ecologies

During play, children make use of signs they recognize in their surroundings, creating a dialogue between what is assumed to be and what could be. As they play, meaning and coherence both emerge as a result of their creative process through language and actions (Piaget, 1962).

Children perform various physical actions and interactions while playing. They interact with a small hand-held object in different ways than with a spatial element such as a carpet or a table according to the play scenario and/or the affordances of that object. Play spaces and action patterns display different forms in which children intentionally use and physically transform objects during play. In our analysis of several scenarios reported in the literature, children's interactions with objects show variation in the scale of the spatial experience, and the physical and metaphysical relations between the child and the object during play. We identify four forms of interaction in the physical environment related to body movements and spatial narration:

1. Hand-held form -- hands interacting with objects
2. Inhabited form -- transforming the physical environment that the body is in through narration
3. Abstract form -- narration through giving new meanings to objects
4. Across time and place -- connecting different times and places with digital technologies

In a playscape, all four categories can occur simultaneously. Nonetheless, this conceptual distinction of forms highlights different types of one's active engagement with their environment. In turn, this informs what type of interaction digital technologies may address in designs for spatial narration in children's playscape.

3.1. Hand-held form: Objects to transform

Children are able to transform objects into toys when they play with them. Hand-held form points at a particular kind of relation with objects that can be held and can be transformed physically. In earlier ex-

amples of how hand-held interactions are addressed in the field of child development, kindergarten aids, called the "gifts", were designed to support children in recognizing the common patterns, shapes and forms found in nature (Brosterman, 1997) and the relations between them. The Swiss educator Johann Heinrich Pestalozzi had observed that children learn through their senses and through physical activity. Pestalozzi's hands-on learning methods influenced many educators including Friedrich Froebel whose first kindergartens provided an environment with designated physical objects and physical activity. Maria Montessori extended Froebel's approaches, and she developed a framework in which manipulative materials play a constructive role. Her principles underlying the education of the senses, helped children develop sensory capabilities, control their own learning process and learn through personal exploration (Montessori, 1917). Today's kindergartens still contain diverse collections of manipulative materials such as Pattern Blocks and Lego. These materials support children's "understanding of mathematical concepts such as number, size and shape" (Resnick, 1998). Children learn to set stages and to build props to explore, enact, and ultimately work through many intriguing actions (Ackermann, 2007). The support eventually extends to making sense of and transforming everyday objects. Moreover, the "digital manipulatives", created by Resnick's group at the MIT Media Lab have computer powered traits for dynamic interaction between components and engage children in understanding and creating patterns. Physical artifacts can be digitally augmented to trigger innovative ways of interacting and discovering for children (Ishii et al., 1998) and digital manipulatives are among the best-known toys that incorporate digital technology with hands-on play blocks.

3.2. Inhabited form: Physical environments to adapt

The category of inhabited form addresses the evocative power of the physical environment. Outdoors, children seek adventure and challenge, explore and transform places to create imaginary worlds (Tovey, 2007). They rely first on their self-centered understanding of the world to navigate the environment, and after preschool, they gradually start relying on landmarks (Bechtel & Churchman, 2002). Every space has characteristics that evoke particular mental representations (Tversky et al., 1999) and until landmarks are learnt, physical features of the environment guide how they personalize the relationships with space (Maxwell & Evans, 2002). Comparative studies attest to the different spatial interactions that playgrounds and desks present to children (Bell, 2002). Examples of designs where spatial use of digital technology in the play environment guides bodily movement are Interactive Pathway Project (Seitinger et al., 2006) and The FlowSteps (Valk et al., 2012). In these, children all together engage in multiple play patterns while interacting with a large and mountable object in the environment. However, since these projects offer one shared object, the experience is limited for children's personalized narratives.

3.3. Abstract form: Objects to customize for narration

Narration is a fundamental aspect of meaning construction. The representation of experience in narratives provides a frame for children to interpret their own experiences to one another (Bruner, 1990). The category of abstract form corresponds to the meaning-making process through objects. The child's narrative language is a powerful vehicle that "allows children to designate the meanings of objects, and actions, to assign roles to people" (Engel, 2005). Research on narrative-driven pretend play shows that it requires a decoupling between the signifier and the signified (Piaget, 1962; Perner, 1993). The corollary of this proposition is, making the absent present, giving form to ideas, and bringing ideas to life. When a child uses a stick as a horse in play, s/he knows that it is not really a horse. Once the stick takes part in the child's activities, it begins to reshape her/his original ideas about horses (Ackermann, 2004). Many projects in digitally-enhanced environments that

recognize this "magical" power of objects focus on designing tangible construction kits that enable children to create their own objects. Examples are Topobo (Raffle et al., 2004) and Makerwear (Kazemitabaar et al., 2017). These construction kits typically offer components, such as sensors or actuators, that children can put together or connect to other artifacts to customize them. Another example, MaKey MaKey (Petersen et al., 2015) provides electronics to connect physical input to digital output. One of the popular examples of its use is the banana piano where fruits stand in for piano keys. The kit enables children to build their interactive toys by integrating everyday objects and computer programs. Even though these examples are of a similar scale with the hand-held objects, meaning can be attributed to the surroundings or remote objects as well. The next category achieves that to another extent.

3.4. Interaction across time and place

In addition to the spatial forms of interaction given above, experiences may extend across time and space, such as simultaneous presence in multiple places and varying temporality, as enabled by digital technology. The graphics of a previously created graphic reality, or a remote reality can be projected onto the surfaces of the physical environment. All kinds of surfaces can be augmented by digital display technology as a support for interaction. Commercially available technology such as those of Nintendo Labo, Nintendo Wii, and Microsoft Kinect use artificial visual recognition to detect and incorporate body movement in the virtual and augmented play environments. The natural feel of these interfaces blurs the line between the real and the virtual.

The physical sensing of virtual objects is absent in computer-augmented environments except while holding an implement that extends our sense of self encompassing an object of virtual reality (Shapira, 2016). When a person physically wields reality, his perception of it changes (La'davas, 2002). However, while virtual playgrounds provide children with access to a network and possible contact with the entire world from their personal physical space, they may disconnect children from physically engaging with their immediate surroundings.

These four forms of interaction in the physical environment highlight different modes of body movements relevant to children's spatial narration. Interacting with small objects, inhabited places, customizing the meanings of said objects and spaces, and virtually moving to a scene from the past or the future all provide rich experiences and constitute a vocabulary for initial design ideas. A separate set of categories for how children create narration during play is given below as a second repertoire to cross-link with these forms of interaction.

4. A Repertoire of roles in meaning construction with tangible artifacts

In pretend play, children move from real worlds to imaginary worlds and give new meanings to objects. They distribute character roles and take turns in being the narrator. Between their imagination and the physical environment, they shift from point of view to point of being to reframe the relations between the body and the world, self and other, mind and thought. This is a shift from the visual to the proprioceptive experience (Kerckhove, 2014). While point of view is visually dominant and detached from other sensorial experience, points of being privilege the sensations of the individual over its representations (Kerckhove, 2014). In her model of framing and reframing experience, Ackermann (2004) underlines the importance of a physical shift of position for a child for them to adopt different understandings. An action-perception loop mediates between embodied experiences and meaning making.

Children use narrative structures to invent and reinvent the world (Engel, 2005). In the narrative structures of pretend play, a child transforms what is to what if, for potentially both the meaning and the use of an object (See Figure 1). Children can engage with objects initially in two ways: manipulating description of object's properties or object itself. These engagements are

interrelated with object's affordances and this interrelation triggers the cycle of intentional and physical transformation of objects depending on children's narration. For these transformations, a child moves between different roles. Below, we outline three different modes of narration in play, i.e. self, avatar, and reflection. Our descriptions for each simultaneously offer evidence from eight existing projects that offer venues for these particular roles that children take on in their engagements with objects during spatial narration.

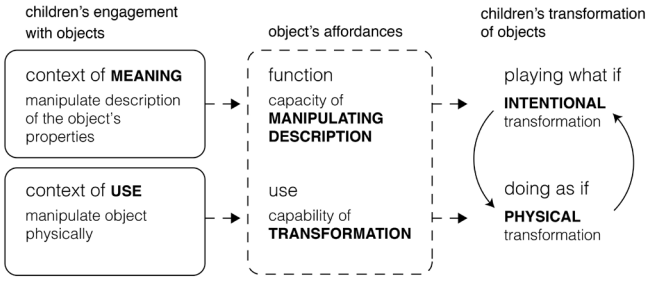

Figure 1. *Narrative structure of pretend play (created by author).*

4.1. Self: Our version of the world/ what is

Through play, the child begins to develop a concept of self. According to Piaget (1962), pretend activity begins with self-representation. For example, when a child pretend sleeps in the context of play, s/he is aware of pretense (Piaget, 1962). Pretend play adds a crucial new dimension to a child's understanding of reality. With expanding symbolic transformation into narrative play, children can differentiate and explore between the real and unreal.

A child has a perspective that gradually develops. Piaget (1972) writes that "the young infant relates everything to his body, as if it were the centre of the universe but a centre that is unaware of itself". An infant's isolated actions such as sucking, looking, and grasping are centred on her own body. When the infant conceives of objects only in terms of her actions on them, she has not yet differentiated the object from her own action on it. Decentration occurs in the infant's first two years after which s/he no longer feels at the centre of the universe but now recognizes herself as part of a world of other objects (Piaget, 1972).

Various designs for interactive narrative environments for children have emphasized the value of the role of objects in cognition. For example, the POGO environment, developed by Decortis and Rizzo (2002), supports the development of children's narrative competence by providing them the opportunity to express themselves through different media channels. The circle of narration starts from the sensorial knowledge of reality and returns to a different version of it through an active transformation of the environment. This environment supports children to express themselves in building a world model. POGO players can capture and manipulate images in various media and combine them in sequential forms to create visual narrations.

4.2. Avatar: Character roles/ what if

In pretend play, children need to view a situation from someone else's point of view. This supports individual's personal and cognitive growth (Piaget 1962; Winnicott, 1971). With character toys children can create interrelationships and plots while practicing their social knowledge (Shantz, 1975). These toys are tangible interfaces that can empower children in constructing personal narratives. A child can talk to her character toys who do not really listen to her. Continuing an "illusion of magical thinking and captive listeners" (Vaucelle, 2010), the child can practice her narrations on imaginary accompanists.

The child may choose to use not only an exterior prop such as a toy but also oneself as a prop (Vaucelle, 2010). In human-computer interaction, this role-playing brings about avatars. Avatars are virtual representations of humans controlled completely by the owner and other agents. An avatar reflects real time behaviour of its human counterpart whereas an agent reflects behaviour according to "a computational algorithm designed to accomplish a specific goal or set of goals" (Bailenson and Blascovich, 2004, p. 64). These environments encourage children to take perspective through narrations.

Several projects build character-based-narrative environments to support children in building their own

narrative pet or character. Three early examples with character-based interactive environments encourage children to construct narrations through characters. In the first with the improvisational puppets (Hayes-Roth & Gent, 1997), children explore different character actions and reactions while manipulating the puppet-characters. Adding emotive facial expressions on the computer screen, Personal Electronic Tellers of Stories (Druin et al., 1999) provide a robotic environment where children name their robotic companion and compile a library of stories. SAGE is another collaborative narrative environment that invites children into a three-way interaction between the child, computer and a stuffed animal (Bers et al., 1998). The stuffed animal becomes the child's listener instead of being the hero of the child's story and holds stories that the child chooses to tell. The children in SAGE can create their own characters and databases of stories, while exploring different notions of self and performing the narrative voices they want or need to hear.

4.3. Reflection: Perspective taking/ what is and what if

During play, children acquire the foundations of self-reflection and abstract thinking to develop complex communication and meta-communication skills (Bateson, 1976). Related to this, metacognition is an awareness of one's own cognitive processes and thinking (Flavell, 1979; Fisher, 1998). Piaget & Inhelder ([1969] 1993) have pointed out that it is possible to engender in children an inner discussion and that later on, this inner discussion starts a kind of reflection.

Metacommunication is fundamental in the development of shared understandings between children as they play together (Bateson, 1976). These shared understandings among co-players are what Bateson calls "play frames" and determine children's actions in a play episode. Play frames are situations when children talk in character about what their characters will do as well as the props they will choose. They are essential for the development of children's self-reflection and the awareness of the rules of communication (Fein, 1980). Children learn to monitor and direct their own progress, asking questions such as "what am I doing now, what else could I be doing instead?"

In narration, voice can be of a narrator, a character, or the author speaking as herself (Cassell & Ryokai, 2001), and can be a tool of reflection as well. There are examples of digital narrative platforms that support voices for individuals or for peer collaboration. Some combine physical objects with digital data. For instance, StoryMat is an augmented digital map that records, stores and recalls children's narrations (Cassell & Ryokai, 2001). It stores not only voices but also the movements of the toys the children play with. It offers a place to experience collaborative narratives regardless of the presence of a co-temporal and co-spatial playmate. Differently, the DiamondTouch table invites children to collaborate over shared digital media (Dietz and Leigh, 2001). And in another example, I/O Brush, children use a paintbrush to gather color, texture, motion information from their surroundings in order to build their visual narrations and share them with their peers digitally (Ryokai et al., 2004).

Overall, the eight projects referred to in the sections above show how an interactive environment that seamlessly supports the self, the avatar and reflection roles dynamically. While POGO and KidsRoom support children to look at their environment more actively and express their way of looking at the world, Improvisational Puppets and Personal Electronic Tellers of Stories and SAGE are designed as platforms for creating character toys for children as their own playmate when narrating. StoryMat and The DiamondTouch Table support collaborative narration and can be also considered as augmented furniture that sustains daily spatial experience. I/O Brush invites children to look at their environment more actively. Blended environments can also offer children intermediary platforms to simultaneously take on different roles and create collaborative spatial narration even when children are at different locations. Narrations that extend across different roles, times and places

constitute a fourth mode.

4.4. Narration beyond time and place

It is already established that children construct stories with characters they identify with and objects that can be held, moved, transformed. Their actions with objects facilitate transitions between thoughts and situations (Turkle & Papert, 1990). In digitally-enhanced environments, these transitions can be to virtual worlds. Referring to some of the examples already mentioned above, a narrative in KidsRoom (Bobick et al., 1999) ties the physical space, the participant's actions, and the different output media together into a coherent experience. A child's own room might stimulate the child's imagination by using images and sounds to transform itself into a fantasy world. As POGO (Fusai et al., 2003) supports different media channels, children can use several interactive tools to compose, edit and perform stories in a virtual world. A simple setting of distributed tools provides a seamless integration of the physical and virtual world through intuitive interaction modalities. This causal link between the physical and the digital enable children to plan what is happening and why, and from this plan precipitate further experiences and interactions.

5. Design principles of digitally-enhanced environment for spatial narration

As articulated in the section above, digitally-enhanced environments can support the reciprocal relation between actions and the environment in children's play by revisiting the role of objects and the actors who manipulate them. Digital interactive technologies can provide unique feedback to children and allow them to be in control of the flow of their play through interventions. The feedback can motivate children to move around in space, pick up and manipulate, or add objects. In line with the categories presented above, we infer below a list of general guides for the design of digitally-enhanced narrative places that sustain bodily and sensorial experiences that support children in constructing their own rules and meaning:

1. Inventing Tools by Manipulating the Object
2. Becoming a Playmate
3. Switching Roles in Collaboration: Planner and Player
4. Being Here and There: traveling across spaces

These follow the categories of children's interaction and roles in narrative play and can be used as guides to integrate the physical environment and the digital environment to the child's playscape narratives.

5.1. Inventing tools by manipulating the object

The first principle is to design an environment to allow children to explore through engagement with objects. Physical engagement with objects can provide intuitive models of interaction where children can develop their own way of expression. Using an object in pretend play, provides children to construct their own spatial narration. While creating their own narratives, children explore their environments (what is) and through their imagination, they also investigate new ways of looking at their environments (what if). Addressing learning through making, Papert's approach shows that the use of external objects helps for self-directed learning that "learners invent for themselves the tools and mediations that best support the exploration of what they most care about" (Ackermann, 2004).

One's physical use of an artifact may turn into a central role in the immersion and engagement activity. If there is also a reaction that transforms the object into a new use or meaning, this role is similar to that in the reflection in action coined by Donald Schön (1983) for designers. In the context of design, action is the trigger of a reflection where following the experience upon the action, the designer switches perspective. Accordingly, a digitally-enhanced environment may enable children to construct their own narratives using physical objects.

5.2. Becoming a playmate

In addition to providing physical objects to interact with in digitally-en-

hanced environments, it is important for children to be able to observe the impressions their moves and engagement with objects create. The idea of triggering reflections provides children to create their narration by interpreting their environment. In doing so, children can experiment character roles and the casual relationship between their action and interaction. Children construct and move within alternative worlds while acting out different roles. Through narration, children develop their own idiosyncratic view of things and also ways of expression (Engel, 2005). Spatial experience may enable children to build their schema, by exploring their reflections among digital and physical environments. Within the context of human-computer interaction, through display surfaces, children manipulate tangible props and observe the augmented scene. They can observe the results of their actions on the augmented scene displayed on a screen. This enables them to perceive and observe the effects of positions by interacting with the system. It may enhance their understanding of the causal links by spatial experiences. Current examples show that augmenting surfaces can act as an interaction modality. Displays are usually used as access layers to common information spaces where children manipulate images through common sets of rules. Digitally-enhanced environments can promote interaction with physical objects and surfaces that children are playmates to or have as playmates.

5.3. Switching roles in collaboration: Planner and player

In the context of play and its relationship to engagement with physical objects and their reflections, the interaction between the children themselves is also essential. This can support children to transform the place that facilitates multiple roles and perspectives to them. During play, children point out things to one another, share their findings, and instruct one another by making up rules. They switch between the roles of the planner who makes up the rules, or the player who performs them. The making up of rules can be through engagement with an object that is also an intermediary for switching one's role from planner to player. Sharing roles, taking turns, and thinking about the activity and the events from another's point of view creates a collaborative environment. Such a collaboration may stimulate the children to externalize their thoughts and share their experiences with others (Price et al., 2003) and such communication between children is likely to enhance their level of engagement, their ways of exploration and ability to reflect on their own experiences. To enable this communicative cycle, digitally-enhanced environments can create semantic links between the use of physical objects and environments where different roles can occur. Physical activity with objects helps to associate new meanings in the physical environment.

5.4. Being here and there

Being actively engaged with the physical and digital environment, whether it is when interacting with another child, an object, or the space, can enhance children's understanding of their actions. Our movements constitute a continuous interaction between our bodies and the environment while the structures governing our sensory faculties characterize our tactile and visual exploration of it (O'Regan and Noë, 2001). While, in tactile exploration, a part of the body touches an object partially or fully, visual exploration reverts to some previous tactile knowledge of the sensed object alongside of the visual attributes.

Physical interaction with objects can trigger new visual explorations and reflections and these capacities are often utilized in play. For instance, objects can be presumed to be bridges or doors for players to move from a physical environment to a digital environment. Digitally-enhanced environments can specify the degree to which the designated object enables travel among environments.

6. Conclusion: Future of playscapes

Addressing the potential of digitally-enhanced environments for children's narrative worlds in pretend play, we identify key features that frame ways to introduce spatial narrative into

playscapes. In the intersection of the fields of design research, child development, and HCI, we present a framework for designing environments for children to co-construct narratives, engage in active exploration and reflect on narrative experiences.

The overview presented here is trifold. Firstly, we categorized the different forms of interaction observed in relevant examples of digitally-enhanced narrative environments for children. The criteria were the distinction of physical and metaphysical scales of the interaction. These categories are the basis for exploring spatial features necessary for children to infuse imaginative play into their everyday places of inhabitation. Secondly, we delineated the narrating behaviors of children in playscapes, based on patterns of full-body engagements with object/space in educational psychology literature and in recent HCI practice. When coupled with the various forms of interaction, these yield to the potential features, both digital and physical, of playscapes. Thirdly, we established four basic design principles for digitally-enhanced playscapes that encompass the categories of interaction and the repertoire of roles towards promoting children's bodily interactions with everyday objects.

By concentrating on narration-heavy pretend play, we expand children's spatial experience in digitally-enhanced environments to encompass active engagements with objects. The framework with categories of interaction and repertoire of roles embodies a unifying approach to designing an environment that sustains the values of bodily and sensorial experiences of playing children. It can also be seen as a formulation of criteria of the essential qualities for spatially enabling narration in play. What is identified as design principles refers to the set of desired affordances for the environment to be designed. It embodies the kinds of experiences for which to reconfigure the physical and digital worlds as well as the sensory and symbolic modalities of interaction.

In order to bridge embodied experience and the construction of meaning, an awareness of the role of the body

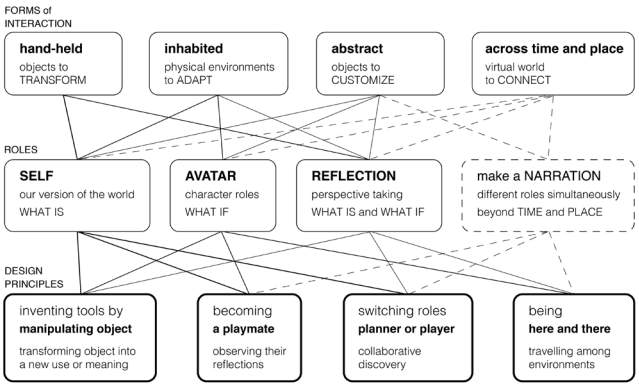

Figure 2. *The links between forms of interaction and narrative behaviours to reveal design principles of digitally-enhanced environment for spatial narration in children's playscapes (created by author).*

and spatial narration in a child's experience is an essential groundwork. Next steps include investigating techniques for creating models of pedagogical planning while undertaking the design of a prototype. Employing an iterative process of designing new environments, implementing prototypes, and conducting empirical studies can further articulate the parameters of narrative-centered playscapes. In ongoing related work, we specifically develop a digitally-enhanced physical play environment that articulates narrations in action with visuals. The premise is to enable children to establish dialogues between fact and fancy, as well as between the eye and the body as they see the results of their thoughtful actions with objects-in-the-world. Thus, we are motivated to use surfaces for display to provide children's own images synchronously to enable the reciprocal connection between the digital and physical environments. By moving around and adding objects to the physical space, children can fictionalize the meaning of that space and compose their own narration embedded in that physical playscape with feedback from a digital environment. The dynamic cycle of action, observation and reflection in the active interface of thus transformed components of an architectural space can continuously create variations that enrichen children's spatial experience and narrative.

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ITU A|Z • Vol 17 No 3 • November 2020 • 169-183

Trends in interoperability in building information modeling (BIM) research: A scientometric analysis of authors and articles

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Received: December 2019 • Final Acceptance: March 2020

Abstract

Stakeholders with various backgrounds from different industries join together to realize a construction project that is unique in nature and is developed by an ad-hoc community. This type of formation shapes a dynamic and cooperative organization. Building information modeling (BIM) technology can be a valuable asset for sustainable, energy-efficient, safe and cost-effective building production. However, the content and context of the construction projects increase the size and complexity of data to be communicated, which in turn results in data loss throughout the demanding and costly project life cycle. Interoperability is the key to handle the data loss problem. The main aim of this research is to picture the status and trend in "interoperability" in BIM research with adopting bibliometric search and scientometric analysis for a broader understanding. Data were collected through an intensive investigation of interoperability in BIM research and selected through using Boolean Syntax, operators, and further limitations. 477 articles from the Scopus database were utilized for scientometric analysis and mapping. The research gaps were diagnosed. The potential future research needs and trends of interoperability in BIM research were proposed. Further, the classification of articles in the research field was suggested as "collaboration and sustainability-based", "BIM adoption", "BIM implementation at process-level", "BIM implementation in-country and at industry-level", and " BIM integration". The research results are expected to contribute to academicians, professionals and industry stakeholders for understanding the gaps and trends in interoperability in BIM research.

Keywords

Article analysis, Author analysis, Building Information Modeling, Interoperability, Scientometric analysis and mapping.

doi: 10.5505/itujfa.2020.79026

1. Introduction

Most of the construction professionals in the construction industry prefer to use Building Information Modeling (BIM) to minimize data loss and ensure integrated high-performance construction project life cycle (Azhar et al., 2012, Onyenobi and Arayici, 2010). BIM is an information platform that is a single fully integrated database that can be created and used seamlessly and sequentially by the design team, construction team, and operators throughout the project lifecycle (Yalcinkaya and Singh, 2019b; Azhar et al., 2012; Shadram et al., 2016; Oh et al., 2015). BIM has the critical model information that plays role in increasing productivity and continuity, decreasing environmental damage, reducing waste of time and cost, adding value to the industry, provide the functional performance of occupants (Zhang et al., 2017; Ma et al., 2018; Heigermoser et al., 2019; Jin et al., 2019; Ugliotti et al., 2016). The best way of communication over data is the integration and interoperability. Architecture, engineering, construction, operation and facility management (AECO/FM) industry needs solutions for the interoperability problem, which is an obstacle for BIM implementation in turn for time and cost-effective construction projects. Interoperability is the way of using different systems to communicate with a basic communication protocol (Yalcinkaya and Singh, 2019a; Pauwels et al., 2011; Venugopal et al., 2012; Chen, et al., 2008). Therefore, protocols and standards have become important to prevent data loss during information sharing, use, and reuse, and for better coordination, and communication. There are international standards, file extensions and spreadsheet formats that are important tools to support BIM for increasing data integration, communication between stakeholders and data hierarchy in BIM research. However, problems in interoperability still exist which negatively effects BIM implementation, BIM adoption, and BIM-related industry concepts (Pauwels et al., 2011; Venugopal et al., 2012). Author and article based scientometric analysis and mapping of "interoperability" in BIM research were realized in this paper to enlighten the impact of authors and articles in the research field. The following parts of the paper express the related research in the field, the gaps, and trends in the research area and conclude with suggestions for future studies.

2. Research background

BIM, as a process of managing building information in an interoperable format, has been studied by researchers recently. BIM is used as a platform for integrated building information that can be utilized throughout the project lifecycle. The data loss throughout the project lifecycle is the main problem in technologically collaborative working environments. Interoperability is the key aspect of solving data loss problems for fully integrated systems. Interoperability is a prerequisite for an integrated system that improves the efficiency and effectiveness of project processes. Interoperability allows diverse software and hardware systems to work together in an integrated manner, which in turn enables integrated project delivery. A robust BIM adoption and implementation can be possible via solving interoperability problems.

2.1. BIM

For many years, architects and engineers that are interested in the construction industry tried to find new methods and ways to build better structures. With the rapid advancement of computing and information technologies in the past two decades, various systems and new technologies have been developed and deployed. The common meaning of BIM knowns as "a digital representation of physical and functional characteristics of a facility and a shared data from the beginning of the project" (Isikdag and Underwood, 2010; Yalcinkaya, 2016; Cavalliere et al., 2018). Because of the complexity of the BIM as an integrated data platform, systems integration, which depends on interoperability, becomes an important prerequisite to achieve efficient and effective adoption and implementation of BIM (Jiang et al., 2016; Vanlande et al., 2008; Pauwels et al., 2011).

2.2. Data exchange and interoperability

Construction project lifecycle consists of initiation, planning, construction, monitoring and controlling, closure, facilities management, and demolition processes throughout which multidisciplinary collaborative work occurs (Gu and London, 2010; Shen et al., 2010; Kent and Becerik-Gerber, 2010). The widespread responsibility area throughout the project life cycle triggers the requisition of interoperable applications for immediate adaptation to BIM adoption. The project team uses various tools to handle with above-mentioned processes. There is plenty of software to handle all the aspects of the project throughout the lifecycle. There is not any unique software that can manage the information of all professions. Interoperability is the seamless data exchange at the software level among diverse applications, each of which may have its own internal data structure (Grilo and Jardim-Goncalves, 2010). However, interoperability is not only the exchange of data but also the exchange of meaning. Interoperability is achieved by mapping parts of each participating application's internal data structure to a universal model and vice versa." (Tommasi et al., 2016; Grilo and Jardim-Goncalves, 2010). Standardization of data for transformation from the internal data structure to an adaptable universal data structure can be achieved through interoperability studies.

Data exchange is vitally needed along with the interoperability of data among cooperative units of projects. Therefore, interoperability via exchange formats is the key concept to determine the data exchange capability of different programs (Eastman et al., 2010; Venugopal et al, 2012). The transformed data consists beyond graphical data such as; geometrical features, energy-related, structural, quantity, material, cost, temporal, and so on. The quality of models increases with fully equipped object-oriented parametric data which leads the collaborative successful processes. For this reason, researchers work on interoperability issues to improve BIM implementations (Irizarry et al., 2013; Redmond et al., 2012; Shadram et al., 2016). BuildingSMART proposed a data standard called industry foundation classes (IFCs) to address the interoperability and data exchange issue for architecture, engineering, and construction professionals. Starting from 1997, IFC Schema is published and IFC4 is the latest issue as of today. Some of the commercial software systems for construction projects adopted an IFC data format for interoperability. However, there are still data errors and data loss (Jeong et al. 2009). In order to establish a collaborative working platform through BIM implementation, interoperability among data files of various disciplines has to be realized for robust data exchange.

- *IFC (Industry Foundation Class):* IFC format is used for information exchange (Redmond et al., 2012; Eastman et al., 2010; Pauwels et al, 2011; Venugopal et al., 2012). The data that it contains forms an object-oriented data model. The model has the system for representing the geometrical attributes and quantities of the objects. The objects like walls, columns, beams, slabs, doors, etc. are represented with their respective costs, schedule, technical information, etc. The latest version of the IFC standard is IFC 4 and approved as ISO 16739 standard. MVD (Model View Definition) defines the specification that is related to the data model. MVD classifies and describes the needed particular information for a specific use. The requested data for a specific validation model must be well defined in a contract.
- *IFD (International Framework for Dictionaries or Data Dictionaries):* While IFC is used to describe elements and processes, IFD, as a data dictionary, forms common understanding by defining the elements and their parameters. IFD is a feasible method, which allows generating product and processes equipped with specific data on IFC-BIM linked to existing knowledge systems for facility management. Moreover, data on the IFC-BIM has translation capability via IFD (Lin et al., 2016).

- *IDM (Information Delivery Manual):* IDM, as the standard of capturing the processes and information throughout the building lifecycle, ensures the quality of communication amongst project stakeholders through increasing the awareness and knowledge of participants with sharing data (Eastman et al., 2010; Arayici et al., 2018)
- *MVD (Model View Definition) / Cobie:* During the project lifecycle, data, content or IFC files' exchange methodology is specified by the model view definition (MVD), which is a standard that supports overall IFC schema (Lee et al., 2016a; Venugopal et al., 2015). National Institute of Building Sciences and building SMART have been working parallel with FM data exchange technologies. National Institute of Building Sciences approved Construction Operations Building Information Exchange (COBie) is an international standard for data exchange, which can be used for Facilities Management (FM). The data can be changed by using it not to lose any information from IFC during the operation (Yalcinkaya and Singh., 2015). COBie standard as part of its NBIMS-US (National Building Information Model) standard. The product of the joint effort of both institutions is Version 3 of the COBie standard. COBie, with the name "Basic IFC Handover View", is an official buildingSMART IFC MVD. BS 1192-4:2014 collaborative production of information Part4: Fulfilling employer's information exchange requirements using COBie – Code of practice is a British standard specifically dedicated to COBie. MVD is a diagram defining the method and content of information exchange for a specific use or workflow. MVD documentation leads the easy, fast, and consistent repeated data exchange among a variety of projects or software (Lee et al., 2016b; Venugopal et al., 2012). The object, relationship, representation, attribute, and concept need of receiving stakeholder is identified and the data to be exchanged is narrowed with an MVD. Since MVD are data-centric, the extent of and content of the model view is determined by the receiving stakeholder's information needs and by the workflow.
- *bSDD (Library respective building SMART Data Dictionary):* The building SMART Data Dictionary (bSDD) is a shared library serving for the AECO/FM industry, which consists of objects and attributes to build a common understanding among stakeholders through providing meaning. bSDD utilizes ISO 12006-3 ontology. The library shares data for construction project stakeholders (architects, engineers, owners, consultants, operators, manufacturers, suppliers, etc.) and is open access and international platform for sharing object and attribute data regardless of language. It is useful for fast, reduced cost, and high-quality data exchange for modeling. bSDD, as a semantic mapping tool, separates the words in any language and connects similar tools based on their meaning by identifying the concepts that the word represents in the construction industry. Common technical language library provides a platform, which may improve collaboration, coordination, cooperation, and communication through a robust knowledge share in the construction industry. bSDD not only translates the meaning but also rearranges the classification systems by mapping. An automatically generated ID number called GUID (the Global Unique Identifier) is needed in bSDD as a unique and language-dependent serial number. GUID number is assigned to each term and definition in bSDD.
- *Plug-in:* Even different BIM software belong to the same modeling category, they individually have own principles. Data exchange can also be achieved via plug-ins, by which the communication among programs is realized. Therefore, programs release new versions with associated plugins for export and import functions. the data exchange may be one-directional or bi-directional (Ugliotto et al., 2016; Gokce et al., 2007).

The time and content of the data to be shared are defined by IFC format, described by IFD format, and permitted by IDM format. The aforementioned standards identify the content of various interoperability levels. Understanding where to apply the format in the interoperability environment is possible with identifying data exchange format and the relationships.

3. Methodology

In this research, an intensive investigation of the literature is realized to acquire data for the scientometric analysis and mapping of the published works regarding interoperability in BIM to obtain an objective view of the current and future tendency of the research field. Researchers suggest three steps to apply for a powerful investigation of the literature (Booth et al., 2012; Petticrew and Roberts, 2005; Denyer and Tranfield, 2009). Conducted steps in this research are namely; planning the investigation, conducting the investigation, and documenting the investigation. The literature investigation approach used in this research has three-steps presented in Figure 1.

3.1. Planning scope of search

BIM search has a wide range of research branch diffused to each other for collaborative building delivery. The research fields consist of but not limited to project management, construction engineering and management, construction automation, structural analysis, performance analysis, facility management, integration of new technologies, and so on (Cao et al., 2018; Mangal and Cheng, 2018; Pinheiro et al., 2018; Ramaji and Memari, 2018; Rodrigues et al., 2018; Santos et al., 2017). This research focuses on interoperability in BIM research. The scope of the research covers the fields of AECO/FM research topics related to the whole project life cycle consisting of pre-construction, construction, and post-construction phases.

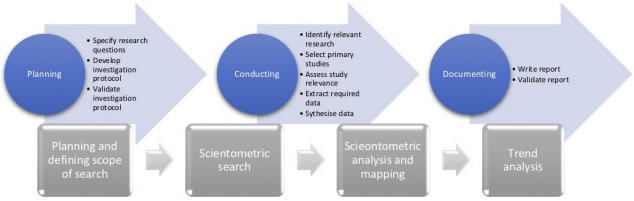

Figure 1. *The three-step workflow of investigation of interoperability in BIM research.*

3.2. Conducting the research

The bibliometric search of articles of interoperability in BIM research was performed in one of the mainstream search engines for scientific researches that are called SCOPUS. Since Scopus coverage of sources is wider than any other database (Aghaei-Chadegani et al., 2013), this paper utilized the Scopus database for realizing its scope. Scopus's search API uses a system called Boolean Syntax for combining keywords with applying operators to consolidate search results for refined data at the end. The data from the Scopus database was used for scientometric analysis to apply science mapping over empirical data, which obtains a display of dynamic and structural aspects of the search area (Cobo et al., 2011). This method minimizes the tendency in prejudgment through intensive and extensive literature investigation of studies related to a particular subject and provides empirical evidence to provide a roadmap for future studies. The aim of using scientometric analysis and mapping in this research is to illustrate the relationship among the most impactful authors and articles in the domain in "interoperability" for BIM research. To realize this aim, VOSviewer software was used for visualizing networks using natural language processing (NLP) algorithms and text-mining. The imported data from the Scopus database about the authors and article was utilized to visualize, compute, and analyze in VOSviewer software. The covert analysis results visualized via mapping and clustering techniques.

3.3. Documenting search

In this research, a quantitative research technique was used to focus on understanding all aspects of interoperability in BIM research. The information gathered provides a deeper understanding of interoperability in the AECO/FM and was used to generate recommendations for the AECO/FM industry. Following the scientometric mapping, a scientometric analysis

was realized in this study. The potential research direction in the field and possible emerging hot topics for future research were proposed for interoperability research for BIM.

4. Scientometric analysis results

The scientometric search was realized via using following terms and operators; TITLE_ABS_KEY: ({interoperability} AND {BIM} OR {Building Information Modelling} OR {Building Information Modeling}) (Figure 2). The search resulted in 2091 articles with predefined keywords in Scopus. Since English is identified as an academic language, the articles written in other languages were excluded (Butler and Visser, 2006). The language limitation decreased the results to 2052 articles. The other types of documents like conference proceedings were excluded from and only journal articles were included (Butler and Visser, 2006). The limitation narrowed the publication number to 886 articles. The search was refined by adding further limitations to consolidate articles related to interoperability in BIM research. The studies that include both interoperability and BIM at the same time were taken into consideration and the studies that include one of them but not both were excluded for a more focused search. Then the paper numbers were decreased to 518. The subject area of the articles was limited to the construction-related main subject areas. The Number of papers finally resulted in 477 articles to be used for the scientometric analysis.

4.1. The literature sample size

The first Scopus-indexed journal article mentioning "interoperability" in BIM for AECO/FM is in 2004. The literature from the first mention of 'interoperability' in BIM research from 2004 to date was reviewed. The number of papers was displayed yearly in Figure 3. There is considerable arise in article numbers to date. The interest in the research field critically accelerated in 2009 with a rate of approximately 385% increase. Especially in the last five years period (the article number of 2019 could not be completely monitored by the time the paper is prepared), the annual average

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{interoperability} AND {BIM} OR {building information modeling} OR {building information modelling} AND ( LIMIT-
TO ( LANGUAGE , "English" ) ) AND ( EXCLUDE ( LANGUAGE , "Italian" ) OR EXCLUDE ( LANGUAGE , "French"
) OR EXCLUDE ( LANGUAGE , "German" ) OR EXCLUDE ( LANGUAGE , "Portuguese" ) OR EXCLUDE ( LANGU
AGE , "Spanish" ) ) AND ( LIMIT-TO ( DOCTYPE , "ar" ) ) AND ( LIMIT-TO ( SRCTYPE , "j" ) ) AND ( LIMIT-
TO ( EXACTKEYWORD , "Building Information Model - BIM" ) OR LIMIT-
TO ( EXACTKEYWORD , "Interoperability" ) OR LIMIT-TO ( EXACTKEYWORD , "Building Information
Modeling" ) OR LIMIT-TO ( EXACTKEYWORD , "Building Information Modelling" ) OR LIMIT-
TO ( EXACTKEYWORD , "Building Information Modeling (BIM)" ) OR LIMIT-TO ( EXACTKEYWORD , "Building
Information Modelling (BIM)" ) OR LIMIT-TO ( EXACTKEYWORD , "Data Interoperability" ) OR LIMIT-
TO ( EXACTKEYWORD , "Building Information Model" ) OR LIMIT-TO ( EXACTKEYWORD , "Building Information
Model (BIM)" ) ) AND ( LIMIT-TO ( SUBJAREA , "ENGI" ) OR LIMIT-TO ( SUBJAREA , "COMP" ) OR LIMIT-
TO ( SUBJAREA , "BUSI" ) OR LIMIT-TO ( SUBJAREA , "ENVI" ) OR LIMIT-
TO ( SUBJAREA , "SOCI" ) OR LIMIT-TO ( SUBJAREA , "ENER" ) OR LIMIT-
TO ( SUBJAREA , "DECI" ) OR LIMIT-TO ( SUBJAREA , "ARTS" ) OR LIMIT-
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TO ( SUBJAREA , "MULT" ) ) AND ( EXCLUDE ( SUBJAREA , "MATH" ) OR EXCLUDE ( SUBJAREA , "EART" ) O
R EXCLUDE ( SUBJAREA , "MATE" ) OR EXCLUDE ( SUBJAREA , "CHEM" ) OR EXCLUDE ( SUBJAREA , "CEN
G" ) OR EXCLUDE ( SUBJAREA , "MEDI" ) OR EXCLUDE ( SUBJAREA , "PHYS" ) OR EXCLUDE ( SUBJAREA , "
BIOC" ) )
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Figure 2. *Scientometric search input summary.*

article number increased around three times. The trend of interoperability in BIM research shows an incredibly high growth performance. The increasing interest in the research area evidences the major impact of it on the scientific platform. The graph visualizing the sharp growth line highlighted the possible improvement in the research field for the future.

The distribution of research outputs about "interoperability" in BIM shows that the researchers tend to publish about interoperability in Engineering (53.7%) and Computer Science (19%) research domains followed by Business and Management (14.1%). There are supportive contributions from other research domains such as; Environmental Science (3.3%), Social Sciences (3.1%), Decision Science (2.7%), Energy (2.5%), Arts and Humanities (1.1%), Economics (0.3%), and Multidisciplinary (0.3%). The technical structure of the research domain results in researchers' tendency on engineering and computer-based domains. Therefore, most of the interoperability studies place in Engineering and Computer Science research domains. In terms of research density, the technical

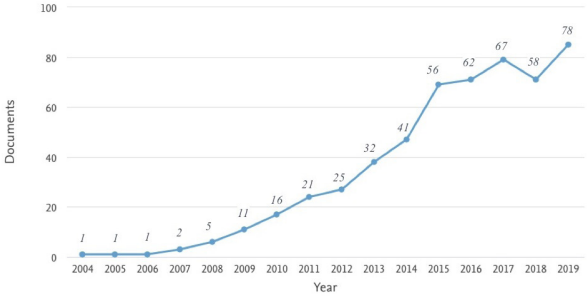

Figure 3. *Yearly Number of papers from 2004 to 2019. (Note: The number of papers in 2019 is not complete as the articles selected in 2019 were up to the end of August 2019).*

part of the research is followed by Business and Management, which includes a major implementation area such as facility management. However, the industry has yet to considerably utilize interoperability throughout AECO/FM activities.

4.2. Scientometric analysis and mapping of authors

Authors that studied about interoperability in BIM were mapped via VOSviewer software to understand their impact on the research field and relatedness among each other. Figure 4 shows the network visualization map of citation analysis of authors with a minimum number of 1 document and with a minimum number of 310 citations per document of an author. There were 15 authors, who met the threshold. Data related to authors were tabulated in Table 1. Figure 4 depicts a sharp distinction that represents the research tendency of authors. From afar perspective, research areas may be separated into two branches namely; *interoperability in BIM theory research* and *interoperability in BIM practice research. "Interoperability in BIM theory research*" cluster represents the studies including ontology, framework, standards, and technical integration kinds of BIM theory approaches. *"Interoperability in BIM practice research*" cluster represents the studies including BIM implementation approaches related to applications, adoption, implementation, and practical integration of all BIM framework, standards, codes and etc.

The citation analysis of authors result was presented with a network visualization diagram in Figure 4. The lines, colors, and distance between circles show the relatedness of author pairs by mutual citations. The color of the circle indicates in which cluster the author's scope falls within. The link lines between the authors displays inter-relations among authors. The distance between authors identifies the relatedness of the authors in terms of citation links. Figure 4 illustrates circles to represent authors. The size of circles and labels of the author is determined by the weight of the author. The higher contribution of the author to the research area, the larger is the size of the circle and the font. *R.L.R. Jardim-Goncalves, C.M. Eastman, R. Sacks, and A. Grillo* are among the most influential authors.

Seven major quantitative factors; Field-Weighted Citation Impact (FWCI), the article number of author related to interoperability in BIM research, the total article number of authors, the percentage of the related field article number of the author within all her/his article numbers, H-Index (Hirsch Index), link, total link strength (TLS), and average normalized citation data about the authors were tabulated in Table 1. FWCI metric is useful to benchmark regardless of differences in size, disciplinary profile, age and publication type composition, and provides a useful way to evaluate the prestige of a researcher's citation performance. FWCI considers the differences in research behavior across disciplines. FWCI is the ratio of the total citations received by the author's output, and the total citations that would be expected based on the average of the subject field. An FWCI of greater than 1.00 indicates that the publications have been cited more than would be expected based on the world average for similar publications. FWCI metric was used to benchmark and evaluate the prestige of a researcher's citation performance. The FWCI results depict that B. Becerik-Gerber is the highest-ranked author in the field of "Buildings | Construction Industry | Information Modeling" (the

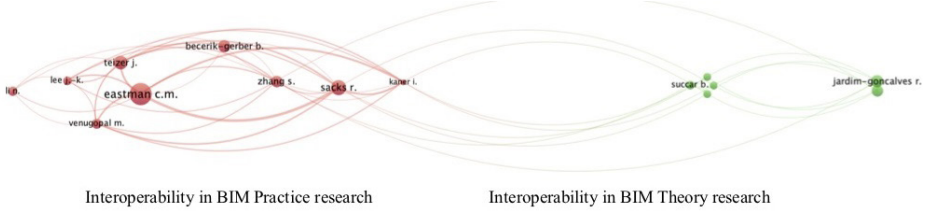

Figure 4. *Network map visualization of authors focused on interoperability in BIM research (between 2004-2019).*

Scopus defined field) in terms of citation performance compared to other researchers. Article numbers related to interoperability in BIM research show the authors' tendency in the research field. R.I.R. Jardim-Goncalves, C.M. Eastman, and R. Sacks have the highest number of articles related to interoperability in the BIM research field. The total number of articles indicates the contribution of the author in the whole literature. *R.I.R. Jardim-Goncalves, J. Teizer, and C.M. Eastman* have the highest total number of articles. H-index measures the impact of an author on the literature. The highest H-index belongs to *J. Teizer, R. Sacks, B. Becerik-Gerber, and C.M. Eastman*. The links attribute indicates the interrelatedness of the given author to other authors. The total link strength attribute indicates the strength of the relationship of an author with other authors. The highest scored link number belongs to *J. Zhang, R. Sacks, I. Kaner, C.M. Eastman, and J. Teizer.* However, TLS shows the most interrelated authors in terms of citations are J. Teizer, I. Kaner, and M. Venuggopal. The average normalized citation indicates the average normalized number of citations received by the documents published by an author. However, *C.M. Eastman, R. Sacks, and J. Teizer* score the highest three average normalized citation values between 2004 and 2019 among interoperability in BIM researchers.

The highest FWCI, H-index, links, total link strength, and average normalized citation scores belong to authors in the Interoperability in BIM Practice (Table 1). The results of the citation analysis of authors indicate that the major impact authors and articles of the interoperability in BIM research is within *"the Interoperability in BIM Practice"*. Authors studying the interoperability issues in BIM practice may get more citations, stronger links with other authors and may increase H-index and FWCI scores.

Table 1. *The authors focused on the research of interoperability in BIM (between 2004-2019).*

Cluster Name	Author	FWCI	Ar. Num. related to Subject	Total Num. of Art.	H-index	Link	TLS	Ave. Norm. Citation
Interoperability in BIM Practice (Red-coded)	Becerik-Gerber, B.	1.64	3	124	30	5	5	10,33
	Eastman, C.M.	1.29	23	146	30	8	16	21,03
	Kaner, I.	---	4	4	4	10	43	4,08
	Lee, J.K.	1.29	5	48	11	7	25	6,61
	Li, N.	1.29	1	58	14	5	6	7,49
	Sacks, R.	1.29	13	123	34	10	6	13,07
	Teizer, J.	1.29	5	152	36	8	49	11,75
	Venuggopal, M.	1.29	2	9	16	7	40	7,77
	Zhang, S.	1.29	2	17	11	11	27	9,40
Interoperability in BIM Theory (Green-coded)	Broquetas, M.	---	1	1	1	5	5	5,97
	Bryde, D.	1.29	1	50	15	5	5	5,97
	Grilo, A.	0.93	2	90	14	5	11	9,78
	Jardim-Gonçalves, R.L.R.	0.93	44	248	20	5	11	10,45
	Succar, B.	1.29	3	6	6	4	4	6,92
	Volm, J.M.	---	2	2	2	5	5	5,97

* Topic Field-Weighted Citation Impact: shows how well the documents in the topic are cited compared to similar documents. A value greater than 1.00 means the documents are more cited than expected.

* "---" Refers to the documents which were published earlier than 3 years. So that Topic FWCI cannot be calculated.

4.3. Scientometric analysis and mapping of articles

Articles about interoperability in BIM research were mapped via VOSviewer to understand their impact on literature. Figure 5 shows the network visualization map of citation analysis of articles based on bibliographic data with a minimum number of 100 citations per document of an author. There are 16 authors, who met the criteria were represented in Figure 5. The color of an article identifies the cluster that the article belongs to. The articles were grouped in five clusters (Figure 5). The name of the clusters was determined according to the field of study that the article belongs to (Table 2) *namely collaboration and sustainability (red-coded), BIM adoption (green-coded), BIM implementation at the process level (blue-coded), BIM implementation in-country and at industry-level (yellow-coded), and BIM integration (purple-coded).*

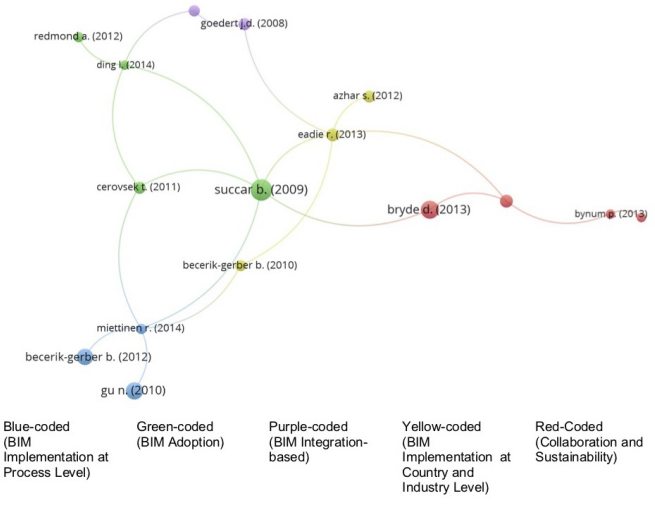

Figure 5. *Network map visualization of articles focused on interoperability in BIM research (between 2004-2019).*

Table 2. *The articles focused on the research field of interoperability in BIM (between 2004-2019).*

Cluster Name	Article	Title	FWCI	Link	Citation	Normalized Citation
Collaboration and Sustainability-based (Red-coded)	Bryde, et al. (2013)	The project benefits of building information modelling (BIM)	18.56	2	347	6,11
	Bynum et al. (2013)	Building information modeling in support of sustainable design and construction	9.33	2	106	1,87
	Grillo and Jardim-Goncalves (2010)	Value proposition on interoperability of BIM and collaborative working environment	9.74	3	188	1,04
	Taylor and Bernstein (2009)	Paradigm trajectories of building information modeling practice in project networks	4.38	1	101	1,04
BIM Adoption (Green-coded)	Cerovsek (2011)	A review and outlook for a "Building Information Model" (BIM): A multi-standpoint framework for technological development	7.77	3	163	3,61
	Ding et al. (2014)	Building Information modeling (BIM) application framework: The process of expanding from 3D to computable nD	7.59	4	100	3,56
	Redmont et al. (2012)	Exploring how information exchanges can be enhanced through Cloud BIM	6.52	1	117	2,30
	Succar (2009)	Building information modelling framework: A research and delivery foundation for industry stakeholders	12.30	5	498	5,13
BIM Implementation at Process Level (Blue-coded)	Becerik-Gerber et al. (2012)	Application areas and data requirements for BIM-enabled facilities management	15.26	1	287	5,64
	Gu and London (2010)	Understanding and facilitating BIM adoption in the AEC industry	8.29	1	308	3,89
	Miettinen and Paavola (2014)	Beyond the BIM utopia: Approaches to the development and implementation of building information modeling	9.59	5	124	4,42
BIM Implementation at Country and Industry Level (Yellow-coded)	Azhar et al. (2012)	Building information modeling (BIM): Now and beyond	7.81	1	164	3,22
	Becerik-Gerber and Rice (2010)	The perceived value of building information modeling in the U.S. building industry	4.40	2	141	1,78
	Eadie et al. (2013)	BIM implementing throughout the UK construction project lifecycle: An analysis	6.08	5	188	3,31
BIM Integration (Purple-coded)	Goedert and Meadati (2008)	Integrating construction process documentation into building information modeling	5.98	2	162	2,11
	Irizarry et al. (2013)	Integrating BIM and GIS to improve the visual monitoring of construction supply chain management	10.08	2	147	2,59

The articles were displayed in circles and labels (Figure 5). The size of the circle of an article was determined by its weight. A larger size of the circle and label represents a higher weight for an article. The distance between two articles in the network visualization map shows the relatedness of the articles in terms of citation links. In general, close location of two articles in the network visualization map represents a stronger relatedness.

Data related to the citation analysis of articles about interoperability in BIM were tabulated in Table 2, including four major quantitative factors as FWCI, links, citation, and normalized citation values. FWCI metric indicates how the number of citations received by an author's article compares with the average number of citations received by all other analogous articles indexed in the Scopus database. An FWCI value greater than 1.00 indicates that the article is cited more than would be expected based on the average citation for similar articles. The FWCI of *Bryde et al.* (2013) was cited 1856% times more than expected with a score of 18.56 means that the output. Even the lowest FWCI value of 5,98 evidenced that the article was cited 598% times more than the expected citation numbers. The strong citation links between articles visualized by lines. Lines between articles display links. The average normalized citation factor indicates the average normalized number of citations received by the published article. Both of the FWCI and normalized citation results show that the articles with the highest impact in interoperability in BIM literature are *Bryde et al. (2013), Becerik-Gerber et al. (2012), and Succar (2009).* The link values differ from the FWCI and normalized citation values. The link values show that the article that has the most widespread impact is Succar's (2009) research with a 5 link to each article within every 5 clusters. Broad diffusion impact of this article is because of its generic content composed of industry stakeholders for framing BIM adoption.

5. Discussion of the results

Based on the scientometric analysis of bibliometric data about interoperability in BIM related topics, following future research trend directions were recommended. As stated in the science mapping of authors and articles evidenced that the research topics are generically grouped under *interoperability in BIM practice and interoperability in BIM theory* headings. According to citation analysis of articles interoperability in BIM research is mainly categorized into five groups such as;

a. Collaboration and Sustainability (red-coded in Figure 5)

b. BIM Adoption (green-coded in Figure 5)

c. BIM Implementation at Process-level (blue-coded in Figure 5)

d. BIM Implementation in-Country and at Industry-level (yellow-coded in Figure 5)

e. BIM Integration (purple-coded in Figure 5)

According to the results of science mapping of articles (Figure 5 and Table 2) *"BIM adoption"* studies interact with 4 clusters (*"BIM implementation in-country and at industry-level"* studies, *"BIM integration"* studies,

"BIM implementation at process-level", and "collaboration and sustainability-based" studies). *"BIM implementation in-country and at industry-level"* studies also interact 4 clusters (*"BIM adoption" studies, "BIM integration"* studies, *"BIM implementation at process-level", and "collaboration and sustainability-based"* studies). Whereas, *"collaboration and sustainability-based"* studies, *"BIM implementation at process level"* and *"BIM integration"* studies each interact only 2 clusters. Less interacting clusters have research gaps in terms of integrating the other subjects' perspectives. Therefore, researchers should consider studying the combination of process-level BIM implementation, integration, collaboration, and sustainability issues in their future researches to have a high impact within interoperability in BIM research.

5.1. Leading researchers of interoperability in BIM research

According to the author analysis, the interoperability research by authors mainly accumulated under *"BIM theory"* and *"BIM practice"* categories. As seen in Figure 4, the interoperability in *"BIM theory"* researches (green coded authors in Figure 4) are clearly separated into two groups namely, *"BIM framework"* (Succar, B.; Broquetas, M.; Bryde, D.; Volm, J.M.) and *"BIM advantages and research areas"* (Jardim-Goncalves, R.L.R.; Grilo, A.) sub-categories. However, there is not any clear distinction between interoperability in *"BIM practice"* researches. When one focuses on Figure 4 and Table 1 and on the authors' published documents, one can understand that the interoperability in BIM practice research (red coded authors in Figure 4) categories can be interpreted in four sub-categories namely *industry-based approaches* (Becerik-Gerber, B.), *process-based approaches* (Li, N.; Becerik-Gerber, B.), *BIM data exchange* (Eastman, C.M.; Sacks, R.; Kaner, I.; Zhang, S.), and *BIM information exchange* (Eastman, C.M.; Teizer, J.; Venuggopal, M.; Lee, J.K.).

The most influential authors in the field are *Teizer, S.; Sacks, R.; Eastman, C.M. and Becerik-Gerber, B.* Apart from this, since interoperability subject places in the technical part of BIM research, *"BIM practice"* studies are more in need of the solution of interoperability related problems than *"BIM theory"* researches. Figure 4 indicates that the researches about interoperability in *"BIM practice"* attract more audiences than *"BIM theory"* research. Furthermore, with a chronological point of view, from the emergence of BIM technology as an information platform to the current time of practical application of BIM, the research focus skewed to more practical problems like interoperability. Therefore, the research trend of interoperability in BIM seems to examine the practical implications and implementation opportunities for BIM technology.

5.2. Leading studies of interoperability in BIM research

Article Analysis results suggest that the studies are mainly clustered into five categories. Article analysis obtained more detailed cluster results rather than author analysis. As seen in the Figure 5 interoperability in BIM research was divided into five main clusters called; *"collaboration and sustainability-based"* (red-coded articles), *"BIM adoption"* (green-coded), *"BIM implementation at process-level"* (blue-coded), *"BIM implementation in-country and at industry-level"* (yellow-coded), *"BIM integration"* (purple-coded). In accordance with the results, since the subject relies on the technical side of the BIM research area, the acceleration in the number of new studies is rapid. Therefore, FWCI scores indicate an extraordinarily and unexpectedly very high based on the similar articles' citation data. The article analysis results indicate that *"collaboration and sustainability-based"* studies are the most influential researches in the field. The impact of the articles related to collaboration and sustainability increases in time. The reason for this is collaboration via BIM platform can be achieved successfully with improvements in the BIM adoption, so that the building information is available to use in sustainability and in other design, construction, operation, and facility management studies. The next highest impact articles fall within the

"BIM implementation at process level" category. Chronologically, the studies focused on model development, model interaction, model integration, implementation of model information and so on in the first phase of the BIM research. However, a process-based point of view in BIM implementation researches is relatively new and needs to be further analyzed. The third highest impact research category is the *"BIM adaption",* in which model-based technological issues are addressed. Model development, improvement, and integration-related researches fall within this category, which has attracted many researchers since the emergence of BIM and will always be in the focus for further developments in the model. However, there are still gaps in *"BIM implementation in-country and industry-level"* and "BIM integration' related studies in the interoperability field. The BIM adaptation occurs in the model, modeling, and process level, therefore country-based approaches and BIM integration with new technologies are still could not reach the expected maturity.

The interoperability may be a barrier for the Level 2 and Level 3 BIM implementation, in which information sharing and exchange of information across different stages of a construction project should be smooth. BIM adoption and BIM integration studies should extend to all stages of the project rather than only in the design stage. Integrated project processes require improvements in the systems integration of BIM models. Integrated project delivery, operations, and facility management may assure sustainable and intelligent buildings. This paper suggests spreading the research tendency to all processes allowing integration for collaborative and sustainable approaches throughout the project lifecycle with in-country and industry-level implementation approaches.

5.3. Research limitations

The paper covers the author and article analysis in interoperability in BIM research. However, future studies in interoperability in BIM research may analyze bibliographic coupling of organizations and countries or apply co-citation and co-authorship analysis for further detailed findings. The language limitation may not be applied in the bibliometric search so that the insight of studies encompasses a global perspective. Books, reviews, conference proceedings or other sources can also be included in the journal articles to capture all points of view from completed and on-going projects. The data for this research was acquired from the Scopus database. However, future studies may merge data from all databases for more robust findings. The stability of data is an important limitation for this type of researches. Therefore, a dynamic data import and dynamic data visualization can be a solution for up-to-date scientometric analysis. Furthermore, the 2D dimensional visualization of data is a barrier in rapidly understanding the gaps and trends. 3D computation of bibliometric data with knowledge graph representation may improve the mapping technique.

6. Conclusion

Interoperability in BIM research has gained significant growth in literature. However, there are still BIM implementation and adoption problems related to data exchange inefficiencies causing limitations in integration, collaboration, and communication in AECO/FM activities throughout the project lifecycle. This paper realized a scientometric analysis and mapping of authors and articles to address the research gaps and tendencies in the field and proposed future trend opportunities for the research field of interoperability in BIM. BIM adoption and BIM implementation in-country and at the industry-level studies interact with all other research subjects. Therefore, the emphasis should be on collaboration and sustainability-based, BIM implementation at the process, and BIM integration-based studies. The scientometric analysis results reveal that articles those have generic context such as; BIM framework, BIM implementation advantages, industry level BIM adoption have high impact in the research field. The next trending articles are related to integrated BIM models for better BIM implementation in project management issues, a collab-

orative platform, approaches for better BIM implementation, respectively. However, more incorporated research approaches in articles are needed in future studies to have a holistic point of view and integrated implementations in the field. Country-based researches and BIM integration-related studies have the potential to pull more attention in the near future. The results of this research serve all AECO/FM industry stakeholders and academics from the field for a broad understanding of current research gaps and trends in interoperability in BIM research. The data sample adopted in this study was from journal articles focusing on academic research, the articles, and the authors, and excludes AECO/FM industry practices and improvements. Future research may be more inclusive of industry practitioners' data to further enrich findings.

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ITU A|Z • Vol 17 No 3 • November 2020 • 185-194

The extended role of building information models (BIM): Mp4 Video of the monument of Gelora Bung Karno of Jakarta

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Received: August 2019 • Final Acceptance: November 2019

Abstract

The two events of the Asian Games as a four-yearly multi-sport event were held in Jakarta. Both, took place at the main stadium of Gelora Bung Karno (GBK) in 1962 and 2018. Because it the venue for historic events then main stadium became a monument site. This multidisciplinary study in architecture, and digital application source from Building Information Models (BIM) related to historical site of the first Indonesian main stadium. By concerned in combining between a mp4 video of 3D Architecture Model and a documentary film as a Life Action film was created. The "Art Insight" program of Metro TV was created to commemorate the 73nd Anniversary of Indonesia's Independence and to celebration of The Asian Games XVIII of 2018. Due the limited of the documentary life action film then, based on the originally drawing archives of "The Mostproject" in the 1959s put together as a quite interesting TV show especially for millennial. The combining mp4 video and the Documentary Films as Life Action Film has enrich the monument site documentary and become the public information in television program.

Keywords
Art insight of MetroTV, Asian games, BIM, Combining Mp4 Video, Mostproject.

doi: 10.5505/itujfa.2020.56563

1. Introduction

To celebrate The Asian Games XVIII of 2018 as the second host, the management of The Indonesian Presidential Museum of "*Balai Kirti*" in Presidential Palace of Bogor had created a temporary exhibition of its monument: Soekarno and Jokowi, Two Indonesian Presidents Host of the Asian Games" (Halim, 2018). The exhibition shows the architectural archives of Asian Games 1962 and architecture models of the sport-venues revitalization project. The center issued is related to the venue of Indonesian main stadium. Two events of Asian Games as a four-yearly multi-sport event were held in 1962 and 2018 in Jakarta. Caused of roles as historical event sport venue then *Gelora Bung Karno* (GBK) to be a monument. The exhibition's curatorial "The Indonesia's Stage for the World" was created based on Indonesian Archives collections. Especially by Mr. Soekarno's speeches of the first Indonesian main stadium (Ardhiati, 2018).

During the exhibition, "Art Insight" program of MetroTV are shown (MetroTV, 2017). The "Art Insight" has shown the Indonesian first President's contribution. During it's preparation Soekarno was totally involved, started from the design process till the construction phase. Soekarno needs to confirm that all of the stadium preparation in the right track. Finally, he very loved the main stadium. The beauty and magnificent of the main stadium have made Indonesian proud. And, to give appreciation to him then it named *Gelora Bung Karno* – GBK. The main stadium has contributed in "*Djakarta City Planning*" as a Soekarno political will. His achievement in architecture, urban planning are the tools to Indonesian mentally reform at that time (Ardhiati, 2013).

In the opening ceremony in 1962, President Soekarno was proudly stated: "*…I have seen them in other countries but ohh.., this Main Stadium of Djakarta is the best in the world !....The building which is steel structured, mesmerized public in the event of the Asian Games IV 1962, and the oval-shaped building which enforced with "Temu Gelang" construction, is able to protect 110,000 visitors from the heat of sun...*" (Soekarno, 1962).

What is "*Temu Gelang*" construction itself? The term of "*Temu Gelang*" means the roof planes rotate so that they meet each other, hence creating a huge circle, is looks like a "bracelet". Why Soekarno took reference the term of "*Temu Gelang*" become the construction's name? Due in period of 1957 he had asked to Indonesian people to explore all of the ancient of Indonesia to enrich the civilization, included in art and architecture. He was very proud and loved the *wayang*- a traditional puppet show which adopted the epic of the *Baratayuda* and *Ramayana*. So, he always portrayed the *wayang*'s hero to be the symbols in art and architecture (Ardhiati, 2005).

At least, two of the *wayang*'s hero was adopted by Soekarno related to the main stadium design preparation. The first, *Bima* is one of the fives heroes of *Pandawa* in the *Baratayuda*'s epic story. In the *wayang* story, the character of a hero is symbolized in his clothes/ accessories and weapons. *Bima* always wears his *Candrakirana*'s bracelets. The *Bima*'s originally bracelet is a circular object placed in the *Bima*'s hand as symbol of the knight's intelligence, depicted as the moonlight. The second, *Sri Rama,* is the actor center of the *Ramayana*'s epic story. *Sri Rama* always wearing his elegance archery as his weapon. Related to the main stadium, the gesture of *Sri Rama* wore his elegance archery becomes a big sculpture of in front of the main stadium. Soekarno also asked to adopt the *Sri Rama*'s gesture became the Asian Games IV logo's graphic design (Ardhiati, 2005).

Before built the venue, President Soekarno's ambition to hold the Asian Games IV in 1962 as the best one was a part of his nation building vision. Then, he sent a proposal to the Asian Games Federation in 1958s to be the host to the next Asian Games IV. But, the committee doubt about the Indonesian sport facilities. After long and heated debate, a voting was held. Indonesia won after Karachi. President Soekarno asked to perfectly as possible by built a "new" sport venue complex in Jakarta. To realizing the main stadium, then he asked to Soviet Premier Nikita Khrushchev to give his techni-

cal support.

Finally, the first Indonesian main stadium was built as the Asian Games IV venue at 1962 was built to conduct an international corporation with the Soviet Union. They had agreement to realizing the main stadium complex as a symbol of friendship between Indonesia and the Soviet Union. The main stadium can be realized based on of the assistance from the Soviet Union, including in terms of architectural design. Moscow committed a soft loan of USD 12.5 millions, and they had involved in the architectural planning of the stadium. During its process of design, Soekarno was asked to the Moskow's Architect to build the construction composition by his basic of ideas to realize a circularly 'form'/shape the main stadium building like a bracelet in association with the *Candrakirana*'s bracelets of *Bima*.

In 1956 the circularly 'form'/shape of main stadium of Luzhniki in Moskow just already opened. Before its renovated in the 1980s, the main stadium Luzhniki in Moskow and the "*Gelora Bung Karno*" in the 1962s in Jakarta. Both has similar in basic 'form'/ shape as well as the circularly of the Colosseum in Rome. By circularly 'form'/ shape, then visitors can watching the game in comfort (Ardhiati, 2013).

The Soekarno's spirit has accommodated by President Joko Widodo. During preparing as the Asian Games 2018 host in Jakarta, he asked to the Minister of Public Works to newness the *Gelora Bung Karno* monument. He needs to actualization the monument by a contemporary touch in order the monument has been designated as "The New Energy And Spirit of Asia". He stated: "*Especially to aesthetic of design, the main stadium of Gelora Bung Karno (GBK) must be have a credit value character of the historical nation heritage*" (Joko Widodo, 2018). Then, the Asian Games XVIII of Architecture's team preparing the new design to show the features archives and other supported artifacts to represent idea of the President.

Meanwhile, the "Art Insight" Program Metro TV @2017 as a documentary film monthly program also need to celebration The Asian Games XVIII of 2018 (MetroTV, 2017). "Art Insight" shows the triumph of the nation was held on 56 years ago held in old stadium. They need to show the originally main stadium in the 1962s. So, they need the originally film documentaries of the Asian Games IV during its construction and the event. It can't show the architectural aerial of view. Due of limited collections of National Archives related to an originally architecture drawings of the main stadium then it needs a creative solution. In other hand, the old architectural drawing archives of "The Mosproject" Book of Moscow was apparently kept by the State Secretariat Office (State Secretary Office, 2018).

On other hand, during it revitalized by PT Adhi Karya Contractor "The Mosproject" images had re-draw by PT Unitri Cipta Consultant (Unitri Cipta, 2018) as well as role as a part of *Gelora Bung Karno* (GBK) archives as the Secretary State Office. "The Mosproject" was traced the Soviet Architect team involved in the planning and design of *Gelora Bung Karno* (GBK) complex consist architects and engineer. Then, it became to be the basic design of Building Information Model (BIM) by PT Adhi Karya - the main contractor of the project revitalization. BIM itself mean a process of architectural work starts with creating a digital 3D model as a virtual/imaginary building, and contains all the information of the building design, which serves as a means to make planning, design, implementation of construction, and maintenance of the building, also the infrastructure for all parties of the project such as consultant, owner, and contractor (Adhi Karya, 2019).

"The Mosproject" book was represented the Architectural-Planning Department of Moscow, which was under the auspices of Moscow City Executive Committee. The team members were: (a) Mr. A.A Osmer as the Director of Institute, (b) Mr. G.N Lwov, the Chief Engineer, (c) Mr. A.F.Khrianov, the Manager Studio No.15, (d) Mr. R.I Semerdjiev, The Architect, (e) Mr. L.A Muromtsev, the Engineer, (f) Mr. J.C.Africanov, Architect, (g) Mr. B.I. Miroshin, Engineer, (h) Mr. A.P. Golubinsky, Engineer (State Secretary Office, 2018).

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2. Method and literature review

The study refers to a qualitative research within a multidisciplinary approach. The approach means that knowledge of several disciplines may be used to contribute and are supplementary to find the best of problem solving. In this study, the multidisciplinary included; (a) Archival Historian, (b) Conceptual Architect, and (c) Architectural BIM Specialist and (d) Commercial Broadcasting Film to create a special television program during the event of Asian Games XVIII in 2018.

The distances of the old event (1962) to the next event (2018) is 56 years, so it needs to catch the huge of data. To enrich the data, then it used an inductive methodology as well as the Grounded Theory Research (Ardhiati, 2018). By used thus method it provides guidelines how to (a) categorized, (b) synthesizing, (c) analyzing, and (d) conceptualizing qualitative data in order to purpose 'a' new theory.

2.1. Main theme

The paper focused in creating the Mp4 Video related to the monument to support A Commercial Broadcasting Film of Metro TV special program to celebration the event of Asian Games XVIII in 2018. The Mp4 Video itself is a part of the 3D architectural model of the Building Information Models (BIM) of *Gelora Bung Karno* (GBK) sport venue. The architectural drawing of BIM was provided in "The Mosproject" archive book of 1959.

2.2. Goals/aims

The study aims to show architectural science into the practical life in this case to a Commercial Broadcasting Film. By combining the Mp4 Video as a part of BIM with the Documentary Films then the "Art Insight" of MetroTV's program was show as public's information of the Old and New of monument. In this episode, "Art Insight" role as the public information related to show how the Western and Eastern architectural expressions of the monument.

They showed the Western of Modern Architecture style knowledge based on "the Mostproject" of the Moscow City Executive Committee, and the Eastern architectural expression based on the *wayang*'s hero of the President Soekarno's idea, represented by the "*Temu Gelang*" architecture shape and construction. In other hand, President Joko Widodo stated that the monument as the Asia Games XVIII 2018 venue it must have a credit value character to enrich to be "the New Energy And the Spirit of Asia".

3. Literature review

3.1. The film genre of architecture animation

Today, animated characters are often seen as National TV program. They show digital effects as well as the Building Information Model (BIM) can expanded as a new creature as imaginary creatures with a special character looks like the real world. They are produced by Artist animation by use of the motion capture has become more interesting. The animation itself related to Computer Generated Imagery (CGI) as visualized by computer program. An animation character a new creature as imaginary may has the uniqueness in 'form'/ shape.

On other hand, Architect animation may use of the motion capture also to create an imaginary of building as visuals created by a computer. An imaginary role as the background of the animated characters, or maybe role as a new creature (Tulijoki, 2018).

Refers to him, an Architect animation so close with 3D software. She/he can continue to designing an imaginer building/space. Through the 3D she/he realized how it feels and continuing to start making a films. Since student architects close to draw digitally, then he can crossover to be a filmmaker as well as a natural progression. Daily practical of Architect in her/his firms are needed to make 3D videos to dazzle their prospective clients. Usually, they use 3D architecture software. They make plans, and engineering drawing for construction. Digitally is one the unit's output to resemble a 3D film program school. Young architects may use various of architecture software.

As well as the famous Architects among others; Zaha Hadid from British, and also Toyo Ito from Ja-

pan. During Zaha Hadid and Patrik Schumacher are work collaboration at Gehry Technologies, especially on Regium Waterfront project in Reggio Calabria Italy in 2007. They used the Maya software. It suitable to developed 3D film to simulate the natural phenomena. Refers to Mr. Schumacher stated, Architecture aimed to emulate the endless 'form' of nature by her/his dynamic designs, the curvilinear, and her/his diverse. Inside their studio, Architects mostly start to work with Maya software. They do more precise, complex in geometries. Refers to Schumacher Gehry Technologies' Project an adaptation of Catia. They feel suitable as well as to develop for an aircraft design. The Gehry Technologies was used Catia in the second stage (Jodidio, 2013). Meanwhile, refers to Toyo Ito, the Japanese Architect said that the 3D virtual are just a tool in his studio. Obviously, all project developed according to their intentions. By used a 3D - three dimensional models help them rationalized and make an organic "form" constructible. They are trying to be able to industrialize the drawing's construction, to create renderings and presentations (Salla, 2014).

That's the point as the one of the success story of Architect presentation is how to make the Client confident with ideas by visualized through the architecture of animation. How to present the ideas show into the digital effects that can make his/her ideas possible. The architecture movie has seen a new creature as imaginary building looks like the real world.

Refers to Bartlett School of Architecture of London, as one of the architecture institution who concerned to prepare student to familiar with the architecture of animation. During their School of Architecture show, students has shown their animated journey into a labyrinth with the dramatic voice over. Their newly-learned in digital animation, and their design skills to break into the architectural film. It's very interesting and important to see the "space through the lens" or it related to the cyberspace (Shaw, 2016). The Bartlett stated, their architectural films was encouraged by an imaginative thinking, and the project management skills by teach fundamental principles of architecture design. Architects may create the 3D animation of building the use animation models software like 3ds Max, Maya and After Effects, because they tend to have the vivid of imagination, and have a strong visual sensibility. Naturally, Architects tempered by her/his capacity for analysis to find a problem solving. One of an animation for Film4 visualized by the Al Rayyan's football stadium as the Press Conference Launch of the Qatar 2022 of World Cup (Shaw, 2016).

3.2. A documentary filmmaking

A film documentary is a kind of non-fictional motion picture. It has created based on the historical archives record. Documentary films usually called an 'actuality' films as a part of a Live Action film. Due, the limited of historical record, then it maybe the short or less duration. Documentaries are also role as the educational tools. But, now televisions and the social media platforms are used in YouTube. The YouTuber allowed the documentary films to easily distribute and to educate the receiver. In other cases, the documentary film has content experts are interviewed to enrich a documentary film. The limitation of the short of historical record be overcome by them. The prominent television stations often added the footages and shooting at the same place so that the documentary film to be an interesting show.

Principles of narrative construction in filmmaking there are; (a) plot of the storyline, (b) the cause of effect, (c) duration of time, (d) the space. Architecture as a part of 'space' has role as the important element of the documentary film genre related to the heritage building as the subject (Bordwell, 2008).

According to Rajala, the documentary film is one of text that has more or less publicly claims to present objects, their states of affairs, or events. They truly exist in the actual world of their presented. A communicative act, the audience has invited to believe that their presented is somehow "true". And, it is sort of the contract between Audience and the filmmaker (Rajala, 2017).

A documentary film known as a

'sub-genre' in 'film' or 'cinema', roles as an umbrella for any audio-visual material. They have the theoretical framework(s) as well as the certain historical approaches in the cinema's study. As well as fiction, documentaries also have kind of genres. One common genre named the compilation film. It was produced by the assembling images from many of archival sources. The documentary characteristically is an ongoing event as it happens by minimal interference of filmmaker. A direct cinema itself, had emerged during 1950 till 1960 when a portable camera, sound equipment was become available and allowed in films.

3.3. A combining 3D and a documentary film

An effective approach to mixing a live action video by 3D graphics. In conjunction with the live action of the event video as well as the BBC News. They use of data being it streamed round the world. By use the small white lines connecting dots to represent the data they are being beamed around the world. It's a fantastic technique of videos by creating Combining the 3D animation with a Documentary film as a Live Action Film (Neale, 2015).

Tulijoki has examined the process for animating the digital characters by adopted the filmed footage. By used a modern visual effects method, the Artists/Architects were studied the process of creating a visual effects and animation. Due to the lack of the professional tools, and their experiences, the results were only mediocre at best (Tulijoki, 2018).

It is possible to create a documentary by compiling several films. They are assembling images from various archival sources. Then, a new genre film produced by mixed-assembling of archival sources with 3D architecture film. Somehow, the historical archives are not found, gone or other reasons, the digital application software is one solution to presenting film-based on the old heritage building. The reconstruction of architecture may use the architectural drawing of 2D into a 3D. Then, by used the Lumion 3D, an animation or mp4 of 3D architecture movie may create. The 3D Dimensional modelling of the architecture drawing of may be used by AutoCAD/SketchUp/3ds max software. Then, improvement and material edit to making 3D movies and still initial images, architecture and design then Architect need the tool. The Lumion 3D is a one of visualization tools for real-time making 3D movie and also provide animation. The Lumion 3D has offers the excellent graphics combined with fast and efficient workflows, saving time and effort. The Lumion 3D sets up scenes by used the GPU-based interface, and the full 3D real-time editing. By adopted the Lumion 3D than it can provides for landscape creation, façades, the interior, the daytime settings like; sun, sky, clouds and water. The offers very excellence rendering makes adding tons of content to scenes as 3D as possible. The Lumion 3D may possible to be mp4 video in short duration beyond the Life Action Film.

3.4. The 3D animation of building reconstruction

The digital software in architecture is a tools of Architects to visualized his/her new or the old projects, start from the preliminary schematics to construction documentation. The 2D architectural drawing then continue into the 3D of architectural 'form'/shape. In virtually, then Architect Architects help to reconstruction the ruined or the damaged of heritage building by redraw and rebuilt as well as the real building. By used the digital software addresses to help the audience understand to the Architect's plan. To improvement the Architect presentation the a prominent software called the Lumion 3D was published, as the one of architecture software to present the 3D architectural video. Related to the heritage building reconstruction project, Architect may use the documentary film to understand the originally building 'form' and facade. A number of architectural drawings are still likely to be reconstructed through a computer program called "digital application of 3D modeling to cultural heritage". The 3D animation of architecture simulation was made through the 3D modelling software to show the actual reconstruction that will be done to reduce the building failures (Cantor & Valencia, 2004).

4. Findings and discussion

4.1. The 3D model animation as the basic of Mp4 video

The excellence of a Grounded Theory Research used to easily arrangement of a huge of data collections as an inductive data. Archival data resources are collecting from (a) the National Archives of Republic Indonesia - ANRI, (b) The Ministry Secretary Archives, (c) Academic Archives, (d) Private Archives, (e) Books and Journals, and (f) the originally archives of architectural drawing of "The Mosproject" of 1959.

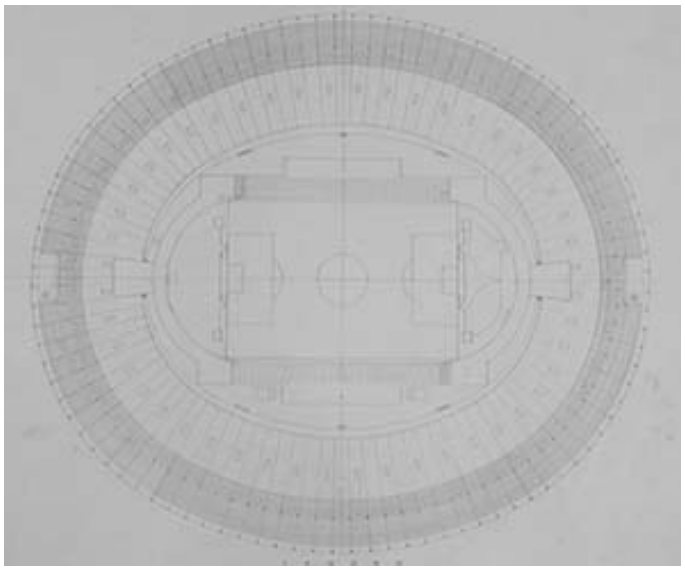

Figure 1. *The originally floor plan of Football Field by "The Mosproject" 1959 as the basic of Building Information Model (BIM) (Source: State Secretary of Indonesia, 2018).*

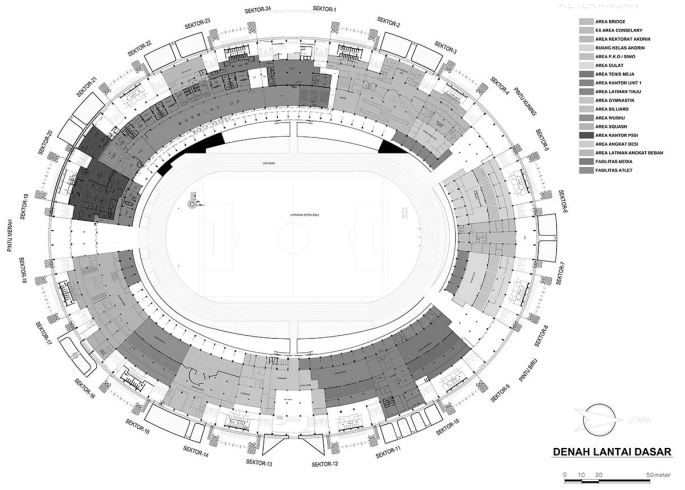

Figure 2. *The floor plan of main stadium after re-draw by Building Information Model (BIM) (Source: State Secretary of Indonesia, 2018).*

The 3D Model Animation itself is the result of Building Information Models (BIM). It was created based on the origin of architectural re-drawing of "The Mosproject" of 1959s. In order they can show the originally architecture of monument then started to prepare the 3D architecture animation refers to Lumion 3D that created based on The Sketchup software. A Lumion software is the prominent fastest 3D rendering for Architectural work. In minutes you can visualized the CAD's model in a video shows a real-life image (Lumion, 2109). In other hand, the Mp4 Video itself was created by the architecture model animation within the Lumion 3D program. Then, a Commercial Broadcasting Film of Metro TV combine the Mp4 Video of the monument with the historical archives to show the Old and the New of the monument.

The software has simple tools, is quite easy, and has a plug-in to easily and quickly process. The old archives of "The Mosproject" was modified into CAD-software. The Cad Software to professional projects may have not suitable to the 3D of Lumion software. Then all archives of "The Mostproject" are needed to convert into the Sketch-Up program. SketchUp is one of the suitable 3D design software to make the 3D modeling whatever you can imagine, especially the SketchUp version 2015 had compatible export to the Lumion 6.0 program. The Lumion 3D software is a software has a level of images/ material resolution that is quite

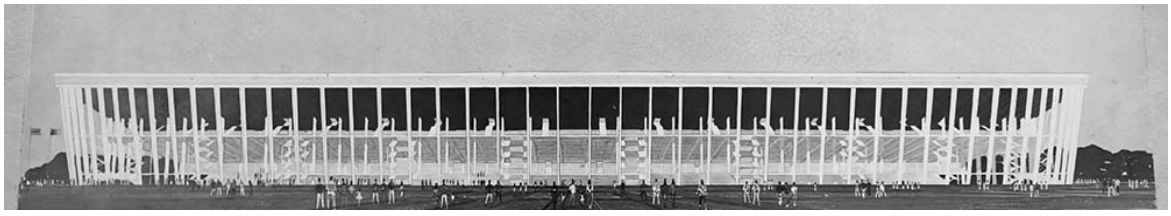

Figure 3. The originally façades alternative-1, proposed by "Mosproject" of Moscow 1959 (Source: State Secretary of Indonesia, 2018).

realistic. It has tools and menus that are quite easy and simple to use.

In terms of comparison with similar software, the 3DS Max software is the excellence output because is almost as realistic of rendering, but 3DS Max has more of tools and menus that tend to be more difficult to use and not practical. The process design there are the description phase of 3D of the video animation process, among others: (1) The Schematic design, among others; (a) determine the type and function of design/ building, (b) determine the basic ideas/ concepts of the building 'form'. Referring to the "*Temu Gelang*" construction - the circular bracelet's construction as the originally archives of "The Mostproject", (c) make a design of transformation sketch to visualized the architectural forms, (d) would be better to create the sketch in several alternative designs, (e) create/ copy the selected design sketches to the computer and keep as the basic idea to create a 3D model by using the SketchUp application, (e) after the 3D model and the architecture detailing are complete, then enter the 3D. In the coloring stage is need to clearly the material specifications, for example glasses is given a transparent color, the floor is colored with marble material, etc. (f) After the Schematic Design of 3D model is completed then enter the animation output stage with final output as mp4 and make the 2D images as the final output of pdf.

The second step is the 2D Images Phase, among others; (a) determine the location of the building section with the tool section in the SketchUp 3D model, (b) determine several horizontal building pieces (plan) to vertical pieces (building section), (c) export the view section to the Autocad (DWG) format by Autocad 2015 version, (d) edit the 2D images that have been exported using Autocad software and plotting images to pdf format. The AutoCad software is used because it is more commonly used for 2D image output work. Compared to other similar software such as ArchiCad or Revit of Architecture software.

The mp4 was created from the old architectural drawing archives of "The Mostproject" in the 1960s. Modified into SketchUp and exported the view section drawing of the Autocad 2015 version. Then, was created to be an animation output by plotting the 2D images. After all of video scenes are rendered in mp4 format, continued into Camtasia Studio 8 serial version.

4.2. "Art insight" of MetroTV as the combine of Mp4 Video with film documentary

Even though, the National Archives

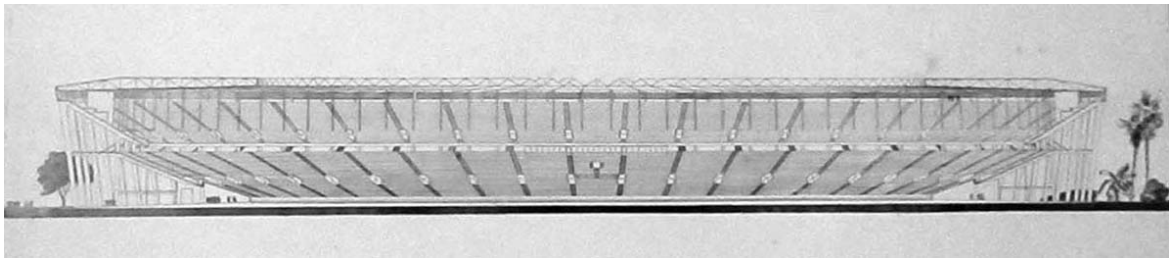

Figure 4. *The originally façade of alternative-2, proposed by "Mosproject" of Moscow 1959 (Source: State Secretary of Indonesia, 2018).*

Figure 5. *The "Temu Gelang" of main stadium construction proposed by President Soekarno (Source: State Secretary of Indonesia, 2018).*

of Republic Indonesia – ANRI was collected more than 100 documentary films of Soekarno's speech during his roles as President especially in his first milestone of the projects or inauguration the buildings, but it not provided the architectural drawing archives of "The Mostproject". Fortunately, the State Secretary Office has collected the architectural drawing of the Soviet Union project archives, and it built to be the mp4 video of architecture. Then, MetroTV studio has created their special television program of the monument by combining the documentary film with mp4 video of architecture. Finally, the "Art Insight" program of MetroTV has successfully shows the Old and New of the *Gelora Bung Karno* (GBK) monument.

Figure 6. *The old images of the Main Stadium of Gelora Bung Karno in the 1962s* (Source: PT Adhi Karya Contractor, 2018).

Figure 7. The New images of the Main Stadium of Gelora Bung Karno in the 2018 (Source: PT Adhi Karya Contractor, 2018).

Figure 8. *The Extended role of BIM inside "Art Insight" of MetroTV show at 27 January 2018 (http://video.metrotvnews.com/art-insight/4KZOrypN-wajah-arsitektur-gelora-bung-karno-1).*

The "Art Insight" entitled "*Wajah Arsitektur Gelora Bung Karno*" or "The Architectural Façade of the Main Stadium of *Gelora Bung Karno*" was aired in 2017 in excellence show. Through program audiences knew related to the architectural drawing archives of "The Mostproject" (1959). The combining filmmaking was created by hybrid of; (a) documentary films of ANRI, (b) recent films and interviews, (c) the private footages, (d) the 3D of Architecture Animation of the monument of *Gelora Bung Karno* (MetroTV, 2017).

5. Conclusion

Due of limitation documentary film related to the historical heritage may re-construct based on the mp4 video of architectural drawing. Based on the mp4 video of the Old and New monument of *Gelora Bung Karno* (GBK) monument shows the Soekarno's and Jokowi's idea of 'Western meets Eastern' expression. Both of the Indonesian Presidents are concerned to proudly the monument as the Western of Modern Architecture's knowledge based on "the Mostproject" of the Moscow City Executive Committee. The Eastern architectural expression itself based on the *wayang's hero* (the Indonesian's puppet show) as the President Soekarno's idea. And, it will be continued by President Joko Widodo to be "the New Energy And the Spirit of Asia". By compose the combining between a mp4 video and the documentary film then the "Art Insight" program of MetroTV was represented the "Stage of Indonesia" to be get closer the millennial to the great of historical memories.

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ITU A|Z • Vol 17 No 3 • November 2020 • 195-209

Students' perceptions of BIM learning scenario in architectural education

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Received: November 2019 • Final Acceptance: February 2020

Abstract
The inclusion of BIM in architecture curricula, in addition to those in engineering and construction, has gathered significant pace over recent years. The patterns of this inclusion vary significantly from country to country having different approaches, strategies, methods, and challenges associated with professional and academic environment. In countries like Turkey, many architecture educators still ask: 'What is BIM and why do we need it?". This paper presents one part of a larger research aiming to develop different 'BIM learning scenarios' for architecture schools which had not yet developed BIM tradition. The BIM learning scenario represents a flexible structure organized within the agenda of four basic questions: why (objectives), what (contents), how (methods), and who (management). The broader research proposes a strategy for introducing BIM in architectural education. The strategy is defined by the means of an exchange of experience between the academic world and practice. It also prioritizes self-learning and student-centered approach which are one of the key requirements of 21st century curricula. The current paper demonstrates students' perceptions of the proposed BIM learning scenario obtained through focus group study. We provide the framework used to plan the scenario, describe the scenario setting, present students' responses obtained through focus group, outline the lessons learned and discuss their implications for the future advancement of BIM in architectural education.

Keywords
Architectural education, Building information modeling (BIM), Focus group, Hybrid model, Learning scenario.

doi: 10.5505/itujfa.2020.87528

1. Introduction

Nowadays, architectural education is going through a transformation, tending towards the adoption of digital technologies and building information modeling (BIM). BIM is a digital model-based technology linked with a database of project information which is led by the idea to reintegrate design, construction, and project management, reducing project delivery time and overall costs (AIA, 2007). BIM represents a large innovation in architecture, engineering, construction and operation (AECO) industry with significant upside potential, but it also represents, as most innovations do, a disruption to entrenched culture and associated models of practice and education.

Teaching BIM is a complex issue which requires understanding and knowledge not only of the tool but also of materials and construction methods used in the aspired professional practice (Cheng, 2006). Students should not only learn the theory and functionality of BIM and understand its current implications, but also 'learn to learn' and continuously upgrade their practical skills and knowledge to be able to respond to the changing requirements of practice.

The inclusion of BIM in architecture, as well as engineering and construction academic curricula has gathered significant pace over recent years (Barison & Santos, 2018). While there is a visible increase of publications in this area and signs that it is becoming a growing field of research, there is a lack of agreement on how to include BIM in academic curricula. One of the major reasons for the still unresolved status of BIM in architectural education can be found in the presence of clearly opposite attitudes towards BIM in architectural education. While some educators (Clayton, M., Ozener, O., Haliburton, J., & Farias, F., 2010; Ambrose, M. A., & Fry, K. M., 2012; Ambrose, 2007; Aksamija, 2017; Cheng, 2006) regard BIM as an inevitable part of 21st century education and the opportunity to improve it, others consider it a threat to the creative development of students and the disruption of long-established models of educating architects (Denzer and Hedges, 2008). Moreover, architecture educators cannot agree on whether BIM should be approached as a tool/skill issue, as a new form of design practice, or as a new professional organizational model (Deamer, 2011). Each of these positions lead to different contents, pedagogical approaches and positioning in curricula (Becerik-Gerber et al., 2011). As a consequence, the question of how and when to introduce BIM into architectural education remains to be open and exploring innovative approaches is needed.

The literature review of articles on implementation of BIM in education shows lack of evidence-based interpretations of implementing BIM in architectural schools, especially in relation to the main actors of the teaching process – students and teachers. It is still not sufficiently illuminated what particular BIM learning scenario is the most effective one and which brings the best results. This prompted us to develop the longitudinal research study that lasted for three semesters and introduced different BIM learning scenario in each semester. Such research design enabled testing of implementation of a certain learning scenario, and at the same time improving it on the basis of previous evaluations. Before explaining our research approach, we shall first discuss different views on BIM in university curricula.

2. BIM in architectural education

Barison and Santos (2018) provided the extensive list of authors and universities who have integrated BIM into their curricula as well as a comprehensive overview of common trends in adoption across disciplines. According to their observations, architecture schools were among pioneers showing interest in BIM adoption when it first appeared. However, today, they are among the ones with the least agreement on how to do it.

One of the major reasons for this can be found in the presence of clearly opposite attitudes towards BIM in architectural education. On one side, BIM is seen as a threat to the explorative character of architectural education and the creative development of students. On the other side, BIM is seen as an

opportunity to improve architectural education by helping to resolve some of its existing issues. BIM is also seen as a promoter of a more sophisticated 'design thinking' by allowing explorations of various dimensions of design solutions (Denzer & Hedges, 2008). According to this view, BIM is an inevitable part of 21st-century architectural curricula.

Another reason for the still unresolved status of BIM in architectural education comes from the fact that BIM means different things for different educators. While some see it as a tool/skill issue, others consider it as a new form of design practice, or a new professional organizational model (Deamer, 2011). Each of these positions leads to very different pedagogical approaches, teaching methods and contents. In addition, BIM is not just a new topic to be added to the existing educational models. Its adoption requires re-considering epistemological, cognitive and pedagogical aspects of education (Kiviniemi, 2013).

Along with potentials, there are also several obstacles and challenges associated with the introduction of BIM to architectural education. Education is built on a rigid and fragmented structure that often resists changes. Kymmell (2007) suggested that misunderstanding of the BIM process, difficulty in learning and using BIM software and issues pertaining to the environment in the academic institution are the main obstacles to its adoption in education (Kymmell, 2007). Furthermore, Deamer and Bernstein (2011) suggested that already overloaded curricula and design-studio centered structure of architectural curriculum are unsuitable for the adoption of BIM (Deamer & Bernstein, 2011).

The general resistance to BIM in architectural education originates from the belief that BIM is suppressing the creative development of the student by congesting his/her mind with a large amount of information and complex tools. Design activity and idea generation is a delicate process which does not always benefit from quantitative information early in the process (Poerschke, U., Holland, R. J., Messner, J. I., & Pihlak, M., 2010). Specifically, if students are not skillful with the tools, design exploration can be hindered by switching the focus from the task and content to learning the tools. Consequently, this can lead to reduced quality of design solution and loss of creativity until the new media becomes an integral part of the designer's mindset.

The development of successful education depends on more than just curricula development. Supporting curricula development there need to be knowledgeable tutors, a body of research and reference material and the appropriate environment in which to learn. BIM has put the learning challenge in front of educators and students equally. As BIM has recently gained popularity among architecture educators, many teachers do not have the required level of knowledge, expertise or design project experience to teach BIM. Most teachers are experts in 2D drafting, some in 3D modeling, but relatively few in BIM (Kiviniemi, 2013). Creating an information-rich virtual model of a building requires much more knowledge than architectural teachers teach. The lack of maturity and expertise of teachers can result in poor learning and teaching outcomes. Therefore, the issue of 'who' will deliver BIM-related knowledge represents an important challenge for its introduction in architectural curricula.

Additionally, developing appropriate educational material is another challenge. This is because, most of the sources of materials are either from research studies, which are only released via publication only, or vendor oriented material, which is biased towards proprietary BIM tools. In order to overcome this limitation, some universities create their own in-house resources that are used by the students and faculty involved in BIM education. however, this again is not shared among universities massively, and each university has to take a similar effort from scratch.

Furthermore, the interest and awareness of BIM, as well as the level of its implementation in practice and academia significantly vary from country to country (Rooney, 2017). Whilst BIM is being widely adopted, and even required by governments in some

countries, in others, BIM is absent from academic curricula. In countries like Turkey, BIM utilization and recognition of its importance has recently started in professional practice under the pressure of international projects and their requirements to use BIM. Educators cognizant of these changes and their significance for education, are searching for the best ways to reflect them in academia. Some of the leading universities in Turkey have already started the introduction of BIM into undergraduate and graduate courses. However, lack of research literature and practical examples of BIM adoption in academic curricula indicates that this issue has not been studied with a significant level of depth locally. Still, the general question among many educators is: 'What is BIM and why do we need it?'. This points to the necessity to raise the local BIM awareness and knowledge which will open the way to its wider adoption among the architectural education community in Turkey.

3. The present study

To address this need and to build on the current scholarly discussion about BIM adoption in architectural education, this study explores ways of introducing BIM in architecture schools without developed BIM tradition. It is difficult (and probably unnecessary) to recommend any single model or curricular change that could be applied to all schools similarly. This paper presents one part of a larger longitudinal exploratory multi-level case study aiming to develop different 'BIM learning scenarios' for architectural education. In the context of this study, the BIM learning scenario represents a flexible structure organized using a framework proposed by Teymur (2007) and UIA (2011), which suggests organization of new inclusions in architectural curricula within the agenda of four basic questions: why (objectives), what (contents), how (methods), and who (management). To avoid congesting students' minds with the complexity of BIM software and concept, the learning scenario consists of the introduction of the main framework that enables one to understand the essential principles of BIM and the logic of its tools in general. The BIM learning scenario made the basis for creating a new culture in education by proposing a strategy for introducing BIM in architectural education. This strategy is defined by the means of an exchange of experience between the academic world and practice to simulate professional practice in the university. In addition, they promote self-learning and student-centered approach which are one of the key requirements of 21st century curricula.

The study was conducted in the period of three academic semesters from Spring 2017– Spring 2019 including intensive research activity aiming at investigating ways of BIM integration into architectural curricula in schools without developed BIM tradition. One segment that this study addressed were students' perceptions of the proposed BIM scenarios. Given the longitudinal character of the study, it was possible to implement BIM learning scenario continuously over the time and to compare different students' perceptions. At the end of the semester, a focus group was organized in order to collect students' perceptions about the BIM learning scenario. In total, 3 focus groups were organized with 17 participants, on average, 5 participants per a group. Students invited for the focus groups were those who had attended the course on BIM learning scenario, for they had relevant experience to draw from.

This paper presents students' perceptions of the proposed BIM learning scenario. For this purpose, the study used focus group, a qualitative research method typically used for obtaining information about participants' feelings, attitudes and perceptions about a particular topic through conversations (Puchta & Potter 2004). As argued by Flick (2009: 204), focus groups have the potential to reveal meanings people have about a certain problem. On the other hand, its limitation originates from relatively small number of participants compared to the overall population, and pragmatic nature of data analysis instead of providing extensive and general interpretations (ibid: 205). As it is the case with qualitative research as such, conclusions made on the basis of focus group data should

be taken more as illustration of how certain patterns work in the given contexts not as the general rule. In order to increase explanatory value of focus group data, we conducted multiple focus groups with different participants enabling thus comparison of students' perceptions.

In the remainder of the text, we will present the framework used to plan the scenario, describe the scenario setting, present students' responses obtained through focus group, outline the lessons learned and discuss their implications for the future advancement of BIM in architectural education. Although the primary focus of this study is on educational practices in Turkey, the issue in this area is present in countries with a similar level of social and technological development.

The study was based on a single institution, imposing obvious limits on the generalizability of our findings. We acknowledge that the findings are suggestive and are in need of replication in multiple institution studies. Nevertheless, in discussing the results, we will speak of universities, rather than just the one studied.

4. Framework

Technological developments in 21st century created new learning opportunities and brought new profiles of students seeks flexible learning structures and create their own self-learning packages according to their own interests and needs (Foqué, 2010). In such a context, the role of university education increasingly becomes to provide the guidelines on an approach of 'learning how to learn' and the classical role of teacher transforms into a moderator in the learning process, like 'scaffolding for a new building' (Niemi, 2009).

In line with this context, this study proposes 'BIM learning scenario', a student-centered flexible framework for organizing the learning activities with the aim to provide guidelines for learning to learn. As a basis for organizing the BIM learning scenario, we used a framework for planning and proposing new contents in architectural education proposed by Teymur (2007), adopted and further elaborated by the International Union of Architects (UIA, 2011). According to this framework, new inclusions in architectural curricula should be organized within the agenda of four basic questions:

a) Contexts and objectives (i.e. why) - the rationale for introducing new content which is defined by considering various contexts of architectural education and specific objectives pertaining to them. The objectives of specific courses are defined within this rationale.

b) Content and curricular structure (i.e. what) - the contents that should be taught and where should they be placed in the curricula.

c) Methods and media (i.e. how) - the modes, means, techniques, and vehicles by which the contents and objectives of courses are achieved.

d) Management and structure (i.e. who) - the management of knowledge, people, time, space and financial resources in educational contexts; who delivers the knowledge, who are the students and who evaluates and validates courses.

All these components are linked, determining and influencing each other in a variety of ways. Although based on a simple set of questions and concerns that already exist in educational studies separately or comprehensively (Pektaş, 2007; Salama & Wilkinson, 2007), this framework represents a unique and le-

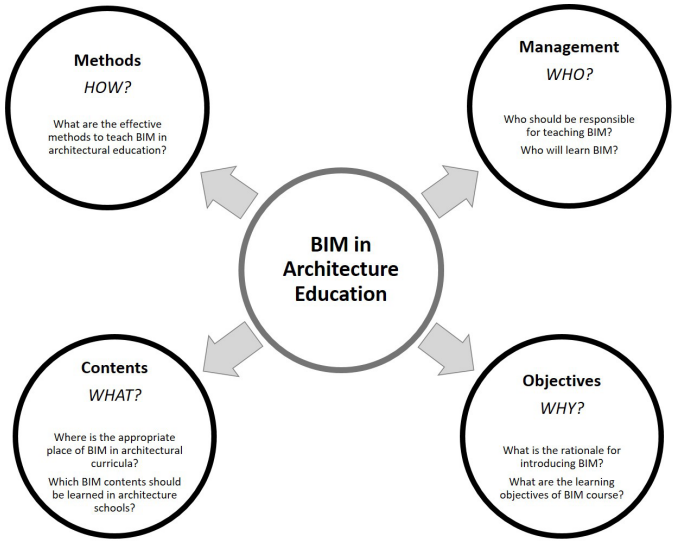

Figure 1. *Framework for BIM in architectural education.*

gitimized approach. Using this framework can contribute to better communication among those interested in BIM in architectural education which is one of the key reasons for its utilization in this study.

5.BIM learning scenario

For the purpose of this study, BIM was introduced in Special Topics in Architecture (MTZ508E), a 3-credit course which is a part of the non-thesis graduate program at Istanbul Technical University (ITU) Faculty of Architecture. The course was developed and taught under the supervision of the Authors. Considering the non-existence of BIM-related courses in the curricula, the selected architecture school does not have developed BIM tradition. The limited course time of 3 hours per week required careful planning of contents that would be introduced to students new to BIM. A homogenous group of 17 architecture students attended the course and agreed to participate in the research. The course required a flexible structure to allow development and the necessary revisions as we gained more understanding of how students responded to BIM.

Following the aforementioned questions, BIM learning scenario was arranged in the following way:

Objectives. The central learning objectives were to: understand the role of BIM in achieving better, more efficient, sustainable, socially and environmentally conscious design solutions; recognize the changing role of architect and the importance of BIM knowledge and skills in contemporary practice; learn the main principles and methods of BIM approach; and learn how to develop BIM knowledge and skills in the future.

Management. The scenario was organized around hybrid model which combined three complementary components (Figure 2):

(I) university class providing the supporting structure and guidelines;

(II) professional practice contributing with expertize and real-life BIM projects;

(III) online learning repository to supplement the in-class learning.

The course was prepared and taught

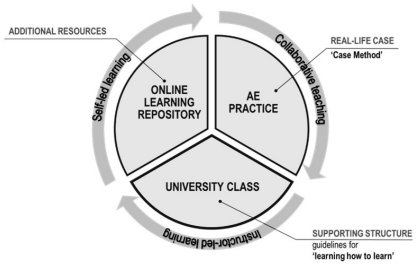

Figure 2. *Hybrid model components.*

in collaboration with BOLD Architecture, an architecture-engineering firm from Istanbul. The reasons for selecting the firm were their interdisciplinary approach and collaborative working methods; experience in BIM utilization and development of effective methods for its implementation; and their readiness to collaborate and openness to share experiences, knowledge with teachers and students. In this setting, the three roles and interactions emerged: learner (student) - moderator (teacher) - practice mentor (architect/engineer). Although practice mentors have valuable project experience and practical skills, they lack theoretical knowledge about specific concepts. They are usually able to do rather than theoretically elaborate on how they did something. To make their contribution effective and to extract the valuable knowledge and adjust it to the level of beginner learner, the teacher's task was to guide them by providing the framework defining the focus and direction of the course.

To meet the course time frame, only the basics and fundamental principles were provided in the class, while students were encouraged to expand their knowledge using course-specific online learning repository. Serving as a supplement to the contents presented in the class, the learning repository contained a variety of texts, websites, and visual materials from BIM-related literature, as well as high-quality tutorials and videos about BIM tools. The content of the repository was continuously updated.

As we agreed with practice mentors that they would not be teaching BIM software skills, nor the time of the class allowed it, the flipped classroom instructional strategy was adopted (Bishop & Verleger, 2013). Students were

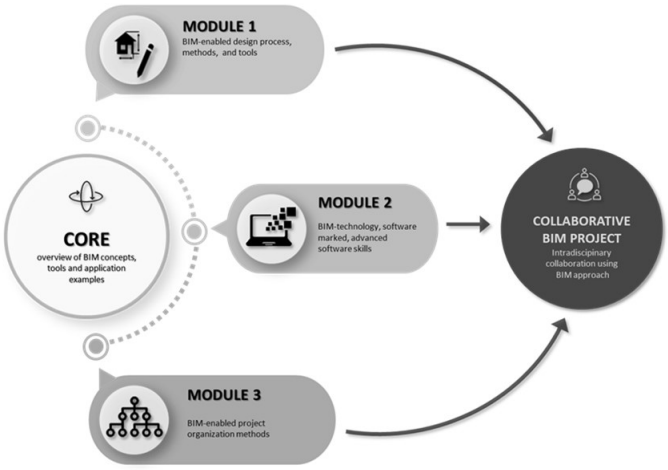

Figure 3. *The three level oganization of scenario contents.*

required to learn the basic technical skills on their own using carefully prepared video tutorials form learning repository. This allowed the in-class time to be use efficiently for the questions about the aspects students could not resolve on their own. Although it was a self-learning process, students were given the framework to follow, such as the required tasks and time to complete them.

Contents. In order to support the gradual development of student's knowledge and skills, and to avoid to avoid congestion in learning with too much content and complexity, BIM content was presented in three levels: (I) Core; (II) Modules; (III) Collaborative project (Figure 3).

The core provided an overview of BIM theory, technology and examples of application in professional practice. This also provided the background for selecting the BIM area students wanted to study in one of the modules they select. The organization into modules was based on the proposition that some students are good in design, some in tool/technology area, while others can be good in organization and leadership. By selecting a module, students could select a BIM area according to their preferences. The main themes from the core were further extended into modules, each focusing on a specific area in more depth. Module 1 focused on design in BIM environment and introduced the concepts and tools for performance-based design. Students explored how building form, its location and orientation, materials and architectural elements influence building performance, its cost, energy consumption and daylighting. Module 2 primarily focused on BIM technology and the proper application of the tools in correct visualization of different types of BIM objects. Module 3 introduced BIM methods for effective organization and communication between project participants, the main principles of the BIM execution plan, BIM process and BIM standards.

Finally, in intradisciplinary collaborative project, students were expected to compile the knowledge and skills learned in individual modules into a common project. Students were divided into teams in which they took the role according to the module they selected previously. The collaborative project aimed to help students in developing communication and teamwork skills and the ability to work efficiently within intradisciplinary teams using BIM technology. The key to this process was for each team member to build awareness, appreciation, and understanding of other members within the team. The projects were not focusing on proposing new designs, rather their purpose was to demonstrate students' understanding of presented contents and their ability to apply them on the given task.

Methods. Pedagogically, the course was designed as a series of lectures and demonstrations followed up by hands-on exercises. In addition, the involvement of practice enabled us to use the case method in delivering BIM knowledge. Although relatively new in architectural education, this method has been used for decades in a wide range of professional schools, such as law, business, and medical schools, to teach the skills required for real-world activities (Garvin, 2003). The top-down process of the case method involves disassembling, analyzing the structure, function, and operation, taking it apart and examining its workings in detail to try to recapture the underlying principles of its creation. The main purpose of using this method was to enable students the exploration of real-life BIM projects and processes that integrate design, construction, mechanics and other sub-disciplines. In this way, the

technological and non-technological principles of a model as an integrated system could be analyzed and examined.

For this purpose, the AE practice provided the 'BIM case', a fully realized BIM model of already designed and completed building and its documentation (Figure 4a, 4b, 4c). Practitioners from each discipline involved in the development of the model, such as architects, structural and MEP engineers presented their components within the model and processes that led to their creation. The role of different disciplines in the overall process and the importance of collaboration between architects and engineers in the development of design solutions were strongly emphasized.

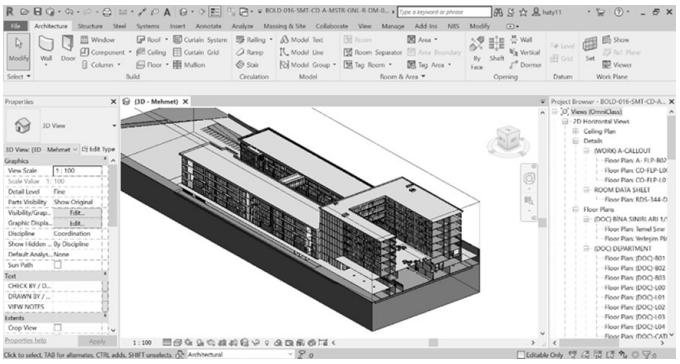

Figure 4a. *The 'print screen' of BIM model provided by BOLD Mimarlik.*

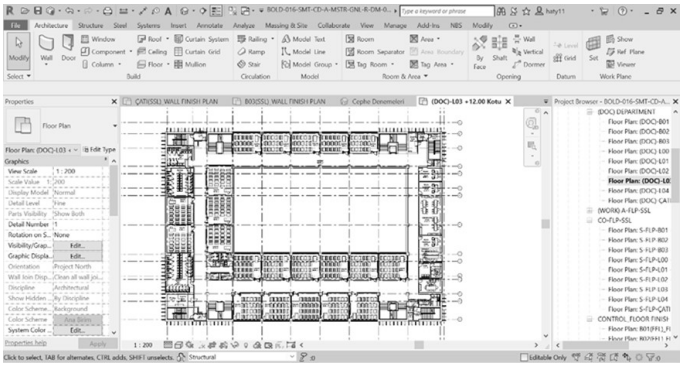

Figure 4b. *The 'print screen' of BIM model provided by BOLD Mimarlik.*

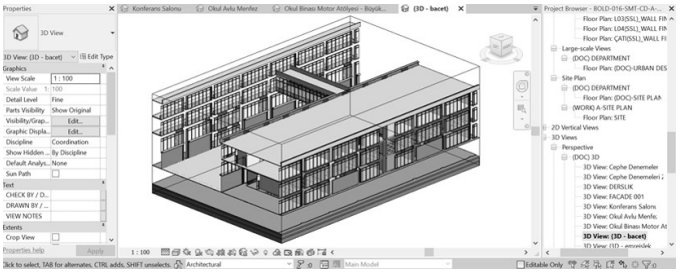

Figure 4c. *The 'print screen' of BIM model provided by BOLD Mimarlik.*

6. Research methodology

This paper describes and discusses one part of a larger exploratory multi-level case study aiming to explore different BIM learning scenarios for architectural education. This paper presents students' perceptions of the proposed BIM learning scenario. For this purpose, together with our observations during the course, using focus group method was considered appropriate and convenient. Focus group is a qualitative research method for obtaining information about participants' feelings, attitudes and perceptions about a particular topic through conversations (Puchta & Potter 2004). In focus group, the researcher can collect in-depth answers to the questions posed and ask supplementary ones if necessary.

In the context of this study, focus groups were used to obtain information about students' attitudes, experiences, and evaluation of several aspects of BIM learning scenario. The focus group was conducted upon completion of the course with 17 architecture students who took the course. The researcher prepared a script for capturing the data which was then circulated to course instructor and practice mentors for comments. An external focus group moderator was engaged to get realistic answers from students. We used Krueger's guidelines for preparation of different categories of questions and their utilization throughout the focus group (Krueger & Casey, 2014).

The focus groups were recorded and transcribed into texts. Together with the notes taken during the focus groups, transcribed texts were coded by highlighting the statements of interest. The texts were analyzed using content analysis as defined by Krippendorff (2018). To ensure that the approach remains unbiased and the findings valid, the course instructor and practice mentors were asked to collaboratively analyze and discuss the focus group findings.

7. Students' perceptions of BIM learning scenario

Analysis of focus group discussions and conversations identified the key themes that were critical in students' experiences and perceptions of BIM learning scenario in every single focus group. Those findings were further compared between the focus groups in order to develop more profound understanding of the commonalities between different students' perceptions in relation to BIM learning scenario. These themes, together with noteworthy quotes, are presented and discussed below.

Firstly, students were asked to rate as 'successful', 'partly successful' or 'not successful' the effectiveness of BIM learning scenario in improving their understanding of BIM. From 17 participants, 11 said that the program had been successful, 4 students said it had been partly successful, and 2 said it was unsuccessful.

7.1. Involvement of practice

All students expressed positive opinions about the involvement of people from practice and their continuous presence in the class. They also appreciated the opportunity to directly communicate with architects and engineers and their openness to share their experiences. Some of the selected responses support this:

'I think practice mentors have much more knowledge about BIM than teachers generally'.

'Honestly, I took the course only because it was mandatory, thinking it will be boring. But at the end, I had the most interesting course so far. Having direct connection with real-life and ability to choose what I am interested in was the exciting part'.

'This is what matters when you graduate, to know how real-life works'.

'I liked that engineers also came to the class, not only architects. The real building is not just architect's work'.

'When I listened to instructor and architect explaining the same thing, no offense, but architect sounds more convincing because they use the example to support what they say and are full of real-life stories'.

Moreover, the presence of practice gave students the confidence that BIM is locally accepted and used, although previously much importance had not been given to it in their education. As one of the students noticed 'BIM seems to make our lives a lot easier. Practice mentor told us they use it more than ten years. I am wondering why nobody taught us BIM before'. Many students believed that practice-mentors should teach BIM because 'BIM is all about making real-life buildings', as one of the students observed. Students also clearly expressed their wish for having people from practice involved in teaching BIM in the future.

7.2. Real-life BIM case

When it comes to using the BIM model from real-life practice, students thought it was useful but still too complex for them as beginners. Furthermore, using real-life example allowed exposure to different tasks and roles in a project which helped students reveal their different interests in different BIM areas. Students also considered it very useful to see '…how it all works in real projects with real parameters'. Similarly, another student considered it useful to see all the elements together: 'I saw these elements for the first time, thanks to the virtual BIM model. I could never guess that there are so many pipes and elements…after all architecture is only one small part'. However, some students thought it is irrelevant for them to know about non-architectural elements: 'I liked to see the MEP elements in the model, but I will never create them. So maybe we could use more time in the class to learn how to create more architectural elements?'

Although students generally thought it is important to have a real-life example, they expressed disappointment about not being able to produce similar models. They felt that they lack knowledge to build the 'complex information-rich BIM models' as they did not think they have enough knowledge about construction, materials, and many other building elements' properties. As one of the students observed: '…the real-life model is completely different from the sample project shown in the tutorial.' They

were aware that it is different from the one they produced and 'far from reality' as one student said.

7.3. Self-learning

Students generally thought they can learn the technical skills more efficiently in the self-learning approach rather than in the classical instructor-led approach. According to their responses, using the learning repositories allowed them the self-defined dynamics and flexibility to choose '…what to learn and when to learn'. For many students, learning the basic commands was not the problem. However, what it all means in the project and how to put the properties correctly represented an issue for many. Students also thought that they needed more time to learn the tool to be able to follow up and understand what was demonstrated in the class. As they were new in BIM tools, it took time to get comfortable with using it. Many of them would return to the 'safer option' of using the tools they are more proficient in. As one of the students commented: 'Revit looks good, but if I need to submit something really important, I would use AutoCAD and Max rather than Revit because I use them for five years and I can do it faster.'

7.4. Modules

Students generally considered the division into modules more dynamic than the classic course setting. They also thought that focusing on a single BIM area is a good way to understand more clearly the specific topic 'without having too many concepts from different BIM areas to learn'. In addition, they also liked the opportunity to choose what they wanted to study, as one of the students commented: 'I liked the idea of modules because BIM looks very complex having too many fields and subfields. It is impossible to learn it all. Everyone should choose something they can be good at.'

One of the main issues that students highlighted was the need for more time for learning BIM. They complained about not having enough time to learn the tool and to follow up with the content of the course. Their suggestion was to have more courses instead of one, so they can 'have more time to organize it all in their minds'. However, some students thought that they would need more knowledge about specific areas to be able to select a specific module. One of the students from module 1 said: 'I selected the design module because I think the design is the most important for architects. But later, I think maybe it was better if I took the module 2 because I would learn the tool better.'

Furthermore, they had difficulty in understanding the meaning of most performance parameters, numeric values produced in the software (daylight factors, energy usage, and carbon footprint). Module 1 students, who focused on design in the BIM environment, were unsatisfied with the lack of knowledge and lectures about building performance. A student from module 1 said: 'I could understand that changing some parameters about building can change the overall energy consumption, for example. But I didn't understand which parameters and how to change them. They seem too complex and I think we should have separate courses for this.'

7.5. Collaboration and teamwork

Although they showed relatively good results in individual module assignments, students could not demonstrate them in collaborative project. They generally lacked collaborative experience. One of the students said: 'I liked the idea that we can create a project together as a team. But most of the time we worked separately, and later we would put it all together in the class.' Although students theoretically understood the concept of collaboration, they lacked skills to apply it. As one of the students observed: 'Collaboration is not only about creating a project and saying that we worked together, it is a process and a way of thinking.'

Another student described negative collaboration experience: 'My role was to organize the team and to follow their progress. I created the BIM execution plan, but it seems that nobody really took it seriously. Everybody did what they wanted and how they wanted.' Another student also commented: 'This was 'individual collaboration', I

did my part for myself, the other for himself and then we put it altogether for submission.'

Another student from module 3 expressed disappointment about the collaborative experience: 'BIM has very good structure and description for everything in the project. What I saw in the class, the documents and technology are well organized. But this is not helping if people are not using it. In our team, nobody followed the plan. So why to make it if nobody will follow it?' Another student also observed that: '…collaboration is all about trust. You can do the job with someone you trust and who will stick to the schedule. No technology can give you trust. You have to build it.'

One student observed that 'For a collaborative project, I think we need more software skills and more collaboration skills. Many of us don't know how to use Revit very well, and at the same time we are not very familiar with how to work with others in the BIM project.'

Table 1. *Comments from students on the course main aspects.*

Course Aspect	Student's comment
Practice involvement	'I think practice mentors have much more knowledge about BIM than teachers generally'.
	'When I listened to instructor and architect explaining the same thing, nc offense, but architect sounds more convincing because they use the example to support what they say and are full of real-life stories'.
	'I liked that engineers also came to the class, not only architects. The real building is not just architect's work'.
Real-life BIM case	'I liked to see the MEP elements in the model, but I will never create them. So maybe we could use more time in the class to learn how to create more architectural elements?'
	'…the real-life model is completely different from the sample project shown in the tutorial.'
	'I saw these elements for the first time, thanks to the virtual BIM model. could never guess that there are so many pipes and elements…after all architecture is only one small part'.
Self-learning	'Revit looks good, but if I need to submit something really important, I would use AutoCAD and Max rather than Revit because I use them for five years and I can do it faster.'
	'I could decide what to learn and when to learn.'
Modules	'I selected the design module because I think the design is the most important for architects. But later, I think maybe it was better if I took the module 2 because I would learn the tool better.'
	'I could understand that changing some parameters about building can change the overall energy consumption, for example. But I didn't understand which parameters and how to change them. They seem too complex and I think we should have separate courses for this.'
Collaboration and teamwork	'This was 'individual collaboration', I did my part for myself, the other for himself and then we put it altogether for submission.'
	'My role was to organize the team and to follow their progress. I created the BIM execution plan, but it seems that nobody really took it seriously. Everybody did what they wanted and how they wanted.'
	'For a collaborative project, I think we need more software skills and more collaboration skills. Many of us don't know how to use Revit very well, and at the same time we are not very familiar with how to work with others in the BIM project.'

These answers demonstrate the general lack of teamwork experience and poor collaboration skills. This points to the need for more collaborative projects and exercises in BIM learning and in education in general. This also points to many aspects of intradisciplinary collaboration that should be learned before moving to interdisciplinary collaboration. For the future, one of the main suggestions that students highlighted is learning to work in a team, designing with BIM tools, and learning about building performance. Some of the students, who used the skills and knowledge for projects in other courses, also suggested that: 'It would be useful to learn more how to use the tools so I can apply them for assignments in other courses.' Another student also suggested making a connection with the design studio, so they can use what they learn in BIM course for the design project.

A summary of representative students' comments on the main themes is presented in Table 1.

8. What have we learned?

The BIM learning scenario proposed and tested in this study represents an approach to introducing BIM to architecture students who are new to BIM concepts and tools. The goal was to introduce students with the main principles and demonstrate its importance in practice and contemporary design project. It also aimed to provide the foundation for learning and development of self-learning skills in the future education and practice. Although every student is individual and different, having his/her own learning patterns, whose exploration is beyond the scope of this study, there are common patterns and conclusions that could be drawn from this study.

The hybrid model proposed in this study is a step towards creating a new culture that merged professional expertise and experience with pedagogical methods and technology based learning environments. This proposition emphasizes the role of university education to provide guidelines on 'learning to learn'. It also well accommodates the real-life dimension of BIM extracted from professional

practice. Students become responsible for determining the dynamics of their self-learning process which extends beyond the boundaries of classroom unit. Seeing architectural practice and education as partners in teaching BIM is beneficial in multiple ways. Involvement of practice not only influenced positively on student learning processes during the course and increased their interest and motivation to learn BIM, but also motivated them to explore BIM further.

Having practice mentors involved in introducing BIM concepts and explaining their application in real-life BIM case improves students' understanding of BIM and gives them confidence that they are learning skills required in today's practice. In addition, the use of real projects makes educational exercises much more meaningful. Students understand and adopt new BIM concepts more easily when their meaning and application in real-life examples are demonstrated to them. They also gained more knowledge about what happens after the design stage and improved understanding of the development of building projects as an interdisciplinary activity. Using real-life examples also allowed exposure to different tasks and roles in a project which helped students reveal their different interests in various BIM areas. BIM concepts and tools should be explained in parallel, having one part of the course explaining a theoretical concept and the other part its application on a specific task. Since all BIM concepts are essentially practical, for students to understand them, each learning unit should involve combination of theory and hands-on application, mind and hand. To make BIM learning more meaningful for architectural student, the clear relationships with architectural knowledge should continuously be made. Theory is important but should not dominate and give space to practical examples.

The complexity of BIM concepts and tools makes it difficult for students to grasp, particularly for beginner learners. Too much content leads to congestion and inability to understand and apply the knowledge on required task. While some architecture students have more interest in design, others have interest in technology or in organization of design projects. New content should be carefully introduced to avoid congestions with too much new information and complex tools. The division of BIM content into learner-defined modules, smaller chunks and more focused topics, which a student can grasp are more effective way of learning then having all students learn everything together. However, the relationship with the overall BIM concept has to be continuously emphasized. Although the areas were divided, there is still a substantial amount of overlap and interaction, among all three of these areas.

This example also emphasized collaboration and teamwork in which student-to-student relationship was specifically important. One of the main goals of the collaborative project was to experience different aspects of collaboration such as trust, team building, role, and responsibilities distribution. However, the negative experiences of students in teamwork showed that none of these aspects is sufficiently developed in architectural education. This indicates the necessity for more collaborative projects and exercises in BIM learning and in architectural education in general. This also points to many aspects of intradisciplinary collaboration that should be learned before moving to interdisciplinary collaboration. Using the top-down approach of the case method, in which the whole finished building is presented first, also demonstrated the need for interdisciplinary approach as well as building as a system of related parts that are created through the efforts of different professionals and disciplines. Teaching the skills and knowledge required for developing such models points to the need for interdisciplinary approach in architecture, engineering and construction education. However, this study showed that before interacting with others, students should be aware of their own disciplinary roles and responsibilities (intradisciplinary). The condicio sine qua non for collaboration with others disciplines is learning to collaborate within one discipline.

Using clear, understandable, high quality and up to date resources and

software tutorials are invaluable supplements to in-class learning and represent complementary component of BIM-related classes. Apart from using external resources such as global websites and links of certified institutes, companies, organizations related to BIM research and application, it is also necessary to produce in-house resources, such as special purpose video tutorials. Using these resources, students learned where to find specific information according to their interests, how to properly use them and how to develop their learning based on self-defined dynamics. This provided the foundation for student's development of BIM knowledge and skills in the future which is important for following up the continuous technological developments. Moreover, the use of video tutorials has, in particular, helped students to acquire the practical BIM skills by self-learning. The in-class time could be used for discussing the advanced issues and real-life aspects that students cannot learn on their own. The impact of self-learning was significant, both in terms of the quality of the results and the level of student engagement and commitment to their own self-selected definitions of success.

9. Future development

The learning scenario proposed in this study concentrated on the introduction of BIM in architectural curricula. This is an open-ended proposition, leaving space for further development. The question for future research is: 'How to advance BIM in architectural curricula'? One of the opportunities for advancement is through the establishment of relationship with other courses in architectural as well as in curricula of related disciplines. To support the curricula development there need to be knowledgeable teachers, a body of research and reference material and the appropriate environment in which to learn. As BIM has recently gained popularity among architecture educators, many teachers do not have the required level of theoretical knowledge or practical design project experience to teach BIM. Creating an information-rich virtual model of a building requires much more knowledge than architecture teachers currently teach. Therefore, along with planning education for students, educating faculty is essential for development of BIM in architectural curricula. Another way for advancement is through development of models for collaboration between practice and education. Architectural education is practice-oriented and needs to look to the advancements from practice as a source for teaching. Future research efforts should develop the ways to make practice and collaborative teaching integral part of university education in BIM adoption process. Finally, BIM is complex and evolving concept. Trends in human-computer interaction (HCI), augmented reality (AR), cloud computing and generative design, continually and rapidly influence the evolution of BIM. The new opportunities they create for architectural design practice and education should be investigated in future research.

No single approach to BIM inclusion in architectural education will suffice. Each academic program is different. The important task still remains for the future: educators and practitioners from architecture and related fields, researchers, institutes and governmental bodies should collaboratively approach to the development of a new educational paradigm in which BIM will have the central role.

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Residential environmental design with nature inspired forms

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Received: November 2019 • Final Acceptance: December 2019

Abstract

Students' works in Environmental Design Project 2 (EDP2) course which focuses on creativity and functional formation were analysed in this study. This study deals with the experiences of the 2nd-year landscape architecture students in the EDP course in regard to developing design and creativity skills and morphological efforts. The landscape architecture education can be defined as decision-making, designing spaces and organizing human activities and in Environmental Design Studios (EDS) these are addressed as a whole. For this reason, "EDS" make up the most dynamic milieu of the landscape architecture education. These are courses that synthesize problem-solving skills built on the information and creativity obtained from other courses. Thus, students are expected both to come up with problem-solving suggestions with their knowledge and use their creative capacities in these suggestions within the scope of the course. Consequently, students are expected to produce creative designs suitable for the objective of the courses. However, the studies on how students perform these tasks in the landscape architecture education are quite limited. In the 1st stage of this study, an approach that will develop the creativity of the students was investigated, and it was aimed to share the experiences on this subject. In the 2nd stage of the study, the students assessed how they utilized inspiration by nature and the benefits of inspiration by nature to their educational and developmental processes.

Keywords
Inspiration by nature, Creativity, Design education.

doi: 10.5505/itujfa.2020.43799

1. Introduction

Design is a complicated structure that deals with definite and indefinite ideas, systematical and chaotic ways of thinking, imagination and mechanical calculations (Lawson, 2005). Therefore, it is an activity that is difficult to be defined, but it may be described with the help of visual and verbal means that are used during the design process because design process is a combination of activities that the designer do through perceiving - thinking - expressing and with used visual - verbal devices. The devices that are made use of in this process affect the process, the output that is an expression of an idea and its perception (Anderson, 2011). However, designing consists of such activities as creativity, information gathering, thinking, analyzing, deciding, trial-and-error and problem solving. Thus, the process of design is an activity in which intellectual power of thought, the data that all senses gather from the environment and inborn talents are synthesized as a whole. To form creative design, personal experiences, education, enriching and diversifying the thinking are also significant in addition to all these. Therefore, the answers to the questions how the designer thinks in this process, what kinds of things lead their ideas, and in which way they lead them show the relationship between the design and inspiration (Melikoğlu Eke, 2015).

For the designer to make use of visual data in order to improve his / her ideas will support his / her creativity, thus increasing the productivity of the design process because in this process, visual data would facilitate the designer as the ideas of the designer are transformed into patterns. Especially in the first years of design education, it is very difficult for the students to sketch the design they form in their minds. To deal with this difficulty, it is significant that the students benefit from knowledge and experience of their design instructors as well as taking advantage of the visual data that the nature provides them. As form knowledge of the students who are in their early years of education is limited, it is not easy for them to create forms and options. Inspiration of the nature is the best source for the students to "create patterns". Thus, students are given the opportunity to discover their own styles / methods. Within the scope of this study, it is aimed to build the skills of the students about how to turn their abstract ideas that are in their minds into concrete ones by making use of the shapes, relationships and colors that exist in nature. As a result, their creativity will also be facilitated. The success in bringing together this stylistic pursuit and the functions that are to be around a building is identified and evaluated by the course instructor.

1.1. Creativity and inspiration

Creativity is the center of new ideas. It is the source of new products and designs, and it is also the vision of perceiving the world in a renewed shape (Canaan, 2003). "Creativity in design" is the ability to think many perspectives, to go beyond the thinking line that is imposed and to think differently from others, and it is also approaching the solutions of the problems from varied aspects, making new relationships or reforming the relationships among the ideas that already exist, being able to think in comfort-fast-independently and quick, and reflecting all these into design (Uzunarslan and Polatkan, 2011). For this reason, in the process of the solution of the problem of design, the way to improve creativity or to teach it is a very important problem of design education (Casakin, 2007; Çubukcu and Gökçen Dündar, 2007) because while creativity is an innate ability, it is also an ability that may be learned, taught and improved by providing the right information at the right time with the help of education (Apaydın, 2015; Weisberg, 2004).In the process of design, the designed form is generated with the help of the sense of creativity that is believed to be related to ability. However, the effect of imagination on creativity should not be disregarded (Çubukcu and Gökçen Dündar, 2007). Imagination is the priority of creativity (Denel, 1981; Çubukcu and Gökçen Dündar, 2007), and inspiration could be a method in development of imagination.

Inspiration is described as the shapes and laws of nature that forms a

sample or a model for art or learning based on a source, inspiring, interpreting and reflecting things (Tunalı, 1998; Ziss, 1984). Inspiration could facilitate thinking in design and could function as a trigger to produce ideas (Eckert, 1997; Mete, 2006). Sources of inspiration play an important role in the design process by improving the creativity, originality and imagination of the designer (Mete, 2006) and are effective on the whole design process. Inspiration is used to develop concepts in the first stage of the design process, ideas that affect design decisions in later stages (Goldschmidt and Smolkov, 2006; Cardoso and Badke-Schaub, 2011) and to transform ideas in the final stage (Authors, 2018). Thus, the ability of the designer to observe the environment and his/her ability to identify the inspiration sources could improve both the quality and creativity of his/her designs (Eckert, 1997; Mete, 2006). Thus, inspiration supports the creative process by helping the designer produce unexpected solutions required by the design problems (Authors, 2018).

In the process of inspiration, designers tend to actively collect visual examples for inspiration (Keller et al., 2009). Especially the habit of architectural designers to describe and research the information hidden in visual images supports the use of visual data in the inspiration process and this was supported by the studies that suggested that designers prefer to use visual data (Authors, 2018; Gonçalves et al., 2014; Casakin, 2005; Hanington, 2003; Eckert and Stacey, 2000; Goldschmidt, 1994). Use of visual resources as inspiration tools in design, their fruitfulness, and the perception of the design process as a discovery activity characterized by visual thinking (Goldschmidt, 1994) are explained with the increase in the quality of design solutions and development of design knowledge/skills and creativity (Casakin and Timmeren van, 2015; Goncalves et al., 2014; Cai et al., 2010; Casakin, 2012). Furthermore, additional visual sources could provide simple and intuitive clues that do not require translation between different perceptual methods (Malaga, 2000). Thus, visual resources can be an effective inspiration tool for beginners in design. One of the challenges encountered by novice design students is the difficulty to transform an abstract design concept into a form and to associate this form with spatial organization (Dogan, 2013). Therefore, visual inspiration sources are very important in design education and nature is an endless source for visual data which the students could utilize to find solutions to design problems during the initial years of their education. Students could analyze and imitate the structure in nature to explain their approaches to a well-defined design problem, to reflect their ideas on design and to express these ideas using drawings. Thus, especially inspiration by the nature was scrutinized in the present study.

1.2. Inspiration by the nature in design

Designers think, fictionalize and design within a system. "Nature" is a very good source to facilitate thinking process and provide difference in design. As a consequence, throughout the history of architecture, natural objects and processes have been a limitless inspiration source for designers. With its features such as shape, color, texture and function, nature plays an active role in forming relationships between the forming of design shapes and their functions. More specifically, designers may easily use the shapes and geometry of the characteristic structures in nature and the visual data related to the worlds of animals and plants (Joye, 2007; Feuerstein, 2002; Lynn, 1999). Thus, nature provides several sources to transform the designer's abstract ideas into a form. In the present study that analyzed the effect of visual data on creative thinking and creating forms, only "nature" was used as the visual data source. Within the context of the study, similarities with the shapes in nature were examined as "inspiration by the nature". The concept of inspiration by the nature in design is transferring the samples in nature by evaluating their shapes, functions and systems to design (Joye, 2007). For a designer to transfer these relationships that exist in nature to design starts with reaching the right visual data, continues with the appropriate analysis of

those data for the aim and ends with its formal and intellectual transferring to the design. Inspiration to nature reflects on design in two ways:

1. Having the form of the natural object and transferring it to design by imitating it due to formal considerations (Hagan, 2001; Kellert, 2005)

2. Inspiring from the form and function in nature (material, form and structure) and with experimental data, it changes into architectural form (Arslan Selçuk and Gönenç Sorguç, 2007).

Why does the designer inspire from nature? The answer to this is that nature has already solved a great number of challenging design problems with the help of its relationships that exist in it, that it has endless data required for imagination and that it enriches the shape knowledge of the students who are at the beginning stage of their education because the process of design is a process which is based on visual thinking and in which the idea of design is improved and shaped. In this process, designers develop and express their ideas through sketching and the final shape is designed step by step. Benefitting from the shapes in nature is a very important contributor for the designer. Especially in the first stage of design education, forming shapes by imitating the lines in nature and sketching these enable the designers to change their dialogues with themselves into shape through concretizing their ideas (Lawson, 2005). As a result, the designers who are in their first stage of education may develop a design understanding which is consistent, readable and that has high creativity when they form a successful connection between the inspiration sources in nature and design problems.

In the education of landscape architecture and especially in the first environment design studio in the second year, improving design abilities and creativity is of great importance. Nevertheless, improving design and creativity is a challenging process that includes uncertainties for the students and instructors in terms of the method because environmental design studios are the places where the students first experience their profession in real terms in the education of landscape architecture, and there the future landscape architects both experience design and learns how to design. During the education of landscape architecture, environmental design studio continues for seven semesters. However, the studio in the second year is the first course in which the students first experience sketching and they firstly turn their abstract ideas that they design in their minds into concrete ones by sketching without having any pre-learning related to turning ideas into shapes. This course is a place that the students both have the anxiety of generating forms and try to match the shape and function, and also it is a place where they need to improve their creativity. Therefore, within the scope of this study, based on the idea that visual thinking is more important in order to improve the ability of the students to create forms, the effect of inspiration by the nature on generating forms is examined. Consequently, the present study aimed to provide an insight for the students who newly experienced the process of design and "how to improve their knowledge of shape" and to help them "gain the ability of generating forms" through inspiring from nature and giving them the opportunity to create similar correlations. Thus, environment design studio courses enable the students in their first year of education to enrich their creative thinking with the help of the approaches like inspiration from nature and enrich their visual memories with the opportunities of generating forms. While the students primarily learn how to generate forms through inspiring from nature, they will gain the ability of creative thinking without realizing it. This would become an effective tool to solve design problems and improve their creativity.

Creativity is from innate but it is an ability which can be learn and develop, consequently this research is based on the following questions:

- What is the contribution of inspritaion from nature to students' learning and development?
- What is the contribution of inspritaion from nature to to the ability of produce form?
- How do students use nature inspirations?

• Do students' inspritation forms from nature support their creativity?

In this context, this research practiced of two stages; the evaluation of the inspiration approach from the nature by the faculty members and students.

2. Materials and method

2.1. First stage: Assessment of the instructor on the inspiration by nature approach

2.1.1. Environmental design studio definition

Environmental design studios are the courses which constitute the education of landscape architecture and where all the concepts of deciding, designing spaces and organizing human activities are dealt with as a whole (Authors, 2017; Eren and Var, 2017; Rodiek, 1998). In these courses, the basis of the education of landscape architecture is formed. "Environmental design studios" constitutes the most dynamic atmospheres of the education of landscape architecture because in the scope of these courses, all the information obtained from all other courses is synthesized with the ability of problem solving that is based on creativity. Therefore, in this course, the students are encouraged by the instructor both to find solutions to the given problem and to use their creativity in these solutions. The design studio environment is a space where thinking takes place through dialectical conversation between the faculty member and the student, and through external representations such as sketches (Schön, 1984; Schön, 1987; Dogan, 2013), and thus, providing the students with a space where they could use their creativity and intellectual capacity.

In the environmental design studios, the students are quite dependent on their instructor in their first stage of studies and it is very important to get complete guidance and approval from them related to their projects to make progress because the critics that they have in these courses is crucial for the learning performance of the students. Therefore, the relationship between student-instructor is like master-apprentice relationship. Studios are the places where the instructor conveys the knowledge and experience to the inexperienced students. Moreover, in this course, the instructor will encourage the students who have newly begun designing to learn, will have positive evaluations, and the instructor has the role of being a source that has varied information and is a guide for the students. On the other hand, the faculty member could be observed as role model by the students and as the person who possesses various types of knowledge they desire to acquire (Goldschmidt et al. 2010).

2.1.2. Environmental design project 2 (EDP2)

This study was conducted in environmental design studio belonging to 2nd year and 3rd term in the Department of Landscape Architecture at KTU. In the 3rd term environmental design studio, as a design problem "Design of Building Environment" was determined and the students were given a villa and its environment as study area. This process takes 12 weeks and the studio course is 8 hours a week. It happens twice a week and each lesson lasts four hours. During the course, the students present their studies, they discuss their studies with their instructor, and they get feedback from their instructor. Feedback is given to the students one by one and each lasts about 30 minutes. The students take notes about their feedback, in the next course they describe the improvements they make to their designs, and they define the feedback. This method means "learning by doing" or "trial-and-error" for the students. The stages of the course are as follows:

2.1.3. Research on the topic

This stage consisted of two steps and this process is completed in two weeks. In the beginning of this stage, the instructor inform the students about how to create original ideas - shapes inspiring from nature, about what kind of natural shapes will help them in generating forms and about what kind of activities may happen in the environment of a building.

In the first step, the students do research on activities in the building and they think which of these activities

may also happen in the environment of the building. While they gather information for this research, they are free to use varied sources such as books, magazines or the Internet, and the research should include information about functional needs of the building and information defining the building and its environment. Especially this information is supported with visual samples that consist of plans and images. A report is written along with these studies.

In the second step, the students prepare varied photo samples that they can inspire from nature through using the sources they want. The instructor expects the students to find samples that are readable and show unity of characteristics in terms of form. These samples make it easier for the students that are in their first stages of education to generate form and create options, and they provide them a starting point.

2.1.4. The process of generating form

This stage consisted of two steps and this step of the study is a process that is aimed to improve the creativity of the students. It lasts between the 3rd and 6th weeks. The aim is to develop students' form generating abilities. In the first step, the students define the formal and characteristics feature of the photos of nature that they choose. The design process that starts with the photo samples that the students find interesting and they may inspire from them continues with the analysis of the samples. In this stage, on the chosen nature photos, the students are enabled to have sketching activities to generate forms, and thus it is enabled for the students to understand the lines of nature and how to imitate it. Later, the instructor evaluated the sketching studies on these photos and they are minimized to five who form understanding is successful.

In the second step, form understanding in sketches that are developed on five nature photos continues to improve with the feedback that the instructor provides to the students. In this step, the students start to reflect their own designer identities to the lines they inspired from nature through reflecting their own abilities to the creating process that they imitate from nature by the help of sketching (Table 1). In this step, each sketching that the students form constitutes the next one and the form pursue of each sketching has more characteristic lines.

At the end of this stage, the instructor reevaluated the forms that were improved from five nature photos that the students studied on and the most developed sketching was chosen. In these evaluations on sketching, it is seen that the efforts that the students gave to generate forms were generally successful. The instructor find out that the forms that the students generated inspiring from nature had strong relationships with each other and they had a structure that functioned well like in nature.

2.1.5. The relationship among form-space-function

In this step, the forms that were improved independent from function were changed into spaces. In this study, the students managed to bidimensionally express the form that they generated through inspiring from nature and the functions that they imagined in their minds or they succeeded in changing an idea into form by inspiring from nature and explaining this in architectural terms. The students were enabled to interpret based on the model they chose, to decide the type of open space they design and the kind of activities that take place in it by improving the model and planning the form - function relationship. In this stage, combining the form that was generated through inspiring from nature and the function was completed (Table 2). However, certain students, who construct the correlation between form, space and function at this stage went beyond the mere replication of the form in the relation between de-

Table 1. *Generating form from the sample inspiration from nature.*

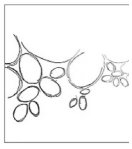
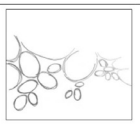
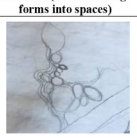
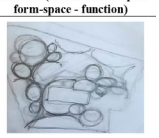
General view of the sample inspired from nature	Detailed view	Inspiring from the forms	Generating forms
			

Table 2. *Changing the forms generated from the sample inspired from nature into spaces.*

Sample inspired from nature	Generated form	Sketch I (Transforming forms into spaces)	Sketch II (The relationship of form-space - function)
			
Integration of the produced form to be defined similar to the nature			
	**Inspiration by the nature:** To reflect the natural forms in the design, the forms should be repetitive and similar.		
	**Inspiration by the nature:** As the form is similar and repetitive, its scale and direction changes. To remove the monotony in similar and repetitive form, orientation and size of the forms should be varied. Thus, the contrast between the size and direction of the forms would lead to non-monotonous systems similar to nature.		

sign and nature by analyzing both the form and functions and relations in the nature (Figure 1). These students (Students 1-2-3) attempted to construct how the forms present in the nature come together. Based on their professional experience, the researchers considered that students reflected the ideas they obtained from this construction the their final product as follows:

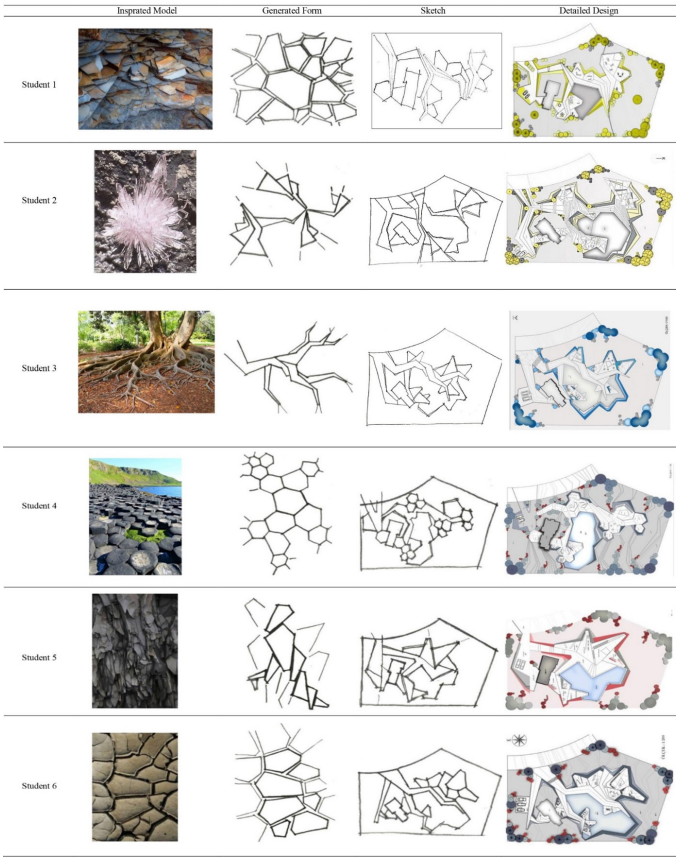


Figure 1. *The examples of student studies.*

Similar to nature, shapes (that were transformed into spaces) repeat themselves in terms of direction and dimension and contain similarities. Thus, the forms are combined in harmony and aim to create a holistic impact.

The repetition in nature is not monotonous, especially since it contains contrast in size and direction. The students attempted to prevent monotony in their designs by utilizing the variations in direction and scale when designing the spatial construct of the forms they produced by emulating nature in their designs. A group of students (Students 4-5-6) considered the idea of inspiration by the nature as a mere imitation of the forms (Figure 1). Similar to nature, shapes (that were transformed into spaces) repeat themselves in terms of direction and dimension and contain similarities. Thus, the forms are combined in harmony and aim to create a holistic impact, however due to the lack of a significant change in dimension and direction, it was concluded that the products produced by this group were monotonous compared to the students in the other group. The products of these two groups are presented in Figures 1.

2.2. Second stage: Survey about the student assessments on inspiration by nature approach

The survey was applied to 73 students, who took the same course in different semesters (2015-2016 fall semester, 2016-2017 fall semester), to determine the achievements in the course at the end of the semester. The survey was conducted to determine the contribution of the inspiration by nature method to form creating skills of the students in the course and its effects on learning. Students responded to two groups of questions in the survey: the first group of questions aimed to assess how the students utilized the inspiration by nature concept to create forms and the second group of questions aimed to assess the benefits of nature visuals for their learning and development (Table 3).

The first group of survey responses ensured the analysis of the inspira-

tion by nature by the researchers and the second group of responses enabled the researchers to assess the students' learning and development processes. The responses were assessed using a 5-point Likert scale that ranged between 1 = "very poor" and 5 = "very good".

The survey was conducted after the announcement of students' grades in order to eliminate the students' possibility to respond to survey questions with a concern to get better grades. Thus, objective student responses were ensured.

2.2.1. Data analysis

The collected data were analyzed on Statistical Package for the Social Sciences (SPSS, Version: 27.0) Software. At this stage, whether the correlation between the students' responses to questions on the contribution of inspiration by nature to the process of form-creation and creativity of the students was significant and the arithmetic means for these questions were determined. The results of the statistical tests demonstrated that the contribution of inspiration by nature to the students was statistically significant (p / 0.01), and it was found that the correlation between inspiration by nature and the form analysis process was statistically significant (p / 0.01).

3. Findings

The contribution of the inspiration by nature approach to the environmental design project 2 course was evaluated by the students. Averages for the responses given to each question were calculated for the general assessment on inspiration by nature. Comparisons of the use of inspiration by nature by the students were evaluated with ANOVA test.

3.1. Findings on the contribution of inspiration by nature to form-creation skills and learning

The highest arithmetic mean value in the questions posed to determine the most effective quality of inspiration by nature on the form-creation skills of the students and the correlation between this quality and its benefits for the learning and development

Table 3. *Survey questions.*

1st GROUP QUESTIONS	The analysis of inspiration by nature	What are the methods used by the students in inspiration by nature?	Q1	I used it to analyze the form of nature visuals, to develop their lines to produce new forms.
			Q2	I directly copied the form of nature visuals
			Q3	I analyzed the systems in nature visuals and utilized the principles/organic relations in these visuals to establish a form, space and function relationship
			Q4	Nature visuals support form creation and learning creativity
2nd GROUP QUESTIONS	Learning and development process of students	How inspiration by nature contributes to the learning and development of the students?	Q5	It revealed my creative powers and potential
			Q6	It develops aesthetical thinking and awareness
			Q7	It helped me to concretize my mental designs
			Q8	It helps me acquire the skill to transform abstract thoughts into concrete
			Q9	It facilitated drafting
			Q10	It develops understanding of basic design concepts such as repetition and rhythm and transferring these into drawing
			Q11	It improves the skill to transfer analyzed samples into drawing
			Q12	Inspiration by nature supports learning creativity and increases my motivation for creativity
			Q13	Inspiration by nature teaches to establish links between unrelated concepts and visual elements
			Q14	Inspiration by nature enables flexible thinking
			Q15	Investigation and inquiry about all types of relationships in the nature should be a part of the design process to obtain sustainable products or design
			Q16	Inspiration by nature had a positive impact on my perspective on nature
			Q17	Inspiration by nature made me realize the amazing harmony and balance in the nature

of the students was identified in the first group question of "I used it to analyze the form of nature visuals, to develop their lines to produce new forms (Q1)" and " Nature visuals support form creation and learning creativity (Q4)". The highest mean was observed in the following second group questions: "It develops understanding of basic design concepts such as repetition and rhythm and transferring these into drawing (Q10)" and "It helps me acquire the skill to transform abstract thoughts into concrete (Q8)". Also, high arithmetic mean values were observed in the second group questions of "It facilitates drafting (Q9)" and "Inspiration by nature teaches to establish

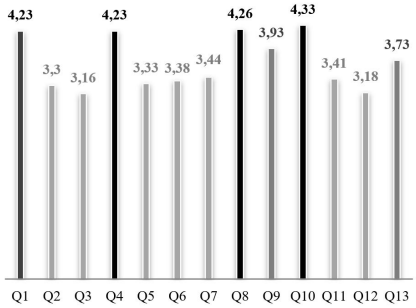


Figure 2. *Arithmetic mean figures obtained in the responses .*

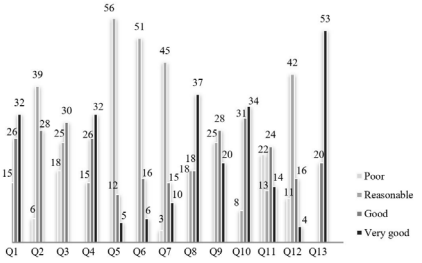


Figure 3. *Response frequency distribution graph.*

Table 4. *Skewness/kurtosis values for the analysis of nature visuals.*

		Std. Deviation	Skewness	Kurtosis	Chi-Square	df
Analysis of nature visuals	Using nature visuals by copying their forms	,697	,018	-,892	11,534[a]	2
	Using nature visuals by analyzing their system	,789	,074	-1,382	1,014[a]	2
	Using nature visuals by analyzing their forms	,809	,205	-1,440	1,342[a]	2
	Supporting form-creation and creativity with nature visuals	,786	,412	-1,259	27,110[b]	3

Table 5. *Assessment of the methods of using inspiration by nature concept Anova.*

		Sum of Squares	df	Mean Square	F	Sig.
Using nature visuals by copying their forms	Between Groups	25,178	3	8,393	59,037	,000
	Within Groups	9,809	69	,142		
	Total	34,986	72			
Using nature visuals by analyzing their system	Between Groups	32,218	3	10,739	58,538	,000
	Within Groups	12,659	69	,183		
	Total	44,877	72			
Using nature visuals by analyzing their forms	Between Groups	40,263	3	13,421	**134,994**	,000
	Within Groups	6,860	69	,099		
	Total	47,123	72			

Table 6. *The concepts with a correlation with form analysis process.*

		2nd GROUP QUESTIONS												
		Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17
students' learning and development process	Q5	-	,841**	,948**	,511**	1,000**	,605**	,702**	,917**	,825**	,926**	,805**	,764**	,786**
	Q6		-	,856**	,583**	,841**	,691**	,817**	,764**	,787**	,903**	,786**	,782**	,603**
	Q7			-	,538**	,948**	,638**	,728**	,935**	,856**	,886**	,779**	,759**	,823**
	Q8				-	,511**	,901**	,819**	,457**	,698**	,517**	,670**	,812**	,314**
	Q9					-	,605**	,702**	,917**	,825**	,926**	,805**	,764**	,786**
	Q10						-	,884**	,541**	,772**	,613**	,712**	,841**	,372**
	Q11							-	,632**	,794**	,731**	,778**	,835**	,466**
	Q12								-	,831**	,842**	,809**	,701**	,861**
	Q13									-	,783**	,759**	,842**	,732**
	Q14										-	,823**	,767**	,675**
	Q15											-	,789**	,533**
	Q16												-	,599**
	Q17													-
Form Analysis		**,913****	,880**	**,959****	,567**	**,913****	,671**	,758**	**,904****	,884**	,858**	,765**	,767**	,848**

Table 7. *Correlation between "form analysis" and "students' learning and development process".*

Highest level correlation (r=0,959**- r=0,904; p<0,01)	It revealed my creative powers and potential
	It helped me to concretize my mental designs
	It facilitated drafting.
	Inspiration by nature supports learning creativity and increases my motivation for creativity
High correlation (r=0,880**- r=0,758; p<0,01)	Inspiration by nature teaches to establish links between unrelated concepts and visual elements.
	It develops aesthetical thinking and awareness
	Inspiration by nature enables flexible thinking
	Inspiration by nature made me realize the amazing harmony and balance in the nature
	It improves the skill to transfer analyzed samples into drawing
	Investigation and inquiry about all types of relationships in the nature should be a part of the design process to obtain sustainable products or design
	Inspiration by nature had a positive impact on my perspective on nature
Intermediate correlation (r=0,567**- r=0,671; p<0,01).	It helps acquire the skill to transform abstract thoughts into concrete
	It develops understanding of basic design concepts such as repetition and rhythm and transferring these into drawing

links between unrelated concepts and visual elements (Q13)" (Figure 2).

The frequency distribution of the scores given based on the assessment scale for each question are presented in Figure 3. Thus, the concepts with high arithmetic mean values, namely Q13, Q8, Q10, Q4 and Q1 were scored by the subjects mostly as "very good," the highest score on the assessment scale.

3.2. Findings on the analysis of inspiration by nature

The mean, standard deviation, and skewness-kurtosis values for each variable assessed by the subjects were identified to demonstrate the impact of inspiration by nature on form creation and the process of learning creativity. Since the skewness and kurtosis values for the data presented in Table 4 were between +1.5 and -1.5, it was determined that the data exhibited normal distribution (Tabachnick and Fidell 2011). Thus, parametric tests (ANOVA and correlation) were used in subsequent evaluations in the study.

ANOVA analysis findings demonstrated that there was a statistically significant difference between the values of the variables that constituted the analysis of nature visuals ($p < 0.01$). ANOVA analysis results are presented in Table 5. Based on the presented data, "using nature visuals by analyzing their forms," which had the highest F value ($F = 134.994$, $p < 0.01$), demonstrated the strongest difference. Based on this finding, it was revealed that "using nature visuals by analyzing their forms" contributed the most to form-creation and learning creativity processes (Table 5).

Correlation analysis was conducted to determine the relationship between "using nature visuals by analyzing their forms (form analysis)" and "students' learning and development process" (Table 6).

Based on the analysis results, it was determined that the highest correlation between "form analysis" and " students' learning and development process " in Q5, Q7, Q9 and Q12, high level correlation was determined in Q13, Q6, Q14, Q17, Q11, Q15 and Q16, and intermediate correlation was determined in Q8 and Q10 (Table 7).

4. Discussion

Concretization of the ideas about a design problem is quite important in design education. Nature could be a good resource to facilitate this process of thought and to create a difference in design. Thus, throughout the history of architecture, natural objects and processes have been an infinite source of inspiration for the designer. The perfect system in nature was expressed by Galilei as follows: the universe is written in the language of mathematics and its letters include triangles, circles and other geometric forms. Without them, not a single word could be understood, without these, the universe is like navigating in a dark maze (Galilei 2008; Alpak et al., 2018). Understanding the language of the nature facilitates the designer's work; the nature, color, tex-

ture, and functions in the nature could play an active role in the formation and the correlation between the functions of the design product. Thus, while inspiration from nature is significant for the disciplines that focused on design and it is a source of inspiration that is commonly used in those disciplines, it a quite new concept for the education of landscape architecture. This study aims to share student experiences in this issue by focusing on how to create a form in the design of a residential environment by inspiring from nature. Creativity is a process that occurs with a source of inspiration. In this course, especially the creativity of the students was supported through creating forms with inspiration by nature. For, it was aimed to provide ease for the form and alternative producing efforts of the students, who have limited knowledge on forms since they are in the initial period of their education. Hence, each student was given a chance to discover his/her own way. It was eventually aimed to provide students with the ability to transform abstract mental ideas into concrete images using the forms and relations in nature. In the first part of the study, the final products of the process of the quest of creating a form by the students were assessed by the researchers based on their professional experiences. It was observed that a group of students could easily reflect the geometry and relationships within the nature (form, size and direction) in their designs through inspiration by the nature, while the other group of students perceived inspiration by the nature as a simple process of imitation, concluding their query for form as such. It was observed that they were not very successful in reflecting the relationships (size and direction) in the nature in their designs. However, it was observed that students in both groups are able to create new information from what they have revealed with their studies and when they confront with a design problem, they have the ability to find different and creative solutions because when the students do research on forms in nature and when they understand the order very well, they feel comfortable not only generating forms but also changing them into spaces and forming functional relationship. As a result of this, it was found that self-esteem of the students also increased. The assessment of the researchers on the final products of the students was consistent with the statement by Dogan (2013) that inspiration by nature enables the comprehension of the rhythm of the nature and transformation of this rhythm to designs.

In the second part of the study that included the survey, students were given the opportunity to assess how they used inspiration by nature and the benefits of inspiration by nature for their learning and development. The assessment findings demonstrated that inspiration by nature was mostly used by the students to develop their drawings by analyzing the form of the inspired sample, it supported form creation and learning creativity, allowed them to concretize their ideas and facilitated drawing sketches. Based these results, the inspiration by nature means inspiration rather than copying nature, taking the nature as an example, and developing their drawings utilizing the aesthetic approaches in the nature. These results are supported by the study by Ruskin, who indicated that the nature is a source of inspiration and an example (Ruskin 2009; Doğan, 2013; Alpak et al., 2018). The views of Viollet le Duc, who stated that architecture is an art and we have to follow its path and the logical relationships it uses, were consistent with the findings of the present study on the methods adopted by the students in using nature (Viollet-le-Duc, 1990). In particular, findings on the development of creativity by inspiration by nature were similar to the findings in literature that visual clues develop creativity (Casakin and Goldschmidt, 1999; Çubukcu and-Cetintahra, 2010; Chai et al., 2015).

Based on the results on the correlation between form analysis and the students' learning and development process, inspiration by nature improved the students' creativity and contributed to their ability to create solutions for design problems such as linking unrelated concepts and visual elements, reflecting the harmony and balance in the nature on the design via analysis and the relationships of aesthetics and inte-

gration in the nature and harmony on the design. Based on the findings, the approach that is acquired by the students through inspiration by nature is a significant instrument that strengthens the creative thinking skills of designers (Casakin and Goldschmidt, 1999; Casakin and Goldschmidt, 2000) and to facilitate sketching. One of the important relations between form analysis and students' learning and development process was their ability to analyze the forms in the nature and to facilitate their efforts to transform abstract ideas into concrete forms. Because, for the novice students, it is more difficult to express their ideas when compared to those who are experienced in reflecting their ideas on design and in creativity. Inspiration by nature facilitates this process, especially the findings of the present study demonstrated that visual data are very useful in stimulating creative thinking for the novice students. These findings are also consistent with previous studies in the literature (Çubukcu and Cetintahra, 2010; Çubukcu and Gökçen Dündar, 2007; Dogan, 2013). Visual data can also support the development of creativity since it can provide the opportunity to imitate and interpret the things they observe for novice students without the need for prior knowledge. Because, novice students organize their knowledge based on the superficial characteristics of information, while experienced designers could analyze the information they acquire (Lawson, 2004; Gonçalves et al., 2014).

Unlike the findings of other studies in the literature, the present study demonstrated that inspiration by nature helps students to concretize basic design principles and to understand these concepts. However, the basic design principles are abstract for novice students and it is quite difficult for them to comprehend the relationship between the visual world and these principles. Thus, the inspiration by nature could inspire innovative ideas that both facilitate the resolution of design problems and provide different perspectives for designers, and to allow novice students to comprehend abstract concepts via concretization.

5. Conclusion

Design students experience problems in formulation of an abstract design concept at the initial stage of design and to relate this idea to spatial design (Doğan, 2013). Thus, inspiration sources are powerful tools at every stage of the problem-solving process for these students. Therefore, it is important to understand how and what kind of inspiration sources are used by students in design education and to develop new strategies in the design studio. Nature is an important source of inspiration due to its diversity; the relation between nature and humans is always the mobilizing aspect of arts (Dewey, 1958). This fact supports the idea that nature could be a source to nurture the artist's soul. In order to shape the landscape as a master artist, the designer should understand and reconstruct the relations in nature (Dee, 2012). In particular, if novice designers examine the formation and development of the forms in nature, they would easily find forms for their abstract ideas.

The present study involved the attempt of landscape architecture students to emulate selected natural forms in order to create original forms. Thus, the study focused on how to create forms in landscape design through inspiration by the nature and shared the experiences of novice designers and the impact of the inspiration by the nature on their development. The study findings demonstrated that inspiration by the nature was used by novice designers by analyzing the form of the sample of inspiration and developing the lines accordingly, and they utilized the forms of integration in nature. The inspiration by the nature supported students' learning on the form and creativity, concretization of the ideas, and facilitated sketching skills. Based on these results, inspiration by the nature meant utilizing the nature as an example, comprehending the aesthetics in the essence of the nature, and utilize this comprehension for the solution of the design problem rather than simply imitating the nature.

In the present study, differences in students' efforts to develop their creativity and knowledge of forms by inspiring from nature were determined,

however, the underlying reasons were not investigated in this study. It is considered that these differences may result from students' personal characteristics, design skills and differences in perceiving the subject. All of these are the focus of future studies, and the reasons for these differences can be shown in a detailed way.

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AZ
ITU Journal of the Faculty of Architecture
Vol 17 No 3 • November 2020

az.itu.edu.tr ISSN 2564-7474