ISSN 1309-6915

MEGARON

Megaron is indexed in Web of Science, Emerging Sources Citation Index (ESCI), Avery Index to Architectural Periodicals (AIAP), TUBITAK TR Index, EBSCO Host Art & Architecture Complete, Arts Premium Collection, ProQuest, SciTech Premium, ERIH Plus, DOAJ, Gale/Cengage Learning and Ulrich's.

Volume 17
Number 4
Year 2022

YTU PRESS

www.megaronjournal.com

ISSN 1309-6915

MEGARON

Volume 17 Number 4 Year 2022 - December

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ISSN 1309-6915

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ISSN 1309-6915

MEGARON

Volume 17 Number 4 Year 2022 - December

Abstracting and Indexing: Indexed in Web of Science, Emerging Sources Citation Index (ESCI), Avery Index to Architectural Periodicals (AIAP), TUBITAK ULAKBIM, EBSCO Host Art & Architecture Complete, DOAJ, Gale/Cengage Learning, ASOS Index, DRJI, and Ulrich's.

Journal Description: The journal is supported by Yildiz Technical University officially, and is a blind peer-reviewed free open-access journal, published bimontly (March-June-September-December).

Publisher: Yildiz Technical University

Owner: Gülay Zorer Gedik

Managing Director: Gülay Zorer Gedik

Editors: Ayşen Ciravoğlu, Sırma Turgut

Co-Editors: Gökçe Tuna Taygun, Esin Özlem Aktuğlu Aktan

Language of Publication: English

Frequency: 4 Issues

Publication Type: Online e-version

Publisher: Kare Yayıncılık

Correnspondence Address: Yıldız Teknik Üniversitesi, Mimarlık Fakültesi, Merkez Yerleşim, Beşiktaş, 34349 İstanbul, Turkey

Tel: +90 (0)212 383 25 85

Fax: +90 (0)212 383 26 50

E-mail: megaron@yildiz.edu.tr

Web: www.megaronjournal.com

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Free full-text articles in Turkish and English are available at www.megaronjournal.com.

ISSN 1309-6915

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Megaron, Vol. 17, No. 4, pp. 575–588, December 2022

Megaron
https://megaron.yildiz.edu.tr - https://megaronjournal.com
DOI: https://doi.org/10.14744/MEGARON.2022.82346

Article

Urban interventions and public pedagogies for raising public awareness on sustainability

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ARTICLE INFO

Article history
Received: 14 March 2022
Revised: 18 November 2022
Accepted: 21 November 2022

Key words:
Democracy and urban design; informal learning in public sphere; learning about sustainability; urban interventions; urban pedagogies

ABSTRACT

Learning experience infiltrates the lives of individuals by taking shape in parallel with many other developments such as technology, today's conditions, media systems, and educational methods of the time. In parallel with this, learning cannot be thought of without time and place; it is essential to associate it with the context of the current time and lived moment. Alternative and informal learning modes – such as learning by doing, experience-based learning, playful learning, and Place-Based learning – have strong ties with the spatial organisation. The relationship between space and learning experience has turned into a situation that needs to unfold and be re-discussed. Especially learning in urban open spaces and the relationship of public pedagogies with public spaces need to be highlighted and unfolded. Learning about sustainability is essential to cultivate sustainable habits in citizens' daily practices. Scarcity, destruction of natural areas, urbanisation problems, epidemics are not separate concepts. This study, in which informal learning about sustainability is discussed, also questions the informal teaching potentials of urban open spaces. The article also scans the potential of public spaces and informal learning experiences about sustainability. The study, which aims to emphasise the importance of programming public spaces to raise awareness about sustainability and small-scale interventions to be made in these areas, focuses primarily on a literature review on learning experiences about nature-human relationships. It then opens a discussion on small-scale interventions in public spaces and their potential to raise awareness of sustainability. Samples are selected in parallel with the characteristics clarified in parallel with the literature review and the selected public space interventions are examined. The common characteristics and keywords of these interventions, which focus on learning about sustainability in public spaces, are extracted. The study focuses on public pedagogies and raising awareness of sustainability in public spaces while aiming to create a common ground for future interventions. Secondly, it underlines the socio-ecological transformation potential of public spaces.

Cite this article as: Sabır Onat B. Urban interventions and public pedagogies for raising public awareness on sustainability. Megaron 2022;17(4):575–588.

INTRODUCTION

For a sustainable future raising ecological awareness – starting from the individual scale – is of great importance. In urban spaces, public spaces have the potential to transform the habits of the inhabitants' social

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Published by Yıldız Technical University Press, İstanbul, Turkey
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consciousness and strengthen their connections with the environment. Therefore, the main issue of this study is based on creating a common ground for public space design and interventions that may raise public awareness of sustainability.

After the pandemic, situations such as scarcity and lack of resources become more profound; on the other hand, people's connection with nature, environmental awareness, and the places to be shaped with this awareness are among discussion topics. Based on the human-nature-space relationship, in line with the view that the transformation of human ecological consciousness and its relationship with the environment will bring along positive behavioural changes in many scales with a systemic acceleration. This paper will pursue raising public awareness of sustainability in public spaces through the urban interventions and informal learning processes.

The first section scans the processes behind the human and its environment, the separation of this pair and learning processes are examined to strengthen the relationship between nature and humans. In parallel with the questioning of education and learning methods emphasis is placed on the idea that critical awareness and ecological consciousness can be strengthened by public space design and interventions. The study questions our learning potential and awareness raising regarding the environment in public open spaces and daily life. Figure 1 explains the continuous learning potential of public spaces.

Figure 1 explains (on the left) the climate crisis, environmental problems, and pandemics, the places of education and learning also need to change shape. Instead of learning spaces stuck in a single volume, the spatial fiction that infiltrate the city should be constructed with an experiential and informal learning process. On the right; the infiltration of learning into everyday life, learning in public spaces, learning as a continuous experience.

Methodology

Design is not only searching for aesthetics, but we as designers also have the responsibility to create inspirational places that transform the social and ecological structure of society. That is why public spaces need to be interpreted in this manner and handled in these manners. In public spaces, we can interact, share, gather and exchange. Therefore, it is a crucial opportunity to inspire and learn from each other, designers should start developing these ideas and create more inspirational and experiential spaces where people not only spend time but learn from the space and from each other about sustainability.

Here are the main questions that create the main ground of this paper: Which spatial features can support raising awareness on sustainability in public spaces? How can we design our public spaces in a more educative and awareness-raising way? How can the places of learning spread into our daily lives? The method of this study is based on such questions, and it continues with a literature review, a relational, multi-layered reading and a discussion of learning and space theories. Samples around the world are examined in the light of the theoretical framework, which mentions the contribution of spaces to the learning process regarding the environment and sustainability and the learning spaces that infiltrate daily life after the pandemic. Main characteristics have been selected after the literature review and then, samples have been selected through these characteristics. Therefore, the literature review supported to choose the samples. And these samples are evaluated through the spatial qualities and design applications aiming to create a common ground for discussing the public spaces

Figure 1. Public spaces and learning experience relation.

that have the potential for social transformation and raising awareness of sustainability. And this study aims to create a common ground for future studies about public space interventions that focus on public pedagogies.

HUMAN-NATURE SEPARATION

Many theorists have evaluated the human-nature distinction in the historical process and associated it with various effects. Descola (2013) dissects the universal conception of nature with deconstruction; he underlines that the difference between nature and culture is not a universal one but a Western-oriented one. Descola deconstructs nature, states that it does not exist as a single universal truth. Moreover, Descola (2013) mentions that modern man shaped the world organisation with the concept of Western cosmology in the 17th century, and he defines this dualist separation as naturalism. According to him, in parallel with Western dualist thought, society and nature are defined as two different states, consisting of humans and non-humans. This segregation brings along societies moving away from the environment, unplanned urbanisation processes, famine, and climatic crisis. They affect each other on a systemic scale.

Kaika (2017) criticises the smart city concept, which is presented as a solution in line with sustainability today and mentions the necessity of having unique solutions for each region. Kaika underlines the necessity of producing solutions by absorbing the knowledge of nature and the place-stating that our enhanced sustainability and smart cities could be the disaster of someone else's social environment. Kaika (2017) continues as follows; cities should be understood by examining beyond the geographical; for this reason, we cannot treat the nature of the cities as if it was different entity from them.

Kaika (2017) stated that instead of separating the words as city or nature, it is necessary to understand the process in cities as urbanisation of nature with a metabolic flow. For this reason, people need to come together and meet with nature again.

While issues such as energy, climate change, scarcity, and environmental issues have become increasingly important and new solutions need to be found, the systems approach can have significant potential in creating solutions to these problems, which are not singular, stand-alone problems, they are all interrelated and should be handled with a relational, holistic, systemic approach rather than singular solutions.

Von Bertalanffy (1968) defines the general system theory and explains it as the interaction of more than one discipline. These interrelations happen between social, cultural, biological, physical, and biological systems. Von Bertalanffy (1968) explains the system as a complex hole that has interacting elements with each other and with their environments. Therefore, the system is explained as a self-regulating concept, in continual evolution and focuses on holistic wholeness.

This evolutionary concept overlaps with Latour's (1991) term bricolage, for emphasising the holistic and systemic link between humans and non-humans (can be nature, technology) in the system and the necessity of handling it together. Therefore, man cannot be considered separate from the systems around him, and environmental problems must be evaluated within a whole system by relating them to social dimensions. Society and individuals have the potential to rearrange their behaviour, their relations with the environment, and their cultural values.

"Bringing sustainability to home is about cultivating a sustainability culture that suits the characteristics of the place" (Van der Ryn and Cowan, 2007, p. 83). Ecological thinking begins at home. In the change of the individual's daily behaviour, there is always a relationship between micro and macro, and the improvement of the environmental system starts with the individual.

One of the main issues put into the basis of the study is that; to "restore" this transformation of man against nature and the distancing from it – that can be called blindness – the potential to support sustainable habits and being a responsible and aware individual towards the environment, to re-establish the human-nature relationship. In this sense, public spaces – where daily life passes and shapes our values, and our culture as well – are interpreted as crucial laboratories that have the potential to raise public awareness of sustainability.

LEARNING ABOUT SUSTAINABILITY AND RAISING THE PUBLIC AWARENESS

Learning and education methods are a subject that has been researched for a long time, but where and how we learn falls into a different field of research. Information is not only shared in schools; alternative learning spaces also have an essential value for the sharing of knowledge.

The freedom of building our cities and ourselves is directly related to the educational processes (Harvey, 2008). As Aristotle emphasises, we need to learn before doing things, and to learn; we need to practice them (Bynum and Porter, 2005).

In parallel with this, many concepts and theories have been proposed, such as learning by doing, practicing, and learning in the city as informal processes. Social justice and democracy cannot be separated from learning and education, is defined by Freire (2005) as enlightenment (critical consciousness-*conscientização*) that must be developed to be free from oppression. It is underlined that

the potential of individuals to change their environment is possible with social critical, political step-taking power, and self-actualisation.

Critical consciousness involves taking action against oppressive attitudes in individuals' lives. (Mustakova-Possardt, 2003). "Since sustainability is a cultural process, it depends on the everyday actions of ordinary people" (Van der Ryn and Cowan, 2007, p.82). In this sense, there is an essential link between the transformation of individuals and the awakening of their critical consciousness. Schools and the current education system are insufficient in this sense; the practice of sustainability can be realised with spatial fiction that infiltrate daily life.

Parallel with the critical pedagogy he put forward, Freire (2005) defines today's education system as a one-way method that descends from the instructor to the student, in a closed space and is limited to specific tools, in terms of critical consciousness. Freire (2005) refers to the power of learning and education to transform individuals in critical and critical inquiry. He argues that it will make students active and actionable against situations and the realities of the time. In parallel with this, he proposes a praxis-oriented education model.

Freire (2005) defines the "problem-posing model" (Chapter 2) and emphasises the importance of this model for critically perceiving the dynamic world in constant transformation and formation. This model proposes to provide the transfer of knowledge by addressing a problem, thus bringing with it the process of questioning, criticising, filtering the events by looking critically instead of memorising, and thus learning by practicing. The problem-posing model requires "to listen, to dialogue, and to take action" (Wallerstein, 1987, p. 35).

Conditions such as listening to each other, communication, dialogue, participation, action, experimentation, learning by experiment can be placed at the basis of learning models in public spaces, and they may form the main ideas at the basis of public space designs (See Figures 2 and 3).

In these two micro-scale designs and interventions; there are processes such as urban dialogue, experimentation,

Figure 2. Tandem, located in Madrid, encourages citizens to take ownership of the public space by jointly managing their energy use (XXI, 2020).

Figure 3. Ciencia Pública. While explaining the transformation of grey water as a process, this project, which has turned into a gathering and sharing space as an urban furniture, will be examined in detail in the following sections (Exploratorium, n.d.).

observation, and coming together. These examples, which are encountered and joined by chance in daily life, are essential in the learning process.

There are learning processes and potentials related to daily life in all these typologies, such as experimentation, sharing, participation, and communication. In the space, a learning process that occurs through the experience of the space itself should be a priority instead of a person or institution telling a subject and informing it as a one-way process. De Certeau (1984) mentioned; just as the practiced space becomes the place, the practiced spaces have a great potential to teach by experience.

De Certeau (1984) mentions the power of ordinary people in everyday life and underlines that the dominant power can be opposed to the tactics created by the ordinary man. In parallel with this, Freire (2005), in his Pedagogy of the Oppressed study, mentions the transformation of tactics and the learning methods of ordinary people and the development of critical consciousness.

Raising Public Awareness On Sustainability Through Public Spaces

Giroux (2007) takes urban education as a bottom-up approach and states that it supports people's cultural mobilisation, emphasises the importance of cultural studies and educators. Lefebvre (1991), on the other hand, states that a bottom-up urban learning method will give the citizens the potential to transform their position in society with the practice of learning by making them productive.

Biesta et al. (2014) interprets civic learning as a practice associated with transformation. Sacré and De Visscher (2017), on the other hand, support the loading of the learning experience into the city by examining the city in a cultural context with an educational focus and talk about the transformation of the city into a curriculum on its own. They state that; the re-establishment of the city-culture-learning relationship can be achieved through a new understanding of urbanism that can go beyond the socio-spatial perception of the city consisting only of people and buildings.

As McLuhan (1957) mentioned in his "City as a Classroom" study; it is time to focus on spatial constructions that emphasise the relationship of everyday life with education and adaptive solutions for creative, playful situations, rather than the one-sided, top-down structure of the education system which is limited in space and tools. In the introduction of Illich's (1973) De-schooling Society, he criticises the one-sidedness of education by likening the current education system to a funnel and, in contrast, emphasises the overall change of institutions. With an emphasis on educational networks, he discusses individuals' learning in daily life and their potential to transform these times into moments that they learn, share and care about each other and nature.

Discussing the place of learning in everyday life and the place of public open spaces in learning about sustainability, this paper aims to scan the spaces for sharing and informal learning in parallel with these ideas because informal "learning" has the potential to steer experimental, playful situations.

"Learning; is the process of creating knowledge by transforming experience" (Kolb, 1984, p. 38). The experiential learning model put forward by Kolb is in parallel with informal learning in this sense. Jacobs (1999) defines experiential learning as a process in which the learner produces knowledge, skills, and values directly from experiences (p. 51). Therefore, learning by doing is also included in this process.

Learning in the city is vital in terms of the potential to develop the critical awareness of the inhabitants, to develop their coexistence by recognising the power of the citizens, and to realise that the ordinary person, who is the primary determinant of daily life, can be a guide in the place where they live in. De Certeau (1984) mentions that ordinary people realise the power to transform their lives using daily life tactics. In Pedagogy of Oppressed, Freire (2005) explains the development of critical awareness as, in a similar parallel, the participation of ordinary people in life and management, starting to questione the city and participating in decision-making. Critical awareness, the ability to take responsibility, and knowledge of the requirements of a sustainable city are required in making environmental and urban decisions.

As Sacré and De Visscher (2017) stated, although the city is seen by all urban actors as a community, produced by daily activities, urban learning now needs a new paradigm (p. 10). The design and management of cities, in parallel with this, must respond to current needs with new tactics, small-scale interventions, share information with their users, and prepare them for a prosperous future. Informal education and experience, and the learning process by sharing, have a great place in this regard.

Commoning of Public Spaces

"Public spaces are promoted as part of active social networks, which are essential in knowledge transmission."[1]

According to Gehl and Gemzoe (2001), there was not much work on public spaces between the years 1930–1970, but after the 1970s, public spaces began to occupy an important place in architectural and urban debates. In parallel with the changing dynamics in cities – especially in terms of production, consumption, and socialisation – public spaces are produced. Therefore, the definition, meaning, task,

[1] Madanipour, 2011, p.153.

perception, and content of public spaces, pass through important breaking points.

Especially today, cities and public spaces are reinterpreted and understood in parallel with issues such as climate change, resource scarcity, and resilience, and solutions are tried to be produced with new approaches. It is necessary to adopt new insights and install new lenses in order to make the city more ecological, more sustainable, and more resistant to future conditions: There is a need for a paradigm change that will be reshaped by establishing relationships with public spaces within keywords such as; sharing, small intervention, participation, interaction, hybridity, third spaces, flexibility, change of consciousness, behaviour change, multi-purpose, and multi-layered.

Everyday Life and Tactics in the Public Space

There is an intricate relationship between the place and the individual. The individual reshapes and transforms the space in line with his own experience so that a dialogue between the city and the urbanite emerges. With a two-sided flow of information, the individual of the city and the individual have the potential to transform and remake the city. This "dialogue" is the essence of this transformational process. The idea of social autopoiesis – the city's self-repair – is possible through the dialogue between the city and all parts of the system. The dynamic and interactive process between the city and its users is read from public spaces.

"Cities have the capability of providing something for everybody, only because, and only when, they are created by everybody" (Jacobs, 1962, p. 238). The existence of ordinary man in daily life is possible with the development of critical awareness in a free and democratic way by getting rid of the power mechanism with the help of tactics. The "practiced space", which De Certeau refers to, is a place where interaction, participation, collaboration, communication passes, where the boundaries of contrasts are melted, where they can be practiced and existed in a free, democratic way with critical awareness, and they can transform the concept into a meaningful place.

Small-Scale Interventions, Third Places and Collective Learning

The idea of intervening in the city at scales smaller than the urban planning scale emerged due to the common emphasis on the need for a human-oriented, humanist social and physical environment, which has been included in the criticisms of the modernist urban planning approach since the 1950s (Akgün Yüksekli and Kabakoğlu, 2016).

The places where the learning processes will occur should be designed to be pluralistic, open to dialogue, and inclusive of the learning process. Parallel to this, it would be appropriate to examine small-scale interventions and discuss their place in the process of learning about the environment and gaining critical ecological awareness. De Certeau (1984) put forward the term tactic, which is the unplanned actions of ordinary people in daily life, as opposed to strategy. "Tactics reshape the urban space in an unplanned way, with their informal activities. They offer us options on space that have not been considered before" (Çınar and Yirmibeşoğlu, 2020).

Garcia and Lydon (2015) define tactical urbanisation as short-term, low-budget, simple interventions. Tactical; literally, it means that small-scale applications serve larger purposes (Garcia and Lydon, 2015, p. 3). "Micro-spatial urban practices" that intervene in the city on a small- or micro-scale are approaches that are developed to make the urban environment liveable and comprehend urban problems from districts, neighbourhoods, streets, buildings, or smaller scales (Akgün Yüksekli and Kabakoğlu, 2016). This synergy created through micro-interventions in the city may have the potential to increase knowledge and awareness of the urban environment, ecosystem, and sustainable urban behaviour.

In the third space theory, which is a post-colonial theory, Bhabha (2004) underlines the potential of such spaces as a kind of synthesised, hybrid space to bring different cultures together interactively and creatively, and states that there is a place for the "new" in the third spaces. In parallel with the post-colonial discourse, cultural hybridity becomes possible with the melting of the boundaries between the self and the other and the increase of communication and relationship networks. In parallel with the concept of hybridity, which is reflected in spatial situations, two different cultures can create a new formation – unity through coexistence, communication, relationship, and creative bonds instead of suppressing or suppressing each other. Thus, third areas can be defined as places standing in the middle, in between, and where creative ties emerge. The spatial boundaries and melting of cultural differences in the public sphere have great potential, especially for heterogeneous cultures and communities (Figure 4).

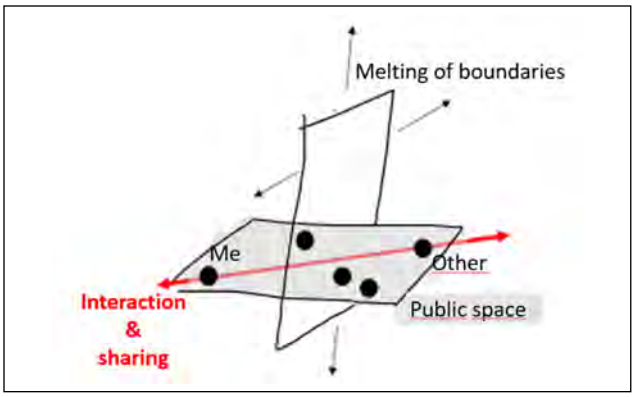

Figure 4. Hybridity in the public domain. The third spaces are important in terms of informal learning in the city with its structure that includes coexistence and differences (Source: Developed by the authors in parallel with Bhabha's (2004) concepts).

In parallel with encounters in the public sphere and the potential for hybridity, the boundaries between self and others may melt. Along with factors such as interaction and sharing, the urban learning process can begin by coming together. In this sense, micro-scale interventions and urban tactics to be made in the public sphere are of great importance. The boundary between people's participation in this process and the self-other; has the potential to dissolve in a productive, creative, sharing, interactive way. These small-scale interventions can create a hybrid (third) space by raising an issue against environmental problems and creating a dialogue space.

ASSESSING THE CONTRIBUTION OF PUBLIC SPACE INTERVENTIONS FOR RAISING PUBLIC AWARENESS ON SUSTAINABILITY: CREATING A COMMON GROUND

Just as the practiced space – mentioned by De Certeau – turns into space, the practiced spaces have important teaching and experience potential and will be discussed with examples as fieldwork. As the spatial content and provided criteria in the small-scale interventions examined below, with processes such as creating a space for urban dialogue, learning by experiment, observing, listening to each other, getting together, the learning process occurs.

In all the samples examined, there are potentials of the learning process with practices related to daily life such as experiment, sharing, participation, and communication. Firstly, the typical spatial features found in the examples were determined; later, the spatial criteria and informal learning methods of these selected examples were brought together and discussed in relation.

Informal Learning from the Place to Raise the Public Awareness On Sustainability

The learning pyramid that has been developed by Edgar Dale in the NTL Institute, was taken as the basis for to define the learning styles in public spaces in this work (Wikipedia, n.d.). The cone of experience or learning pyramid explains the learning activities and categorises learning methods from passive to active ways of learning. This model has been developed in 1946 and these categories and methods need to be updated and new methods can be related to the categories. Since technology, media systems, the internet and new learning bases are developed, therefore learning in the open spaces can use these new technologies as well. VR technologies, internet-based learning, media facades and various methods can be included as a way of learning and these methods can be included under a new category – since they cover more than the audio-visual methods of 1950s when Dale developed this learning pyramid.

Nowadays new media surfaces and interactive spheres create strong connections between human – non-human and the pyramid needs an edition with the addition of new interactive mediums that cannot be added under the category of audio-visual. As it can be noticed, auditory and visual ways of learning are not efficient on learning. However, in the kinaesthetic part, discussion, gathering, problem posing, sharing ideas may come to the surface, and a democratic way of citizenship may occur-cultivated. Practicing what you are learning, experiencing, applying your knowledge, experiencing, and participating in the learning process is also active. Therefore, in the pyramid from lecture-listening to down-part teaching others, the learning experience becomes more active. The

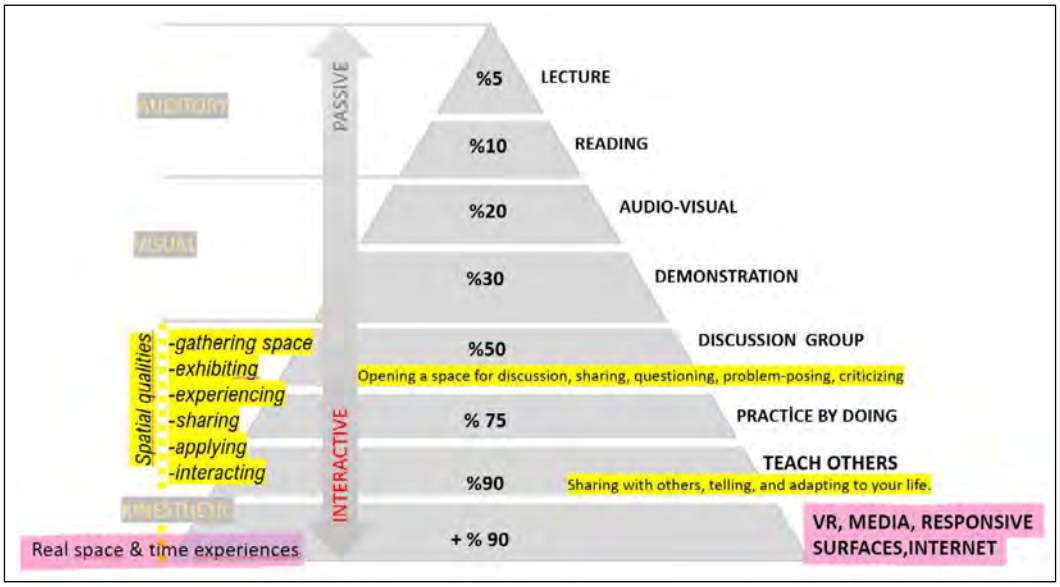

Figure 5. Adapted from the pyramid model "cone of learning", was developed by Edgar Dale in 1946, in the National Training Laboratories Institute, Bethel, Maine.

spatial qualities and necessities of that phase have some requirements discussed in the following topic.

Following Figure 5, new modes/mediums of learning that enhance the learning experience have been included in Dale's cone of experience diagram. With technological developments internet, media surfaces, VR, interactive surfaces are being included in the public spheres – those new modes may have the capacity to enhance learning efficiency. It is a form of creating a human-non-human relationship. Therefore, the author edited the pyramid, and in the following case studies, these learning modes and spatial qualities and requirements will be discussed.

Spatial Requirements and Characteristics of Urban Interventions and Public Spaces for Raising the Public Awareness On Sustainability

McFarlane (2011), who put the concept of aggregation as the basis of urban learning as a spatial grammar, explains the state of gathering as a concept related to urban perception, interaction, and creation, as a context that defines the unity that can occur between differences/otherness.

In this parallel, McFarlane (2011) explains urban learning as the gathering activity where the inhabitants produce the city. Parallel to this, all examples of spaces that provide a basis for gathering and gathering in public open spaces talk about the spaces encountered by chance and joined by individual desires in daily life. Therefore, they are essential in terms of the learning process.

On the other hand, it is an essential step for the public space design and interventions to be made for the inclusion of learning in the practice of daily life, to connect with the metabolic flow and systemic relations of that system, and to share this information with the user in an experiential way within the design.

After the literature review some characteristics of public spaces have been defined and explained below:

a. Creating space for urban dialogue: Gathering, listening to each other, discussing, participation activities should be developed related to public space interventions. As it is explained in the learning pyramid, interaction and democratic citizenship are crucial for learning together and learning from each other during everyday life to develop public pedagogies.

b. Exhibiting, showing the ecological cycle: In the sense of strengthening the human-nature equality and the bonding of the system in parallel with the systems approach, interventions should explain the interrelations of humans and non-humans. That way by experiencing, seeing the strong relations of humans with nature and with the systems, we can evolve and raise awareness of sustainability.

c. Interacting between humans and non-humans (media, technology, nature): As it is explained above, the connection and relation of human-non-human should be highlighted in the intervention programs for public spaces.

d. Trying, playing and experiencing the space and the intervention. Therefore, the interventions that are planned in public spaces should carry an interactive role. Their programs should include these characteristics.

All five projects reviewed below meet the main spatial requirements mentioned above. The Alternative City Stops, Alternative Cycle, PS1 Public Farm, Tandem, and Public Science projects are examined in detail. As a sixth example, the inadequacy of the environmental learning system based on visual images and reading in Antalya Karaalioğlu Park is also examined.

Alternative City Stops, London Design Biennial, 2016

Temporary pavilions designed by Asif Khan aim to cross the paths of people living in their flow in modern city life and offer them alternative spaces to stimulate their relaxation and creativity in the period between home and work. The three pavilions named "Connect, Create, and Relax" covered with plants feed on the idea of *"shinrin-yoku"*, which means "forest bathing" in Japanese culture. The plants specially selected by the expert Jin Ahn strengthen the forest atmosphere and stimulate people's senses, offering both individual and shared experiences. Visitors who can take plants can also bring their plants and leave them in the rooms (Figure 6).

This small-scale intervention opens space for environmental learning to infiltrate into everyday life. In this sense, it has conditions such as human-non-human (nature) small-scale intervention, creating space, exhibiting, interacting, experimenting, and experiencing by doing. Therefore, from the characteristics above, we can see that points b and c have been applied to the program of this intervention.

Alternative Cycle, Rotterdam (Rotterdam Floating Park), 2018

The floating park, produced with recycled materials collected from the river within the scope of the project, aims to prevent plastic waste from reaching the open sea, aims to raise awareness, and improve the ecosystem of the city. In Rotterdam, a prototype project carried out by The Recycled Island Foundation, which wants to draw attention to plastic waste pollution in water, is opened to visitors. Using plastic waste that has been collected from rivers and ports, this floating island participates in the ecological cycle in the city, highlighting the possibilities of the recycling movement (Figure 7).

Aiming to demonstrate that recyclable plastic is a valuable material, the 140 m2 floating structure consists of a series of hexagonal blocks made entirely from plastic waste collected from the Nieuwe Mass River. In addition to the positive environmental impact of these green blocks, the designed

Figure 6. How do small-scale interventions create space while experiencing and teaching about the environment? Some main spatial characteristics and keywords are added to the images (XXI, 2016).

Figure 7. How do small-scale interventions create space while experiencing and teaching about the environment? Some main spatial characteristics and keywords are added to the images (Stinson, 2018).

park also benefits the river and harbour ecosystem. It offers a habitat for micro- and macro-fauna, including snails, flatworms, insects, and fish.

From the characteristics above, points b and c have been applied to this intervention and design.

PS1 – Public Farm One, 2008

It is possible to see public spaces being perceived as city laboratories and organised at the intersection of urban interactions and public spaces for learning and sharing purposes in MoMA-PS1. In this urban experiment initiated under Public Space – PS1 in the backyard of the Museum of Modern Arts, public projects and interventions are put into action by regularly hosting designers and architects in parallel with the Young Architects Program. Public Farm One, realised in parallel with the same program, was implemented by WORK Architecture Company in 2008 (Figure 8).

From the characteristics that have been defined above in the previous section, a point has been applied to this intervention. People can interact, gather, share, and learn together in daily life.

Tandem – An Energy Self-Sufficient Public Space, Madrid, 2018

The project encourages the citizens to take ownership of the public space by jointly managing their energy use, focuses on the self-sufficiency of the public space in terms of energy, and the functioning of the urbanites as a laboratory for energy management.

The intervention, consisting of an open classroom, a small stage, and a knowledge point-energy collector, provides

Figure 8. How do small-scale interventions create space while experiencing and teaching about the environment? (de Boer, 2009 and Mas Context, n.d.).

Figure 9. How do small-scale interventions experience and teach about the environment while creating space? Tandem encourages citizens to take ownership of the public space by jointly managing their energy use (XXI, 2020).

energy for all users who need it in the square to use urban devices. These three devices are also interconnected. They can perform functions such as leaving messages on LED screens. In this project, the relationship between humans and non-humans (technology and media) can be read. The project's main idea is to test how energy self-efficacy can play a vital role for urban dwellers to stimulate and jointly manage (liberate) activities in the public sphere (Figure 9).

The second important issue regarding energy and public space is related to urban pedagogy. The fact that solar-collecting batteries can produce, and store limited energy teaches citizens to use shared energy in a responsible way. Thirdly, it is emphasised that the "instant" can become a "habit," and it is emphasised that the ownership of the public space should not be expected only from institutions. Solar panels, the classroom and the stage are connected

to a social media machine that controls some interactions with the users, such as the possibility to switch the colour of the artificial lighting of the square, to make selfies using a webcam or to leave messages displayed on a LED screen. The project allows to demonstrate that energy self-sufficiency can become a trigger for the activation, promotion, and joint management of citizen activities in public spaces. Thus, the generated energy is not only for individual use, such as charging electronic devices but also for new, collective uses, such as the screening of movies during the summer or the lighting for concerts or other events. Energy self-sufficiency allows citizens to use public spaces for initiatives that were not even conceivable before due to the absence of free energy allowing them to realize them publicly.

TANDEM is also an educational laboratory, as it educates the public about the responsible use of energy, making people wonder: "How can I use it in the best possible way?" Figure 10 shows that different methods of learning are applied in this example. Interactive LED screens and activities create a new experience.

From the characteristics that have been explained in the previous section, we can see that the points a, b, c and d have been applied to the program of this small-scale intervention.

Public Science Parklet, Madrid (Ciencia Pública: Agua), 2015

While the small-scale intervention called Public Science is focusing on sustainable water use. It describes the transformation of grey water as a process, it also turns into a gathering and sharing space as a piece of urban furniture. Public Science aims to support informal education in science, technology, engineering, and mathematics (STEM). The Project is in two parking spaces of a parklet.

From the characteristics that have been explained in the previous section, we can see a, b, c and d have been applied to the program of this small-scale intervention.

Karaalioğlu Park, Antalya

Karaalioğlu Park is a Republic-era Park built with the participation of the public. It was designed to be integrated with the Community Centre and some other social buildings. The Public House, located near the park, makes people aware of issues such as construction and agriculture, and this function has been considered in integrity with the park.

As shown in Figure 11, the sharing of vegetative diversity in daily life with the public takes place through the method of "reading and visual images." As mentioned in the learning pyramid, the interaction and effectiveness of these methods are low, so this space's informal learning experience and learning levels are inefficient.

Figure 10. How do small-scale interventions create space while experiencing and teaching about the environment? (Exploratorium, n.d.).

Figure 11. On environmental learning inside the park, applications provided with reading and visual images (Image: Author).

There is no applied characteristic to the program of this design from the characteristics that have been explained in the previous section. Therefore it is hard to say that informal learning can happen in this example. For to develop this example, the intervention may provide a program inside considering the characteristics that have been explained in the previous section. Thus, while raising awareness of the bio-diversity and the plants in this park and region, there can be a small-scale intervention mentioning the cycle of these plants, or there can be an interaction between humans and these plants, there can be a gathering space around this zone where people can interact with these plants, learn and share, or there can be playful digital installations that interact with people. All these ideas follow the interactive stages of the learning pyramid that has been explained above.

DISCUSSION AND CONCLUSION

Perspectives that will open space for the relationship between the design of public open spaces and the learning experience will have an important place.

Learning about sustainability and gaining self-sufficient habits can be experienced in everyday life – instead of formal education methods. In parallel with this, public spaces where daily life takes place, and instant encounters and experiences occur; can be thought of as laboratories or machines that trigger social and behavioural transformation. Rather than concrete, finished spaces, spatial designs that are happening and experienced, reshaped, and then deteriorated again, "focusing on the experience and learning process rather than the final product" are essential for the transformation potential of individuals.

This paper questions the relationship between public spaces and the transformative power of that spaces. Secondly, highlights the role of design and mentions the social role of design. Third, aims to open a discussion on developing public spaces in this manner that have the potential to raise public awareness of sustainability. Therefore, the paper lastly aims to create a common ground for the evaluation and interpretation of public spaces in relation to learning about sustainability in these spaces. By doing so, the paper highlights various criteria of learning spaces in daily life regarding sustainability while trying to read education and learning methods, human-nature relationships, and spatial theories in an inter-relational, multi-layered manner.

Bottom-up decisions in parallel with participation support

learning processes in the city. For a sustainable future, education and learning should be integrated into a multi-layered framework parallel with the democratic spaces and systems approach; this is important for the city constructions that will take shape in the future.

Following the literature review during the paper's research process, education, learning methods, informal learning processes were examined and discussed concerning an interactive and interdisciplinary reading with public open spaces and small-scale intervention methods, in parallel with spatial theories. Later the literature study and scanning of case studies, determine "the common criteria of public sphere interventions" that provide a basis/common ground for future public space developments.

On the other hand, the learning methods are determined in parallel with the informal learning process. Six samples in total were scanned; five examples support the informal learning process, while the sixth last example is insufficient in this sense.

We may declare for future comparisons that; if the interaction is high and learning experience efficiency is high in an intervention, in these spaces, informal learning is expected to be the highest. In the sixth example, the park, where reading and visual images are used among informal learning methods, has low efficiency.

In Turkey, our public spaces generally are not developed with public pedagogies and programs of public spaces and interventions that take place in these spaces do not include any pedagogical approach that may raise awareness of sustainability. There should be regulations on a national level and pedagogical layers behind the public spaces should be unfolded and discussed in an interdisciplinary way.

As the paper discusses, public spaces carry crucial potential on activating the public and have the role of a socio-ecological transformation of its time. Public interventions should be handled with these characteristics that have been explained during this study, in order to create sustainable futures.

This paper aims to propose a basis for the evaluation of informal learning processes regarding the environment in future public open spaces. The study also aims to create a common ground to compare the efficiencies of public interventions that aim to cultivate sustainable habits and educate citizens about sustainability.

McFarlane (2011) aims to develop an innovative understanding of urbanism for the future; conceptualised urban learning as a necessary "lived and shared/discussed" area, where citizens come together. In parallel with this, Certeau's practice of everyday life work and Freire's critical pedagogy overlap at this point. They give clues to daily life practices and public space programs where informal learning can take place.

McFarlane (2011) defines learning as a process (where knowledge is created and transformed) and as a practice and interaction. McFarlane (2011) underlines that learning is generated through relationships between people, materials, and the environment. Again, we come across a systemic and metabolic approach. Systemic relationships and cycles between humans and non-humans are essential for the emergence of learning. With the establishment of these relationships and processes, the learning process takes place. The human-non-human relationship can create ties between human-nature, human-media, human-technology, or human-different time experiences. These examples which consist of various modes of teaching and using technology and interactivity are essential because they create strong ties between the knowledge and user. Also, they create interactive learning environments which should be included open space interventions and designs.

In parallel with this, it is time to evaluate and associate all parts of the system, such as individual-society-nature-technology together. Cities should be approached sustainably and systematically, with their humans and non-humans components. The cities of the future should not be analysed separately from their users. The transformation that begins on an individual scale is vital for healthy and self-sufficient future cities.

Therefore, the spread of small-scale interventions to be positioned in open public spaces with bottom-up strategies, creating grounds that reveal democratic communication, coexistence, critical awareness, comprehension of the practice of daily life and including informal processes designed specifically for that region are of great importance in the process of socio-ecological transformation.

ETHICS: There are no ethical issues with the publication of this manuscript.

PEER-REVIEW: Externally peer-reviewed.

CONFLICT OF INTEREST: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

FINANCIAL DISCLOSURE: The authors declared that this study has received no financial support.

REFERENCES

Akgün Yüksekli, B. and Kabakoğlu, A. D. (2016). Mikro Taktiklerden Kentsel Tasarım Stratejilerine Taktiksel Kentçilik: Kentsel Bir Sanat Ve Zanaat Biçimi. Imcofe: International Multidisciplinary Congress of Eurasia, Proceedings Vol: 1, Odessa, Ukraine, p. 502–513.

Bhabha, H. (2004). The Location of Culture. Abingdon: Routledge.

Biesta, G., de Bie, M., and Wildemeersch, D. (eds). (2014). Civic Learning, Democratic Citizenship, and the

Public Space. Springer, Netherlands, pp.1-11.
Bynum, W. F. and Porter, R. (eds). (2005). Oxford Dictionary of Scientific Quotations. Oxford University Press. 21:9.
Çınar, H. S. and Yirmibeşoğlu, F. (2020). Kentlerde Taktiksel Yaklaşımla Domino Etkisi Yaratmak: Türkiye'de Taktiksel Yaklaşım. Mimarlık, Planlama ve Tasarım Alanında Akademik Çalışmalar, Gece Kitaplığı, Ankara.
De Boer, J. (2009, January 23). Public Farming in New York City. https://popupcity.net/observations/public-farming-in-new-york-city/
De Certeau, M. (1984). The Practice of Everyday Life. University of California Press, Berkeley.
Descola, P. (2013). Beyond Nature and Culture. Translated by Janet Lloyd. University of Chicago Press.
Exploratorium. (n.d.). Ciencia Pública: Agua. https://www.exploratorium.edu/publicspaces/projects/ciencia-publica
Freire, P. (2005). Pedagogy of the Oppressed. New York, NY: Continuum.
Garcia, A. and Lydon, M. (2015). Tactical Urbanism: Short-term Action for Long-term Change, Island Press, Washington, DC, pp.3.
Gehl, J. and Gemzoe, L. (2001). New City Spaces. Copenhagen: The Danish Architectural Press.
Giroux, H. (2007). Utopian thinking in dangerous times: Critical pedagogy and the project of educated hope. Utopian Pedagogy: Radical Experiments Against Neoliberal Globalization 25–42.
Harvey, D. (2008). The Right to the City. New Leftist Review 53:23–40.
Illich, I. (1973). De-schooling Society. Harmondsworth: Penguin.
Jacobs, J. (1962). The Death and Life of Great American Cities. Random House, New York, NY, USA.
Jacobs, J. (1999). Experiential Education: The main dish, not just the side course. Boulder, CO: Association for Experiential Education. Kaika, M. (2017). Don't call me Resilient Again! The New Urban Agenda as Immunology …or what happens when communities refuse to be vaccinated with smart cities and indicators. Environment and Urbanization 29:89–102.
Kolb, D. A. (1984). Experiential learning: Experience as the source of learning and development (Vol. 1). Englewood Cliffs, NJ: Prentice-Hall.
Latour, B. (1991). We Have Never Been Modern. Cambridge: Harvard University Press.
Lefebvre, H. (1991). The Production of Space. Oxford: Blackwell.
Madanipour, A. (2011). Knowledge Economy and the City: Spaces of Knowledge. Taylor & Francis Group.
Mas Context. (n.d.). Case Study 2: Public Farm 1. https://www.mascontext.com/issues/5-energy-spring-10/case-study-2-public-farm-1/
McLuhan, M. (1957). Classroom without walls. Explorations: Studies in culture and communication. Explorations in Communications 7:1–3.
McFarlane, C. (2011). Learning the City: Knowledge and Trans-local Assemblage. Chichester: John Wiley & Sons.
Mustakova-Possardt, M (2003). Is there a roadmap to critical consciousness? Critical consciousness: A study of morality in global, historical context. One Country 15(2).
Sacré, H. and De Visscher, S. (eds) (2017). Learning the City: Cultural Approaches to Civic Learning in Urban Spaces. Springer Briefs in Education, eBook.
Stinson, L. (2018, July 16). This floating park is made entirely from recycled plastic. https://archive.curbed.com/2018/7/16/17574220/rotterdam-floating-park-recycled-waste#:~:text=This%20floating%20park%20is%20made%20entirely%20from%20recycled%20plastic&text=At%20least%20that%27s%20the%20case,a%20year%20and%20a%20half
Van der Ryn, S. and Cowan, S. (2007). (Eds.). Ecological Design. Island Press.
Wallerstein, N. (1987). Problem-Posing Education: Freire's Method for Transformation. Freire for the Classroom, Edited by Ira Shor.
Wikipedia. (n.d.). Edgar Dale. https://en.wikipedia.org/wiki/Edgar_Dale
XXI. (2016, September 29). Alternatif Kent Durakları. https://xxi.com.tr/i/alternatif-kent-duraklari
XXI. (2020, May 04). Kamusal Mekanı Canlandıran Enerji. https://xxi.com.tr/i/kamusal-mekani-canlandiran
Von Bertalanffy, L. (1968). General System Theory: Foundations, Development, Applications. NY: George Braziller Inc.

Megaron, Vol. 17, No. 4, pp. 589–601, December 2022

Megaron
https://megaron.yildiz.edu.tr - https://megaronjournal.com
DOI: https://doi.org/10.14744/MEGARON.2022.70457

Article

Teaching basic design online during the Covid-19 pandemic: An evaluation of the conventional and innovative pedagogies

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ARTICLE INFO

Article history
Received: 15 June 2022
Revised: 13 November 2022
Accepted: 14 November 2022

Key words:
Basic design; design pedagogy, design studio; online education

ABSTRACT

This article presents multiple pedagogical methods employed for urban planning students' first-year basic design studio course during the rapid shift to an online environment in response to Covid-19. The aim is to critically discuss the conventional and innovative tools and techniques in design teaching during the online education system in the 2020–2021 academic year at Middle East Technical University City and Regional Planning Department. To do this, the basic design and planning studio course preparation itineraries, student projects and reflections are analysed to unveil the process of creating a non-linear and open (online) studio course. Although the central question in this study is how to prepare for an online design course, which is traditionally a hands-on experience in an active face-to-face studio environment, the outcomes of this article are noteworthy to evaluate from a broader perspective of basic design education for urban planners. The pedagogical strategies for a non-linear and open studio present significant lessons learned for a similar future experience. For this, the study discusses the outcomes as integrating conventional and digital tools, collaboration with students in preparing the course content, a flexible course program, and a process-based design. The results suggest combining new and conventional pedagogical approaches to adapt not only to an online education system but also to a possible revision of the course programs of design studios.

Cite this article as: Cihanger Ribeiro D. Teaching basic design online during the Covid-19 pandemic: An evaluation of the conventional and innovative pedagogies. Megaron 2022;17(4):589–601.

INTRODUCTION

The first wave of the pandemic coincided with the spring semester of 2020, which compelled universities and instructors to employ emergency remote teaching (Veletsianos & Houlden, 2020). This education in an emergency was conducted through several online platforms although many were not prepared for this system (Hodges et al., 2020; Pokhrel & Chhetri, 2021). By the start of the following academic year, universities began to explore the possible benefits of online education without forgetting the challenges posed to both instructors and students (Charters & Murphy, 2021). While adapting any conventional course to an online environment requires time and research, design studios need a highly different organisation. The peculiarity of the design courses in comparison to the theoretical

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Published by Yıldız Technical University Press, İstanbul, Turkey
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academic courses lies in the fact that "design knowledge is difficult to externalise and is more tacit" (Polanyi 1966 cited in Park 2020). Within this context, the basic design studios during this period are significant platforms as they seem to be impossible to continue online due to the hands-on requirements.

The basic design studio is based on John Dewey's concept of learning by doing (Decandia, 2020) where students explore the concepts and discussions of theoretical courses through hands-on experience (Schön, 1983) and it is a participatory "creative space where students gather with peers and tutors to solve design problems" (Hettithanthri & Hansen, 2021, 2343). Students learn abstract thinking, creative problem-solving techniques through visual compositions in a studio-based learning experience (Orbey & Sarıoğlu Erdoğdu, 2020; Park, 2020; Kumar et al., 2021) that is a physical container and a shared space created for the social interaction of students and design tutors (Corazzoa, 2019; Charters & Murphy, 2021). This education simply aims to pass soft skills "such as communication, decision-making, and collaborative performance" (Park, 2020, 525) and is characterised by the notion of creativity (Ozkar, 2004; Greene et al., 2019; Uysal Ürey, 2021). Creativity is already a vague process and almost an obstacle in conventional studios as the students have a highly rational high school education (Günay, 2007; Alizadeh et al., 2016) that is detached from the sensory experience (Arnheim, 1965, 3). Despite the importance, there is a limited number of studies examining the fully online design studios in the existing literature as it is fairly a new phenomenon (Fleischmann, 2019; Alawad, 2021) mostly with a specific focus on the blended learning environments where online activities are merged with face-to-face instruction (Alizadeh et al., 2021).

Online design studios have some characteristics such as not having a fixed location, mediation through digital platforms, digital collaboration tools, peer support, critics, juries, and process-based learning according to Hettithanthri & Hansen (2021). To advance this list and discussion, the online design studio case during the 2020–2021 academic year for the first-year undergraduate urban planning students at (Middle East Technical University) is significant for revealing the potential and limitations of online design teaching. The conventional design studio was adapted into a digital learning environment (Pokhrel & Chhetri, 2021) through re-formulation of the course content, syllabus, and its pedogeological methods by keeping in mind the negative implications of COVID-19 on the mental health of the class participants (Amro, 2021; Callahan, 2021). Furthermore, the teaching process had to leave room for interpretation, critical reflection for the students during the adaptation.

In this context, the article will focus on the teaching methods and design pedagogies employed throughout 2020–2021 in the first-year basic design studio of the urban planning department at (Middle East Technical University). For this, the study first explores the pedagogical approaches to prepare an online basic design course. This exploration emphasises the importance to build a non-linear design studio to adapt to an online teaching environment and to push the limits of conventional basic design teaching strategies. Respectively, the applied pedagogies for a non-linear design studio, the methods will be unfolded as (i) the integration of the digital and conventional tools to teach design such as conventional hands-on techniques (sketching, note-taking, model making) and new digital methods (digital drawing, online brainstorm meetings); (ii) design feedbacks looking for new ways to remotely handle a usually hands-on experience where students gather with instructors to solve design problems in studios' physical space; (iii) a flexible and collaborative program that includes an incremental syllabus that is open to updates and student feedbacks as the course goes. After the critical presentation of these methods, the second section of this study focuses on the new features to create a more enjoyable, visually communicable and transparent studio experience for the implementation of the studio course. These features include the formation of a visual identity for the course, establishing a website and social media account and organisation of guest lecturers and workshops. Finally, the study ends with a critical evaluation of the potentials and limits of online (design) education, the confrontations and accordance of conventional and digital teaching methods through the student projects, students' follow-up evaluations for the course and the theoretical course content.

HOW TO PREPARE THE (ONLINE) BASIC DESIGN STUDIO?

The university education under the state of exception that Covid-19 pandemic challenged the design studios that mostly depend on hands-on assignments and face-to-face interaction to boost a creative production environment. In order to face this challenge, our course employed several conventional and innovative pedagogies. They followed a narrative lens to the design problems, hybrid approaches between hand and computer-aided exercises, using storytelling as a tool in research, brainstorming, people-centred design methods, coding, generative art, and group works to foster self-regulated learning (Greene et al., 2019) to reinforce "investigative work, inventiveness, capacity for self-assessment" (Lindström, 2006) for students.

In this context, this research explores the (online design) course program preparation and its execution through a critical overview of course itineraries, year-long course experiences of the instructors' and the students' projects and feedback. By enriching this process through theoretical references and in-class project examples, the article presents the pedagogies adapted for a non-linear and open design studio that moderates between the conventional

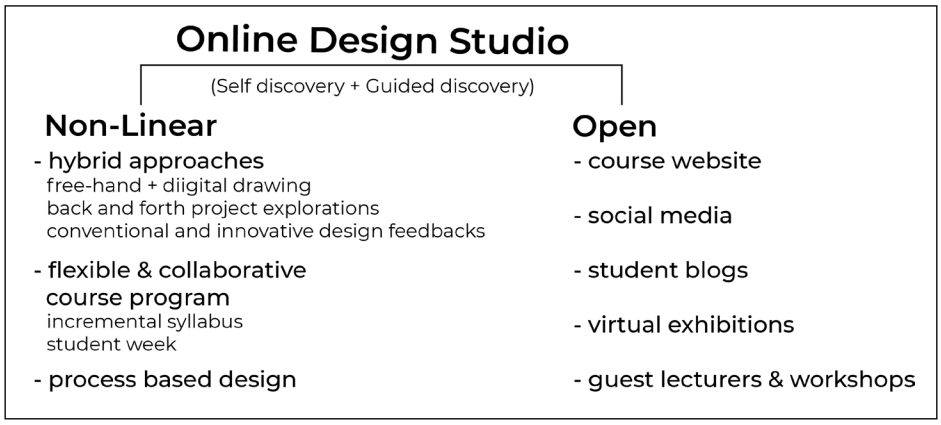

Figure 1. Main pedagogical strategies to build an open and non-linear online studio.

design studio strategies and the novel art-based, digital technologies through the four main pedagogical strategies that will be explained in detail in the upcoming sections:

1) Integration of self-discovery and guided discovery; conventional and digital tools;
2) Flexible and collaborative course program that is open to change;
3) Process-based design teaching;
4) Open Studio for transparency and accessibility (Figure 1).

Pedagogies for a Non-Linear Design Studio

The basic design studio helps students acquire problem-solving and critical-thinking skills for spatial compositions and eventually for actual urban settings. The basis of this process is conventionally to use abstraction as a pedagogical tool and the Gestalt principles of visual perception (continuity, similarity, enclosure, common fate, etc.) at (university name) (Günay, 2007). The self-discovery and guided-discovery methods are relevant within this teaching process as the inductive teaching techniques for design (Esmailizadeh et al., 2019). For both, the students are expected to interact with the instructors and among themselves for the creative problem-solving and abstract thinking processes. Traditionally in basic design studio courses, the instructors mostly follow a complete inductive reasoning process that pushed for the self-discovery learning method at (Middle East Technical University). The students were given an abstract concept to represent in two or three-dimensional mediums – an exploration of form relations, piece, and whole qualities prior to any theoretical approach, the theory came later. For example, the first task of the studio can be "abstraction of a feeling" on "a black and white medium framed in a certain size". The students are "usually" not given further details to tease their curiosity and make them bring along many materials giving room for a rich discussion that is highlighting the trials and errors in the project. Most of these projects were full of "errors" as expected. Although this self-discovery

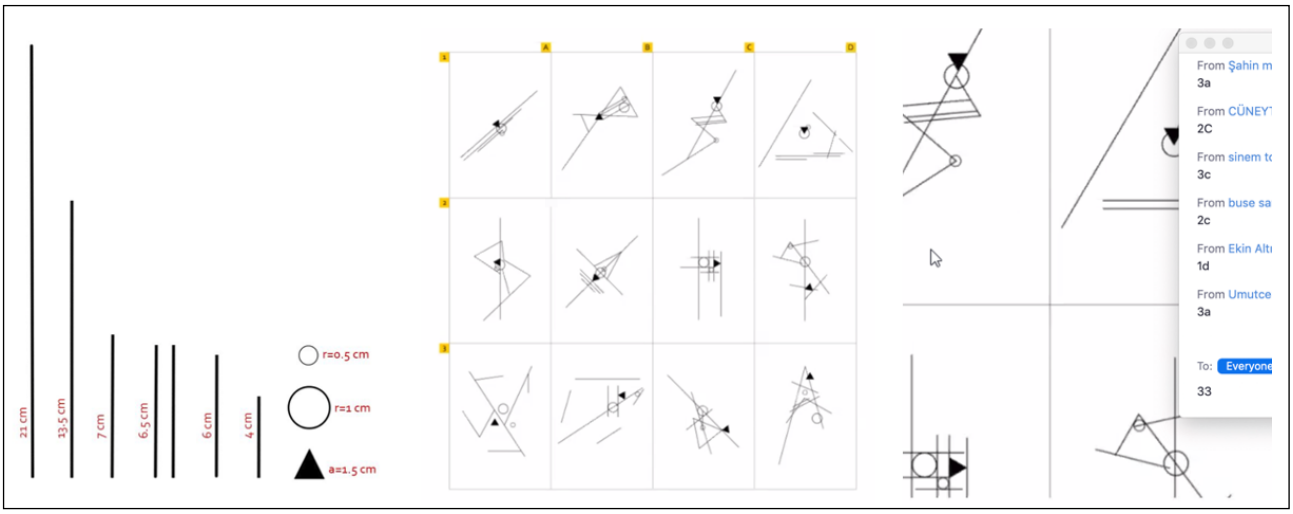

Figure 2. Students actively using Zoom chat box during the class to answer simple guiding questions for the "exploration of dynamics of form" exercise.

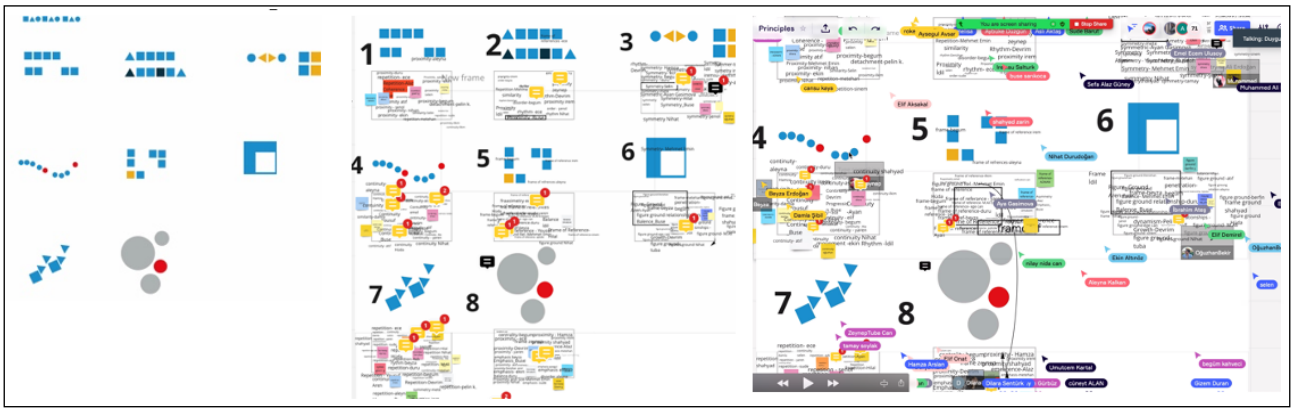

Figure 3. An exemplary online whiteboard exercise to unfold "gestalt principles" through a self-discovery method.

method stimulates discussion in the class and generates a more fruitful outcome than a mere theoretical presentation, the "expected" anxiety of the design process for the students seemed to be problematic for our design course.

During the online design studio program, the new course pursued an open approach through clear and repetitive theoretical explanations and detailed design briefs. The courses and exercises followed an interpretive approach, mixing inductive learning with interactive tools. For this, the course designated course hours, not only after hours as done before, for self-discovery studies prior to a theoretical explanation. This method was supported via digital tools as well. For example, the in-class exercises dissected some forms from Vasili Kandinsky's Composition VIII and asked students to explore several form relations by freehand drawings. Some outcomes were presented in a table and shared with the students as can be seen on the left side of Figure 2. As we have asked the students some overall design-related questions, they could share their answers through zoom's chat box (right-hand side of Figure 2). Besides, the online whiteboards such as Miro helped the class work instantaneously and in large groups. The "Gestalt principles" exercise is an appropriate example, to sum up, our approach and illustrate the use of new tools. Figure 3 shows the initial drawing by the instructor representing the Gestalt principles without any indication of what they stand for. Firstly, this drawing was placed on a collaborative whiteboard and all the students were required to write down the concepts they think that fits at the beginning of the class. The end result was complex and rich in concepts, defying the text-book definitions of this theory and leaving room for students' interpretations. Following this, the edited drawing was integrated into the theoretical presentation during the course break. This incremental approach includes students in the course, manages a good level of participation in a crowded class, and brings new perspectives and dynamism to the theory unlike in a conventional studio.

Integrating the Digital and Conventional Tools

The accessibility to computers and online submissions enabled better use of computer-aided programs and collaborative online platforms during online education. However, teaching basic design traditionally meant emphasising the importance of representation by hand. Still relying on this importance, most of our exercises followed a hybrid approach to find a balance between computer-aided programs and freehand drawings. The hybridity refers to some of the submissions that required both drawing by hand and a computer program. Searching for a mix of methods was not only in terms of drawing but also to enhance students' problem-solving skills and welcome a variety of their proffered techniques. As we passed from the simple compositions to more complex representation techniques of urban space, the students were asked to come back and forth in different visual representation techniques to break down the linear approach of most design studios (Chen, 2016; Hettithanthri & Hansen, 2021). Figure 4 shows how the spatial sketching was later adapted to a more abstract composition. In conventional studios, the abstraction projects are usually left behind as the students learn new skills of spatial representation. By challenging this, our studio aimed to integrate new skills in a non-linear fashion.

Updating the theoretical stand of the course and adapting its pedagogies for online education required us to review the rooted theories commonly used in the previous studio courses. One of these well-established theoretical discussions was Kevin Lynch's (1960) book "the image of the city". The traditional pedagogical attitude in a face-to-face studio has always been to introduce these image elements first and give students to look for their correspondences on the university campus. For an online adaptation, we had two tasks: review the theory and adjust the exercise for an online environment. Before explaining Kevin Lynch's image elements, we asked students to make a 10-minute quick sketch to express their close surroundings. After discussing the primary outcomes and representation techniques, they were given a take-home exercise to

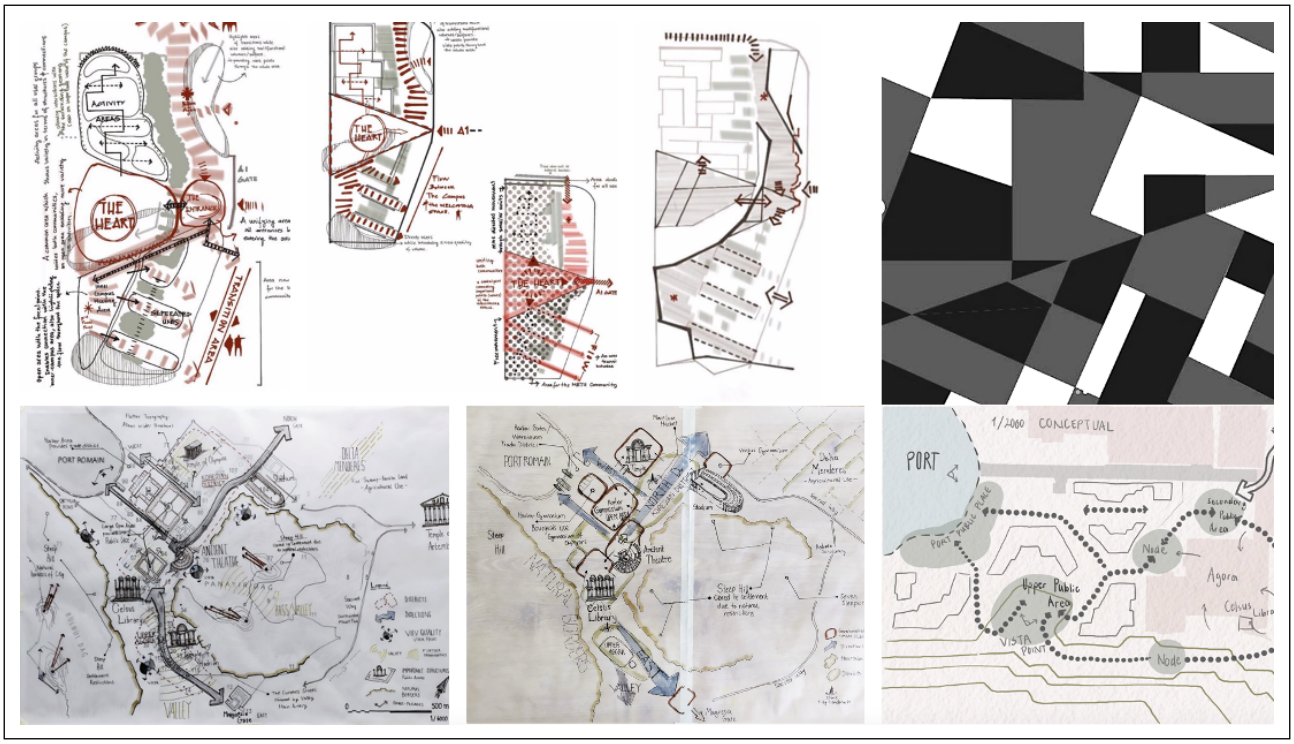

Figure 4. The first row of figures shows a back and forth approach to design as the student (A.Ekin Altınöz) starts with a new task of spatial sketching and proceeds with a more abstract composition, a skill acquired earlier in the studio. The second row includes the integration of hand drawn and computer aided drawings for the same task (M.Emin Sarıhan) to explore potentials and limits of both techniques.

represent their neighbourhoods to answer the question: "How would you map out the places you use/remember in your city?" This assignment helped to unveil the peculiar elements of our students who live in several different cities and even countries, as well as assisting them to explore their living spaces with a new perspective. The assignments were used during the theoretical lecture to critically identify the textbook definition of image elements. Instead, some critical discussions transformed and enhanced some of the definitions as many students brought subjective local qualities. As a final step, we have adapted and transformed the conventional model of sketching the mental maps and carried this style further with an online and interactive environment: ArcGIS story mapping. With the help of a workshop given field, who is a former graduate from our department, the students had the chance to learn how to

Figure 5. Several skills of visual representation such as sketching, drawing, photography shown in ArcGIS story maps for image of the city exercise (by A. Nur Aktaş).

use this program. The resulting projects were an amalgam of personal narratives, stories, photographs, digital and interactive maps, hand-drawn or computer-edited sketches that can be accessed by the public. This approach also enabled students to leave their houses and explore their close surroundings to stimulate students' senses and increase their empathy (Rodriguez et al., 2018; Hettithanthri & Hansen, 2021). Figure 5 illustrates one of the student projects prepared in ArcGIS story maps that integrates several modes of spatial representation that the class learned during lectures, workshops and projects such as photography, hand sketching, digital illustration, mapping and storytelling all pointing out the "inventiveness" used by the students (Lindström, 2006).

Design Feedbacks

One of the design studios' most important learning processes is the one-to-one or group critique sessions where the students are guided over their projects. This process helps to create reflective conversations where the students are given words to follow their questions up or given time to reconsider some of their design choices in the class time (Schön, 1983). Since online education prohibited direct contact between the instructors and the students, we

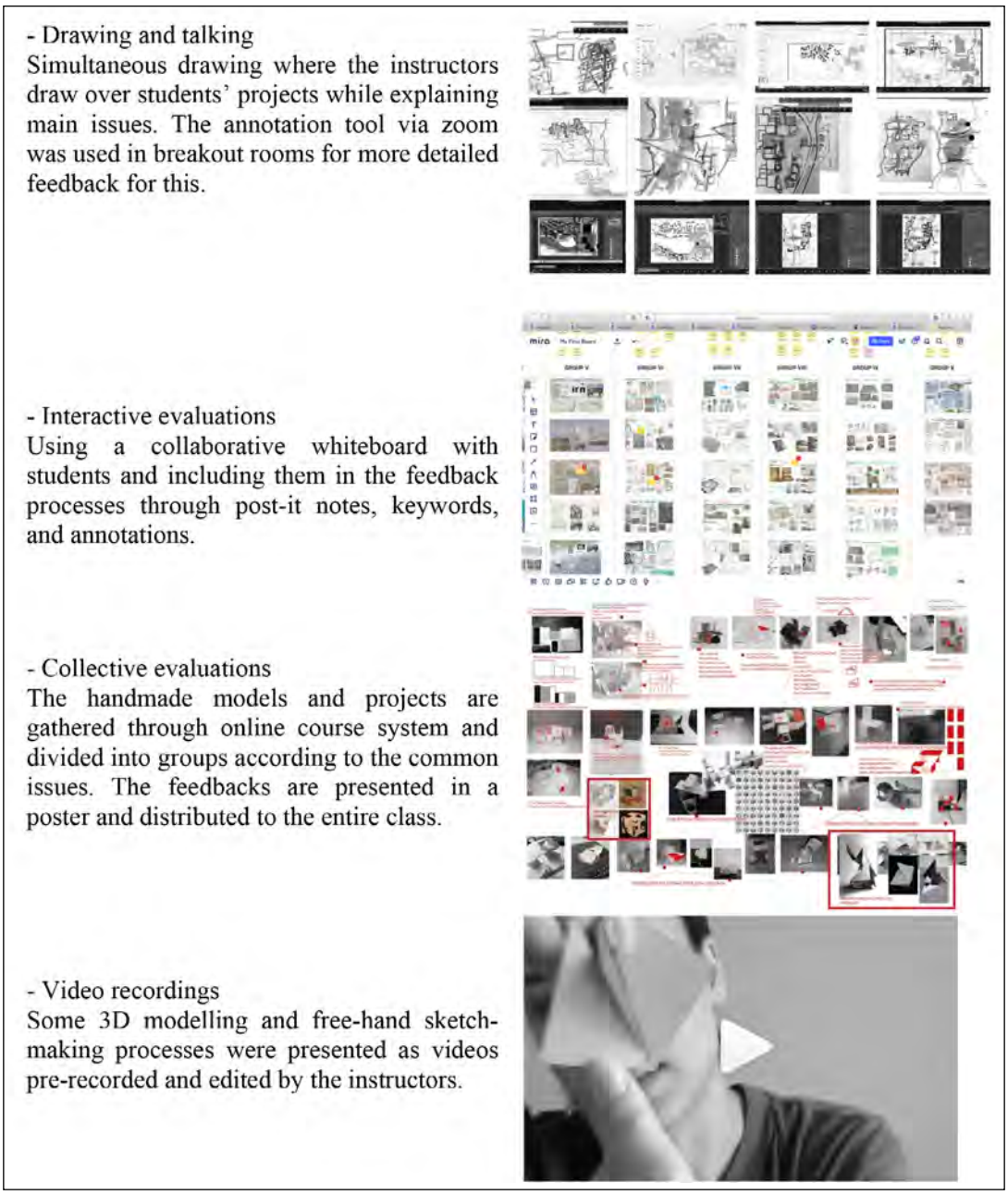

Figure 6. Design feedbacks integrated several tools and methods throughout the online studio classes.

have adapted the critique sessions into the virtual studio environment integrating verbal and non-verbal (Schön, 1983), manual and technological tools such as drawing and talking, interactive and collective evaluations and video recordings which are explained in Figure 6 in detail.

Flexible and Collaborative Program

The first-year design studio is already a collaborative and creative setting aiming to make students familiar with academic research requiring self-discovery, library research, oral and visual representation skills. Moreover, adapting the course program for an online platform under the Covid-19 pandemic restrictions required flexibility (Veletsianos & Houlden, 2020). Despite being advised as a prime asset of online education (Stone et al., 2019), flexibility and adaptability are not new in university education (Selwyn, 2011). However, as Barnett (2014, 30) discusses, "flexibility cannot be all things to all persons, interests or institutions." In the sense of flexible and adaptable course programs, Gordon (2014, 21) states, "the challenge is selecting how much of this flexible offering to adopt ad provide." This challenge brought out a particular type of flexible pedagogy specific to our online design education: a "flexible" course program. Focusing on the pedagogical flexibilities (Barnett, 2014) we followed a system of an incremental syllabus that is open to updates in the assignment requirements and deadlines but updates every three weeks after our observations in the class. The incremental syllabus left room for instructors to observe, evaluate the flow of the course, the students' responses, and monitor a possible increase in the Covid-19 patients in the students or their families. The final version of this new syllabus design highly differs from the ones prepared in the previous studios by being incremental, open to change in the course content, directly including student perspectives and giving very detailed project briefs. The flexible syllabus also meant listening to the students' feedback and looking for ways to build empathy in the class. For instance, we have decided to decrease the number of weekly assignments and the structure of in-class exercises after conducting a colloquium to review the first semester with the students.

To build empathy in the class, we have studied instructor-student communication to foster a more democratic and equitable learning environment in the online studio (Selwyn, 2011). For this, the course devoted one week entirely to the students' program called "student (syllabus) week" for the first time in the department. It was a pedagogical response after observing the weak bounds among the students to compose a class. In face-to-face education, this feeling and responsibility is easy to observe in students since they share a shared space where they listen to the lectures, do their assignments and socialise. The "student (syllabus) week" was organised as an entire week of 12-course hours to be designed by the students. We have asked them some guiding questions: what would they like to discuss and bring to the class's attention? How would they organise equal participation? Which topics would they highlight? We explained that however they choose to coordinate this week, their work will not be graded. Thus, they were free to skip that week and take some holidays as well. Instead, the students organised a meticulous class program with posters, video announcements, presentations and quizzes for the instructors. They have chosen to focus on their final project theme "nature and design" to use their time wisely. Firstly, they sent short videos and posters to announce this work through the course's social media platform. During the course, they formed eight groups concentrating on the topics such as sustainability, climate, everyday life under the main theme "nature and design" and prepared well-defined PowerPoint presentations. They have utilised videos, hand sketches, photographs and collages to support their ideas. There were two moderators selected from the students during these classes controlling the entire class by explaining the flow of the course, giving the floor to the presenters, giving breaks and posing questions. Almost all students took part in presentations, many engaged with the course. They presented a plenty of research skills and interest in the course. Furthermore, this student week seemed to have positive results for the aim of building empathy after this week as there were comments such as: *"We have seen how hard it is to prepare a class, to organize all and keep up with time. We understood you more."*

Process-Based Design Teaching

In their recent study on design studios, Hettithanthri & Hansen (2021) find out that conventional design studios lead students to be more solution-driven rather than caring about the creative process. Typically, the final product in a design studio is printed on heavy paper with its colourful and bold details, or a model is neatly cut and presented for grade evaluation. The instructors acknowledge that they are all an end product of weeks-long sketches and ideas but this process is still expected to be embedded in this final representation accompanied by a fluent project presentation. Considering that the process or the person is usually not included in the design products' evaluation (Uysal Ürey, 2021), we aimed to follow a process-based design teaching in our studio mainly for two reasons. First, not all the students had the physical, social and psychological setting to sustain an online design education. Even though we had only a few students who mentioned their lack of a proper workplace in their homes, we knew that there is always uncertainty and sudden changes due to the pandemic conditions. Secondly, there is an increasing interest in process-oriented design pedagogies highlighting critical thinking and experiential learning to prioritise process-based teaching (Öztürk & Türkkan, 2006). Figure 7 shows some of the critical examples of students' works

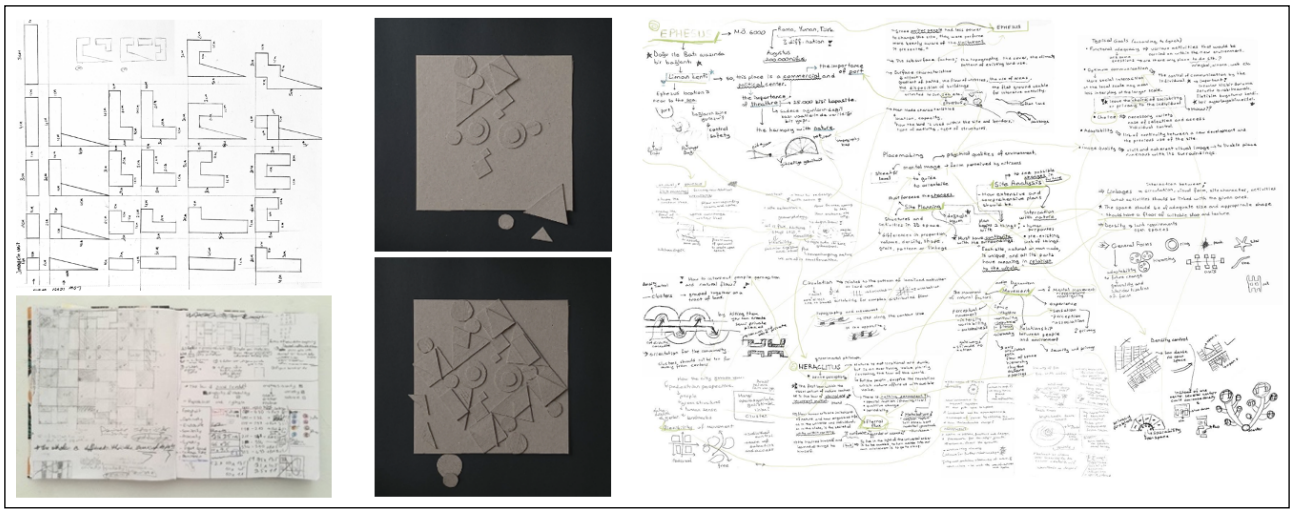

Figure 7. A selection of student works focusing on the design process where they explore the given task through various mediums and media (by Selen Tüfekçioğlu, Ayşegül Avşar, Gizem Gürbüz, Nihan Bağrıaçık).

indicating the process-based teaching model. Instead of presenting an end product, the students were encouraged to submit their conceptual maps, analytical geometrical exploration, notes and time-lapse videos to show their reasoning behind their final compositions.

The student feedback before the second semester showed that the number and variety of assignments should be lower. Hence, we prioritised evaluating design within a learning process (Kolb, 1984, Demirbaş & Demirkan, 2003) by providing several lectures and tasks to the students that incrementally lead to a more complex planning and design problem. This approach in the second semester of online design education enabled students to have experienced the topics since we gave time for them to reflect and act on their decisions which finally resulted in a concrete experience for reflection (Kolb, 1984). Especially in the final project, the students paid attention to their online studio and design journey instead of solely asking for a final product. The grading rubric given in the design brief for the final assignment asked for a complete representation of their process in different formats (videos, sketches, zoom crits) to see an investigative work and a capacity of self-assessment within the groups' design journey (Lindström, 2006). The project brief also highlighted the "design process" as follows:

"Process: The medium of presentation is up to you for the design/plan process throughout your group discussions/ in-class feedbacks. Just present your journey!"

Usually, the students work individually on their final project at the end of the basic design studios. However, giving a "co-design task with an emphasis on the importance of process" (Fathallah, 2021) was necessary for students to meet defying the feeling of solitude during the confinement periods. Therefore, the students came together and worked via online platforms, collaborative white boards, and one-to-one online feedback from the instructors. Students' feedback extensively indicated a sense of relief and ease compared to the first semester's assignments mentioning the positive psychological impact of working in groups in times of isolation. From the instructor's perspective, this approach enabled a collaborative working environment in the studio which is not always prioritised in-physical studio classes (Park, 2020). In the student reflection survey, some comments reflect on the group work both in affirmative and critical connotations:

Affirmative Comments:

"I have established excellent relations with the group work given when I thought I could not make any friends."

"My favorite class activity is a final group working for the second semester."

"No matter how difficult it was and the points we disagreed on, as we got to know each other, it was an enjoyable and useful process."

Critical Comments:

"We were unlucky with group members."

"Working in groups was nice, but it should not be the core as we have to develop as individuals."

"Open studio": Guest Lecturers and the Use of Social Media

The previous sections on the design teaching pedagogies mostly showed adaptations of the formerly applied techniques in the studio or the existing discussions in design teaching for an online process. However, considering mental health within the scope of these discussions can be one of the most peculiar situations that the pandemic brought to academia. Many students and instructors have experienced

psychological and emotional distress (Pokhrel & Chhetri, 2021) at home due to the uncertainties of lockdown, long-term social distancing, and a deadly virus (Carlson, 2020; Amro, 2021). This idea of isolation and loneliness required new ways to make the studio course a more encompassing space. This attempt coincided with the compulsory increase in digital technologies for distance education (Hettithanthri & Hansen, 2021). The medium between the course and the student was personal computers and mobile phones. Utilising this necessity in our favour, we have worked on a digital program to create an open studio, including some strategies such as:

- Visual identity for the course
- Course website, are.na webpage, social media account
- Guest Lecturers and Jury Members
- Student Blogs
- Online Exhibition of Student Projects.

The first step of this so-called open studio was to prepare a visual identity through logos, typefaces, and colour codes to engage and inform visitors of the upcoming works. Furthermore, a coherent visual identity could influence the first-year basic design students by setting a subtle exemplary visual design strategy focusing on continuity, unity in variety, piece, and whole relationship (as in the case of a single post and its relation to Instagram grid). The second step was to publish a course webpage and create a social media account. We aimed for the webpage to be a long-lasting project to create an online archive of studio projects and events. We pursued transparency throughout the academic year by sharing a large selection of student projects on this website. The Instagram features of posts, stories, and polls were actively used almost daily. The account showcases the visual guidelines in coherent graphic language; most of the students' projects, events, and announcements were shared here.

These tools mainly target our students' interests and contribute to their learning process during off-class hours. However, there were many feedbacks from the other planning schools as our work was among the very few visible and accessible to the general public. The Instagram page (IG) created a lot of national and international interaction and interest as well. Our students stated that once their projects were posted, their peers were contacting them, and they sometimes had an online idea exchange opportunity. About 95% of our students stated that they followed the course IG account, and about half of these commented on the positive sides of this by saying *"the most important positive aspect of the studio's website and social media accounts was that it delivered the work we did in the studio to people interested in this field.", "very effective for inspiration," "motivated the students with the homework shown during the semester.", "Easy to access and open to all."*. However, the other half of the students were slightly critical of the use of social media. Despite our prioritisation to include as many and diverse projects in the feed, not all the projects or students were given place equally due to its world of visual sophistication. Students reflected on that by saying: *"despite a few, some friends got ambitious to be featured on the feed.", "maybe not only the best projects but also every project can be posted equally."* Additionally, the social media account was used to share some academic and course-related information and projects such as the case of our are.na website with course-related inspiration boards, student blogs and an online final project exhibition.

The third strategy for an open studio included guest lecturers and contributors working in architecture and urbanism from Turkey and other countries such as Belgium, The Netherlands, Australia, the USA, and Portugal. Online platforms made it easy for the guest lecturers to contribute to our course without traveling or sparing much time. Most of these events require pre-and post-meeting with the guest academics as they wanted to integrate their research issue with the studio content. We had fourteen City Series talks

Figure 8. The logo of the studio, the guest lecturers' posters from the second semester and the social media page.

and three workshops throughout the year. The guests were contacted according to their research interests as they fit our course program. These talks focus on order, complexity, climate change, public space, design, and nature. The workshops were on urban sketching, coding, and collage-making. All these events were organised to enrich our students' perspectives on the urban planning profession and motivate them about the class. Following the talks, the students worked in breakout rooms to share their thoughts on the presentations and their relevance to studio topics. Among the six options listed under the pedagogies of the online studio, (final group project, are.na, student week, office hours, breakout room exercises, and city series) majority of the students (83%) have found the "City Series" as the most useful one. These events helped students get familiar with the ongoing urban issues, know the scope of our profession, and made our studio "act as a bridge between academic and professional communities" and collaborative space (Brandt et al., 2011, 329; Park, 2020) (Figure 8).

LESSONS LEARNED AND CONCLUDING REMARKS

The immediacy of adapting a conventional course to an online system was apparent after the pandemic precautions and distance education decision for the 2020-2021 academic year. This study focused on the potential of an online design studio from a critical point of view, to assess the theoretical and pedagogical approaches while adapting the course to a digital setting. Although the central question in this study is how to prepare for an online design course, the answers are noteworthy to evaluate from a wider perspective of basic design education. Below, the main methods to build an online studio are listed through comparisons with the conventional course before the pandemic.

- Integrating conventional and digital tools

During the online studio, the students were asked to combine freehand and computer drawing techniques as well as videos and photography. They have also followed a back-and-forth approach in some assignments for which the students revisited former tasks. Besides, the hybrid approaches were instrumental in design critics as the instructors combined: on-time sketch-making in adobe illustrator, recording videos of the freehand sketch-making process, utilising zoom annotation tools over students' projects, creating 2D and 3D models to explain a concept better for the students. This hybridity of techniques was not tried in a conventional studio where the main method was handmade projects and models without much focus on digital tools. Hence, there are some differences in the outcomes of these student works between the pandemic traditional studio and the online studios even when the assignments were similar. First of all, the physical frame and scale of projects were smaller for students to spend fewer resources on the material, to easily use their private working spaces. Also, the online projects incorporated supporting sketches and drawings into the main submission which had stronger analytical qualities than the previous projects.

- Flexible program

We have planned a flexible course program and made our intentions open to the students at the beginning semester. In conventional design studios, the syllabi usually were shorter documents indicating some general course topics and main submission deadlines. However, remote teaching necessitated a detailed text clearly explaining the course objectives, course flow and essential deadlines. Moreover, the detailed daily programs and project design briefs, including the guests, theoretical courses were given over three-week periods, leaving room for instructors to adapt and update according to the class's interest and a possible emergency due to pandemics. Another pedagogical flexibility was the organisation of the student week, where the students took over courses for a week and organised a whole program with presentations, quizzes, posters. This method helps to build trust and empathy among the students and instructors. Giving responsibility to the students was something rare in the previous studios and despite many hardships, a digital environment made it possible for a quicker and more meaningful organisation among the students since they could meet easily and work on shared documents.

- Process-based design teaching

The conventional design studio course mainly focused on the quality of the final product. Despite the teaching being based on the design feedback processes and in-class discussions, these rarely are reflected in the final evaluations. Considering the students' limited working conditions at home and the increasing interest to prioritise process-based teaching (Öztürk & Türkkan, 2006), this approach was one of the backbones of our studio's pedagogy. For this, each assignment allowed several iterations through which students update their work after getting feedback. Another technique we used was to grade the students' design processes (sketches, idea presentations, flowcharts, etc.) help to decrease the anxiety regarding the course grades which is one of the prominent challenges in the conventional studio course. Process-based design teaching seems to be an integral part of any design studio, our example showed some tools to strengthen this approach since this perspective should be employed as one of the first strategies both for a conventional and online studio in the future.

- Open studio

The design studios are physical containers where students can interact among themselves and with instructors while learning abstract thinking, creative problem-solving techniques (Corazzoa, 2019; Charters & Murphy, 2021). Although the digital studio could not offer a fixed space (Hettithanthri & Hansen, 2021), it creates a setting that is open not only for students but also for interested parties in a virtual public space with easy access (considering all students had personal computers and internet connection). With this in mind, we pursued transparency and ease of access to our course content which is different from the previous courses which were defined by the limits of the studio space and participants. The courses produced a virtual public space by efficiently using the course website, are.na website, and a social media account. Besides, being open meant including more people in our studio such as guest jury members and guest lecturers for the events we incorporated in the course, called: City Series (public presentations with guest lecturers from the world) and Off-Talks (workshops open only to the course participants). These events helped students get to know other scholars worldwide and enrich their contemporary knowledge of cities. In some cases, we hosted the graduates from our department to show the possible carrier paths for the students. These events resonated very well among the students not to mention the guest audience to the public lectures. However intriguing, there are limitations to an open studio. First, these platforms and activities needed long hours of organisation, constant updates with graphics, edited works and announcements with students' projects, photography, and academic notes. Second, both time and space limitations forced a certain elimination of most of the students' work. Hence, the inclusivity of a greater amount of student work into the social media and website must be of utmost importance for an open design studio in the future.

To conclude, the limitations of the online design studio brought along the potential for re-framing the conventional design studios, which usually prioritise the final product over the design process, self-discovery over guided discovery and hand drawing skills over digital tools. As a result, the course itineraries, student projects and their feedback, the guest jury comments to the final jury showed that the online studio somehow managed to foster self-regulated learning (Greene et al., 2019), especially with the example of "student syllabus week". The participants of the class were engaged in analytical research, in finding inventive solutions and capacity for "self-assessment" (Lindström, 2006). Besides, the pandemic conditions made the first-year students more engaged with digital tools and provided ease of access to university education. The design feedback used to be mostly limited to pin-up sessions and table critiques in the traditional design studios. Whereas the online environment provided a more diverse and interactive feedback session as the digital submissions of the students made it possible for a pre-evaluation by the instructors before the class and each assignment was evaluated according to their peculiarities while preparing the feedback content.

However, the private rooms of the students and instructors had to be public classrooms, the lack of computer literacy of the first-year design students triggered some problems and cause slow progress as all participants had to juggle many new tools at once. Furthermore, as time passed in an online studio with continuous confinement and unclarity of the pandemic, even the meticulously studied methods fell short. Various small-scale pedagogical methods had to be injected into the course flow, especially for the mental health dimension of online teaching. For instance, a fun contest with a new year's theme was organised where the winner was chosen by the students and had a book award; a Spotify music list to accompany the midterm project process was created. Besides, observation of the studio dynamics is harder in an online setting than in a physical space. To succeed, feedback sessions and course evaluation surveys are utilised for a similar approach in the digital course. All these required an immense amount of working and preparation time in and outside the class hours which is a significant dimension to consider such reforms in a conventional course setting. On top of these, the mental health side of the process remains a challenging and understudied topic that requires an interdisciplinary study for future (online) design studios.

The students' feedback both during the semester break and at the end of the academic year indicates the potential of the pedagogical tools we have used in the online course setting. Giving more voice to the students (group works, student-led courses), bringing prominent scholars as guest lecturers, organising workshops and social media platforms are highly praised by the students. However, some methods failed to represent the entire spectrum of projects but highlighted the more successful student works due to the nature of graphics preferred in social media platforms. Keeping these limitations and potentials in mind, this study opens up new ways to adapt a conventional design course into an online environment as well as methods to realise a blended learning environment for future courses.

Acknowledgments
I thank the CRP101 and CRP102 courses' assistants Selen Karadoğan, Ecem Kutlay, Göksun Yıldırım, Nilay Nida Can, Aybüke Balahun, Ayşegül Sarı for their tenacious efforts and Dr Zeynep Eraydın for her valuable support for the CRP101 course. Their work eased the hardships of online design education during the lockdown period of the 2020-2021 academic year.

ETHICS: There are no ethical issues with the publication of this manuscript.

PEER-REVIEW: Externally peer-reviewed.

CONFLICT OF INTEREST: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

FINANCIAL DISCLOSURE: The authors declared that this study has received no financial support.

REFERENCES

Alawad, A. (2021). Evaluating online learning practice in the interior design studio. International Journal of Art and Design Education 40:526–542. https://doi.org/10.1111/jade.12365.

Alizadeh, T., Tomerini, D., and Colbran, S. (2017). Teaching planning studios: An online assessment task to enhance the first year experience. Journal of Planning Education and Research 37(2):234–245. doi:10.1177/0739456X16647162.

Amro, D. K. (2021). The impact of COVID-19 lockdown on design students' performance case study in the UAE. International Journal of Art and Design Education 41(4):108–124. https://doi.org/10.1111/jade.12378.

Arnheim, R. (1965). Visual Thinking, Education of Vision, ed. G. Kepes, George Brazilier Inc., USA.

Barnett, R. (2014). Conditions of flexibility: Securing a more responsive higher education system. York, UK: Higher Education Academy. https://www.advance-he.ac.uk/knowledge-hub/conditions-flexibility-securing-more-responsive-higher-education-system. Accessed 22 September 2020.

Brandt, C. B., Cennamo, K., Douglas, S., et al. (2013). A theoretical framework for the studio as a learning environment. International Journal of Art and Design Education 23:329–348. https://doi.org/10.1007/s10798-011-9181-5.

Fleischmann, K. (2019). Can we teach design online? Canadian Journal of Learning and Technology 45(1):1-18. https://doi.org/10.21432/cjlt27849.

Callahan, K. (2021). Valuing and supporting introverted students in the virtual design classroom. International Journal of Art and Design Education 40(4):714–722. https://doi.org/10.1111/jade.12383.

Carlson, E. (2020). COVID-19 and educational engagement. Journal of Oral and Maxillofacial Surgery 78:1049–1051.

Charters, M. and Murphy, C. (2021), Taking art school online in response to COVID 19: From rapid response to realising potential. International Journal of Art and Design Education 40(4):723–735. https://doi.org/10.1111/jade.12384.

Chen, W. (2016). Exploring the learning problems and resource usage of undergraduate industrial design students in design studio courses. International Journal of Technology and Design Education 26(3):461–487.

Corazzoa, J. (2019). Materializing the studio. A systematic review of the role of the material space of the studio in art, design and architecture education. Design Journal 22:1249–1265. EDSWAH. https://doi.org/10.1080/14606925.2019.1594953.

Decandia, L. (2020). Learning as an Aesthetic Experience: Digital Pedagogies in Planning Didactics, Multimedia Explorations in Urban Policy and Planning Beyond the Flatlands. eds. Leonie Sandercock and Giovanni Attili. Springer.

Demirbaş, O. O., Demirkan, H. (2003). Focus on architectural design process through learning styles. Design Studies 24:437–456.

Esmailizadeh, F., Tabatabaee Lotfi, S. A., and Ashari Tabar, N. (2019). The effects of guided-discovery, self-discovery, and situational-presentation techniques on learning conditional sentences in English. Applied Linguisics Research Journal 3(3):51–63.

Fathallah, R. (2021). Pedagogies for democratic participation in design studios: Towards more inclusive group work among interior design students. International Journal of Art and Design Education 40(4):736–747. https://doi.org/10.1111/jade.12385.

Greene, J. A., Freed, R., and Sawyer, R. K. (2019). Fostering creative performance in art and design education via self-regulated learning. Instructional Science 47:127–149. https://doi.org/10.1007/s11251-018-9479-8.

Günay, B. (2007). Gestalt theory and city planning education. METU Journal of Faculty of Architecture 24(1):93–113.

Gordon, N. (2014). Flexible pedagogies: Technology-enhanced learning. Heslington, York: The Higher Education Academy. https://www.heacademy.ac.uk/system/files/resources/TEL_report_0.pdf. Accessed 7 July 2020.

Hettithanthri, U. and Hansen, P. (2021). Design studio practice in the context of architectural education: A narrative literature review. International Journal of Art and Design Education 32:2343–2364. https://doi.org/10.1007/s10798-021-09694-2.

Hodges, C., Moore, S., Lockee, B., Trust, T., and Bond, A. (2020). The difference between emergency remote teaching and online learning. Educause Review 27 March. https://er.educause.edu/articles/2020/3/the-difference-between-emergency-remote-teaching-and-online-learning. Accessed 24 October 2021.

Kolb, D. A. (1984). Experiential Learning: Experience as the Source of Learning and Development Prentice Hall, Englewood Cliffs, NJ.

Kumar, J. A., Silva, P. A., and Prelath, R. (2021). Implementing studio-based learning for design education: a study on the perception and challenges of Malaysian undergraduates. International Journal of Technol-

ogy and Design Education 31:611–663. https://doi.org/10.1007/s10798-020-09566-1.

Lindström, L. (2006). Creativity: What is it? Can you assess it? Can it be taught? International Journal of Art & Design Education 25:53–66. https://doi.org/10.1111/j.1476-8070.2006.00468.x.

Lynch, K. (1960). The image of the city. Cambridge, MA: MIT Press.

Orbey, B. and Sarıoğlu Erdoğdu, G. P. (2020). Design process re-visited in the first year design studio: Between intuition and reasoning. International Journal of Technology and Design Education 1. https://doi.org/10.1007/s10798-020-09573-2.

Ozkar, M. (2004). Uncertainties of Reason: Pragmatist Plurality in Basic Design Education, Unpublished Ph.D. Dissertation, Massachusetts Institute of Technology.

Öztürk, M. N. and Türkkan, E. E. (2006). The design studio as teaching/learning medium — A process-based approach. International Journal of Art & Design Education 25:96–104. https://doi.org/10.1111/j.1476-8070.2006.00472.x

Park, S. (2020). Rethinking design studios as an integrative multi-layered collaboration environment. Journal of Urban Design 25(4):523–550. https://doi.org/10.1080/13574809.2020.1734449.

Polanyi, M. (1966). The tacit dimension. London: Routledge

Pokhrel, S. and Chhetri, R. A. (2021). Literature review on impact of COVID-19 pandemic on teaching and learning. Higher Education for the Future 8(1):133–141. DOI: 10.1177/2347631120983481.

Rodriguez, C., Hudson, R., and Niblock, C. (2018). Collaborative learning in architectural education: Benefits of combining conventional studio, virtual design studio and live projects. British Journal of Educational Technology 49(3):337–353.

Schön, D. A. (1983). The reflective practitioner: How professionals think in action. New York: Basic Books.

Selwyn, N. (2011). 'Finding an appropriate fit for me': Examining the (in)flexibilities of international distance learning. International Journal of Lifelong Education 30(3):367–383. DOI: 10.1080/02601370.2011.570873.

Stone, C., Freeman, E., Dyment, J. E., Muir, T., and Milthorpe, N. (2019). Equal or equitable?: The role of flexibility within online education. Australian and International Journal of Rural Education 29(2):26–40. https://search.informit.org/doi/10.3316/informit.639619709196818.

Uysal Ürey, Z. Ç. (2021). Fostering creative cognition in design education: a comparative analysis of algorithmic and heuristic educational methods in basic design education. METU Journal of Faculty of Architecture 38(1):53–80. DOI: 10.4305/METU.JFA.2021.1.9.

Veletsianos, G. and Houlden, S. (2020). Radical flexibility and relationality as responses to education in times of crisis. Postdigital Science Education 2:849–862. https://doi.org/10.1007/s42438-020-00196-3.

Megaron, Vol. 17, No. 4, pp. 602–616, December 2022

Megaron
https://megaron.yildiz.edu.tr - https://megaronjournal.com
DOI: https://doi.org/10.14744/MEGARON.2022.77753

Article

Water supply of the Topkapı Palace kitchen complex: Review and interpretation based on new findings

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ARTICLE INFO

Article history
Received: 27 June 2022
Revised: 14 December 2022
Accepted: 20 December 2022

Key words:
Disposing of wastewater; fountains; Topkapı Palace kitchen complex; water supply; water wheel of well.

ABSTRACT

Topkapı Palace's kitchen complex consists of the cooking units (kitchens), dorms, masjids, baths, storages, storerooms and cellars and is where the outer services (Birûn) served the inner ones (Enderûn). These units required water for drinking, cooking, cleaning and watering purposes. The water was supplied from Halkalı and Kırkçeşme. Water towers and wells then transmitted that to the kitchens' fountains, alongside baths, ablutions and restrooms. If the Halkalı and Kırkçeşme water were insufficient, water from the city of Terkos was delivered to the palace, as well. Channels disposed of wastewater into the Marmara Sea. It has been determined that the findings obtained in the literature review do not review a holistic view of the whole study area. In order to fill the gaps, the new documents were provided from the Ottoman Archives of the Turkish Republic Presidency State Archives, archives from the Institute of Ekrem Hakkı Ayverdi, the National Library of France, and The Harvard Map Collection. To prove the accuracy of some of the new documents and to establish spatial relations, surface research and excavations are required within the study area. The aim of this article is to try to search for a context for the whole water supply of the palace kitchens by evaluating all available resources, spatial functions and connections.

Cite this article as: Uysal Engüdar E, Yergün U. Water supply of the Topkapı Palace kitchen complex: Review and interpretation based on new findings. Megaron 2022;17(4):602–616.

INTRODUCTION

Topkapı Palace was constructed during the Mehmed II period (r.1451–1481) in Sarayburnu, Istanbul. Five hundred years' worth of classical, western, and Turkish republican influences are reflected in the palace's architecture. Its kitchen complex consists of cooking units (kitchens), dorms, masjids, baths, storages, storerooms, and cellars (the main units), which are located in the second courtyard with auxiliary buildings nearby (Eldem & Akozan, 1982). Over time, the palace units had been expanded and repaired, non-functional spaces being removed, while others were added. Therefore, considering diversities and transformations, water was provided for various purposes in different ways. For instance; the water was supplied from Beylik Water of Halkalı via the water tower until the 17th century (Necipoğlu, 2013), due to the repairs of the kitchens after the damage of the fire in 1574 (Selânikî, 1999), afterwards, it was supplied from Kırkçeşme via a horse-drawn water wheel until the 19th century (Tezcan, 1989). Eventually, the palace was supplied with electricity (BOA, 1336) and coal gas (BOA, 1344), and

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the wheel was replaced with a water pump; the old haystack and barn became redundant henceforth. In 1918, water supply line from the city of Terkos city – in addition to Kırkçeşme – was used by a French-run company, *Dersaadet Su Şirketi* (Istanbul Water Company), at that point the use of the water pump was temporarily suspended (BOA, 1344). Following a slew of renovations, the wells, the water pump, and the water supply lines were all used together (Öz, 1991). Meanwhile, water was distributed to the water tank of the bath, restrooms and fountains of the kitchen complex. Likewise, apart from the restrooms and fountains found in situ (Eldem & Akozan, 1982), there were also fountains used for dish washing (BOA, 1285) and ablution (BOA, 1291). The wastewater from all of these units was collected in an underground drainage channel beneath the kitchen courtyard (Pouqueville, 1805), and flowed out to sea (Kömürciyan, 1988). However, including the unknown architectural elements, the literature and on-site surveys only provide us with partial data about the water system overall. We otherwise do not know fully about how the water wheel worked, its water capacity, and why there was an unused water tower (Necipoğlu, 2013). Likewise, we also know little about the areas used for washing the dishes and ablution, how the water was discharged, or how many fountains – or, for that matter, restrooms – there were compared to the kitchen's diversity. This study will set out to answer all of these questions (and more) by analysing the water distribution lines, thus filling in the gaps in the current literature.

TOPKAPI PALACE KITCHEN COMPLEX

After the conquest of Istanbul in 1453, and after residing at Blakharnai Palace for a while (Tezcan, 1989), Sultan Mehmed II built himself a palace, the *Old Palace*, in the heart of Istanbul – just north of Forum Tauri – consisting of living, administrative, and harem units (Kuban, 1996). However, it was so close to the city's crowded residential area that there was no way that it could be expanded further. Hence, the Mehmed II began scouting out a new administrative palace. He eventually erected the New Palace (Topkapı Palace) on the site of the ancient Byzantine acropolis. It was surrounded by sea walls and land walls which were connected to sea walls built in Mehmed II period (r.1451–1481). By doing so, Topkapi Palace was guarded against possible attacks. Topkapı became the Sultan's administrative office, whereas Old Palace served as his home and harem (Sakaoğlu, 2002).

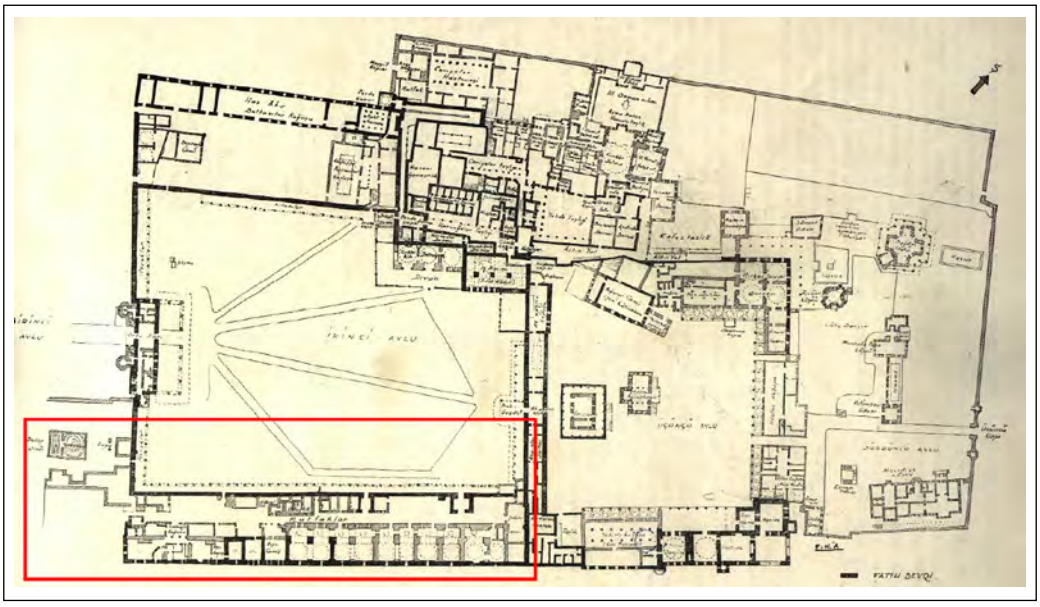

Figure 1. Kitchen complex (mutfaklar) is located at the south west direction of the Topkapı Palace (marked in red rectangular). Remains from the Mehmed II period (r.1451–1481)[2] (Ayverdi, 1953) are indicated in bold.

[1] According to Ottoman historian Gelibolulu Mustafa Âlî (b.1541, d.1600), it would be inappropriate for the sultan to live in the city centre. After residing in the Old Palace for 2 years, he moved to the Topkapı in 1462, which took 8 years to build (Âlî, 1997). Ramazanzâde Nişancı Mehmed Çelebi points out that the Topkapı was built in 1463 (Nişancı, 1983). Another Ottoman historian, Hezârfen, indicates that the palace was completed in 882 AH (1467/1468 CE), and that fortification walls were added the same year; also noting that Fatih had declared this spot as a headquarters and centre administration (Hezârfen, 1998). Byzantine historian Kritovoulos (b.1410, d.1470) states that the Topkapı was completed in 1459. Between 1459 and 1465, towers, wards for male and female staff, bedrooms, recreation rooms, passages, halls, doors, porches, ovens, baths, and gardens filled with fruit trees and various animals to roam were added (Kritovoulos, 1954). In light of these findings, the year 1459 seems like a ground-breaking date since the first courtyard was not mentioned until 1478. Kritovoulos gave us the earliest date (Necipoğlu, 2007).

[2] After the fire of 1574, two and a half *ziras* of space were added from the second yard onto kitchen sections during repairs made by Sinan the Architect (Selânikî, 1999). The main wall of the kitchen's portico (facing the second courtyard) should appear lighter in Ayverdi's restitution plan.

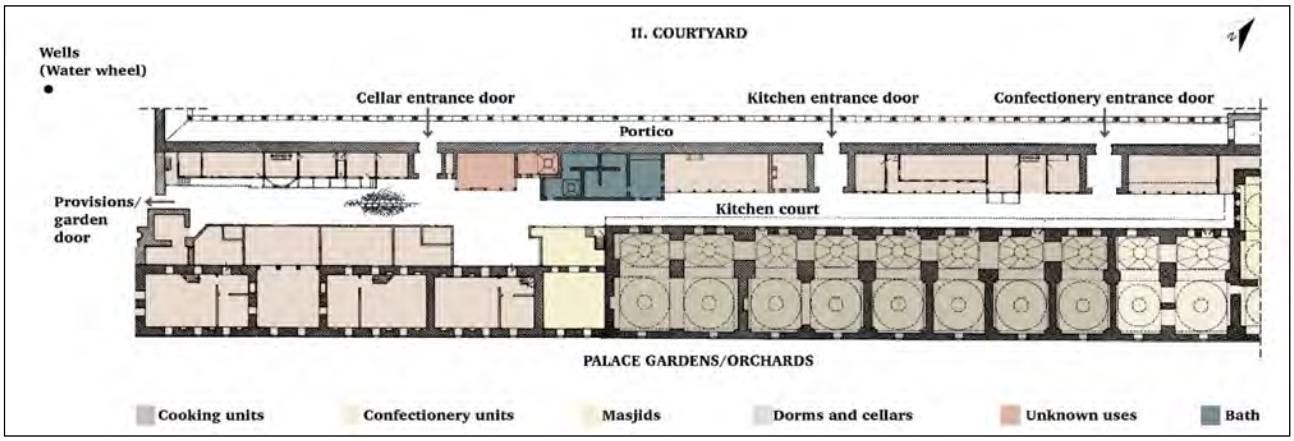

Figure 2. A revised design of Eldem's restitution project circa. The beginning of the 20th century (Eldem & Akozan, 1982) by Ece Uysal Engüdar. This drawing shows the units of the kitchen complex.

The palace was built over two phases.[1] In phase one (1459–1468) the second and third courts were constructed. In phase two (1470–1478) the land walls, outer gardens, and kiosks were completed (Seçkin, 1990). As such, we estimate that the palace kitchens in the second court were built during phase one as well. That said, even if the first two units of the kitchens (Figure 1) are attributed to the Mehmed II period (r.1451–1481) (Ayverdi, 1953), dating them leaves us with question marks, and for two reasons. Reason one is that there was no harem in the Mehmed II period (r.1451–1481), even if one assumes that the palace kitchen scheme should be similar to its predecessor, Edirne Palace (Bozkurt, 2016), in other words, there was no need for space or diversity. Reason two is that kitchens were repaired and rebuilt multiple times due to two earthquakes – 1509 (Çelebi, 2003; Necipoğlu, 2007), 1894 (Ürekli, 1990) – and two fires – 1574 (Selânikî, 1999), 1700 (Topal, 2001). We only know that the architect behind the first two units of the kitchens (15th century) is Ayas Ağa (Bayrak, 1996).

Topkapı's kitchens took on their unique forms after a fire had broken out in the Old Palace. Likewise, that is also when the harem moved out of the New Palace as well. As such, Topkapı Palace became where the sultan lived his private life alongside conducting all of the state's official affairs (Sakaoğlu, 2002). That move also evoked the palace's population to grow in the 16th century. Although we do not know what the kitchens' original architectural plan would have been like, we do know that one would have entered the kitchen courtyard through a cellar door; the kitchen and confectionery doors were located in the porticoes on the right side of the second courtyard. Along these doorways, there are a confectionery dorm, a bath, a place presumed to be a tin house, cooks' dorms and cellars. On the other side, there are oil, sugar and rice warehouses/pantries, a cooks' masjid next to it, cooking areas, a confectionery, and a confectionery masjid (Eldem & Akozan, 1982; Figure 2).

The increase in the palace population rendered the dorms and storage areas insufficient; thus, the kitchen sub-units overflowed from the second into the first courtyard. The first courtyard contains dorms (Kömürciyan, 1988), cellars, warehouses, a masjid (BOA, 1285) and a water wheel (Tezcan, 1984), or *dolap ocağı*, in Turkish (Figure 3).

Figure 3. Units of the kitchen complex in the first courtyard from an anonymous photo dated 1875 (Anonymous, 1875).

The kitchen's wooden dorms were repaired at different times during both the Ottoman and in the Republican (Modern Turkey) periods; however, they collapsed in the early 1900's due to a lack of budget (Eldem & Akozan, 1982). Today, only the kitchen's cooking unit, the confectionery, the cellar door, the kitchen door, the confectionery door, the water tank, the bath, and the pump room (where the water pump used to be) still stand. At different points in time, unrelated buildings were erected in place of destroyed ones; this makes it difficult to fully comprehend everything as a whole. Nevertheless, certain documents allow us to make inferences about the water supply lines, which is the main focus of this article.

THE WATER WHEEL

Supplying water to Topkapı Palace was difficult in the Ottoman period. Because it was built on a steep slope, and hence rainwater flowed away before it could be collected. So, water was supplied from the Halkalı-based Beylik and Kırkçeşme water supply lines. Beylik water was closer to the surface and was sent to the upper levels by water towers. Conversely, the Kırkçeşme water supply line was connected to the lower levels of the palace and sent through the wells (Özkan Aygün, 2014; Özkan Aygün, 2015). Document TSMA D. 10137 found by Necipoğlu shows the past repairs made in the palace's water supply lines. She predicts the document's date as just after the earthquake in 1509 (Çelebi, 2003) which caused heavy damage to the whole system. She illustrates the connections between water towers, partial fountains, shadirvans, and cisterns; hence, we can infer that the source of the water ought to be the Halkalı water supply line, indicating that "the existing system could be used". This suggests that the water towers were not new. Neither of the two towers nearby the Bâbüsselâm fed the kitchen (1/2 *lüle*) and the confectionary fountains (1/2 *lüle*); exist today (Figure 4). Necipoğlu claims that the place of this water tower should be the water tank (Figure 5) – which is next

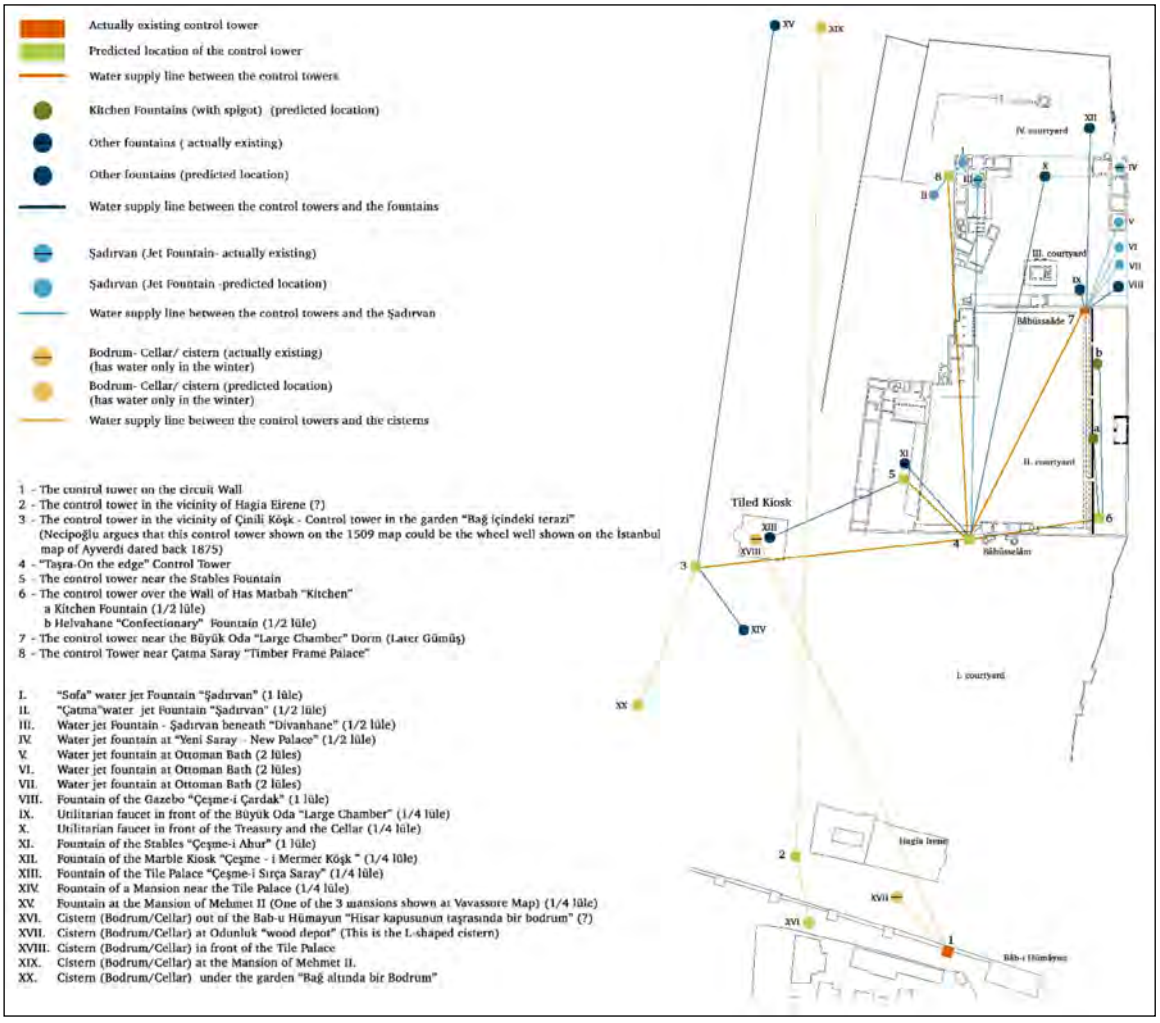

Figure 4. A schema demonstrating the repair of the water supply of Topkapı Palace after the 1509 earthquake. Designed by Ece Uysal Engüdar on the basis of Necipoğlu's article (Necipoğlu, 2013). Special thanks to Çiğdem Özkan Aygün (İTÜ) for advice.

Figure 5. The water tank in kitchen complex, next to the main wall of portico (Uysal Engüdar, 2021).

to the provisions gate today (Necipoğlu, 2013). Next to that gate are the wells that date back Byzantine era; they were discovered and repaired by Sinan the Architect during the *Kanûnî* period (1520–1566) to provide water for the palace (Tezcan, 1989).

In 1574, a fire destroyed the cellar and confectionery. Sinan repaired and rebuilt them adding two and a half *ziras*[3] of the area from the second courtyard for the new kitchen units (Selânikî, 1999). Given that the wells were already in use, Sinan most likely had cancelled the water tower during the expansion and then built a water tank instead. A document from 1886 claims that, presumably after the expansion, four *lüles* of water had been sent from the wells to the kitchens (BOA, 1303), as the standard one *lüle* of water was deemed insufficient. Hereby, the water for the kitchens began to be supplied from the Kırkçeşme water supply line.

There are three maps dated 1584 (Bilge, 1969), 1607 and 1748 indicating the Beylik water supply line. The part of the 1584 map (about Topkapı Palace) is ripped. The map of 1607 shows that the water arrived at the Bab-ı Hümâyun, palace hospital, and water tower next to Bab-ı Hümâyun (all in the first courtyard) as well as to Bâbüsselâm, the palace barn, the dorms of baltadjis, and the water tank in the second courtyard. The 1748 map is more or less the same as the 1607 map (Çeçen & Kolay, 1997). All three maps, however, do not comprise any of the wells where Beylik water arrives at the upper level (Aygün & Kaçan, 2014; Özkan Aygün & Eğilmez, 2015). There is no mention about kitchens, which implies that between 1584 and 1748, they used water supplied by water wheels. A report from 1886 addressed to the ministry (BOA, 1303) states that the kitchen is having problems preparing meals because the water pump is supplying one *lüle* of Kırkçeşme water supply line rather than four *lüles*.[4] Before that, the water from the wells would have been retrieved by horse-drawn water wheels. For instance, a document from 1907 (BOA, 1325) indicates what the horses need: panniers, shovels, shackles, halters, saddles, rope, horseshoes, barley, sackcloth, and straw. Later on, the palace was supplied with electricity and coal gas, the water wheel respectfully was converted into a water pump. One source from 1925 (BOA, 1344) consists of documents written on different dates (listed below in chronological order; some abbreviated) about various repair made in the palace's water supply lines:

- July 4, 1905: From Hagia Sophia distribution line to Dolap Ocağı at Topkapı Palace 597 m tile pipe lines are not repaired, so more than half of the flowing water perished. To prevent that, a sack of stones is in poured every day, the stones remain in the pipes; however, the water has become muddy over time, spoiled its taste, and rendered it unhealthy.
- May 26, 1906: The water flowing into the palace has been completely cut off for a while – even the wells are empty; the kitchens in particular are having major difficulties. The water supply line between the Hagia Sophia distribution line and the *Dolap Ocağı* has perished completely; only one-fifth of the water still flows. Despite the Sultan's orders, the water supply line has yet to be repaired.
- July 16, 1910: Ten thousand kuruş has been spent from the treasury for the repair of the water pump and pumps.
- March 26, 1913: The tank of the water pump had suffered burns, thus becoming unable to keep the water. Excessive coal gas is fed into the pump to compensate for the damage. The water tank needs to be repaired.
- October 10, 1918: Some reports claim that there is no water left in any of the water supply lines flowing to Topkapı Palace. Guests and Enderûn officials reside in the palace. As such, there is a great need for water. Unfortunately, no urgent measures have been taken other than sending water from Terkos to the palace via nearby sources.
- November 12, 1918: Water is supplied to the palace by the Istanbul Water Company; the water pipes have been laid along the existing coal gas pipeline. The gas fumes from the pipes, mixes with the water, causing the water to stink. Moreover, the joints of the gas pipes cannot

[3] *Zira*, which is the Arabic word for Arşın is a unit of measurement that describes the length from the fingertip to the shoulder by marking the finger sections on materials such as wood, steel and iron. In this unit of measure, which has different types, the architect's *zira (zirâ-î mimârî)* corresponds to 75.8 cm (Sönmez, 1997). Thus, 2.5 ziras is equivalent to 189.5 cm.

[4] As proof of that, the kitchens were expanded, ½ *lüles* of water had been being transmitted to the kitchen and confectionary fountain (Necipoğlu, 2013). According to a document from 1886, the amount of the water had been increased to four *lüles* (BOA, 1303).

withstand the pressure of the water and burst. Two hundred and fifty meters of new pipes are required (but cannot be found); however, water cannot be supplied from them because the main pipe drips. As such, water from the Terkos water supply line has been pumped into to abandoned Halkalı water supply line, which used to flow to the palace and but is now interrupted. That said, until now, there has been no need to lay an iron pipe from the tap in Çemberlitaş to the palace. Given that it is possible to pump water to these pipes from the main pipe, we request to authorise the Istanbul Water Company to lay iron pipes laid from Çemberlitaş and pump water from Terkos through them.

- August 21, 1922: The accumulator in the electricity storage in Dolap Ocağı is transferred to Yıldız Palace.
- November 12, 1925: The General Directorate of Antiquities and Museums in Istanbul reported to the mayor that the Kırkçeşme water supply line (that normally flows to the Topkapı Palace Museum) has been cut-off a week due to the bad roads. In it, he also stated that there is a great need for water, at least for 4–5 hours a day.

In Istanbul, the first urban lighting with electricity happened in 1888 with the electricity produced at Golden Horn shipyards (Engin & Gülsoy, 2016). The earliest document relating to electricity that we can find in the Ottoman Archives regarding Topkapı Palace is dated 1899, and show us how much electricians were paid on a daily basis (BOA, 1316). There is also a document from 1918 regarding the electrical operation of the water pump (BOA, 1336). Even though we know that electricity was supplied to the palace at the end of the 19th century, we cannot determine when exactly the water wheel was converted into an electric water pump. The Istanbul Water Company had been pumping water to the city from Lake Terkos since 1873. It was expropriated and transferred over to the Istanbul Water Administration in 1933 in favour of the concessions given by the Ottoman Empire (Yurdakul, 2010).

Coal gas, on the other hand, was obtained by distilling coal from gasworks. This method led to coal gas being supplied in Istanbul at the end of the 19th century, and coal gas was used for heating and illumination (Mazak & Kon, 1999). A document from 1894 demonstrates that coal gas came to Topkapı Palace at the end of the 19th century (BOA, 1312). According to a document from 1925 (BOA, 1344) water used to be extracted by horse-drawn water wheels from wells repaired by Sinan[5] before it was converted into a water pump at the end of the 19th century, upon the supply of electricity and coal gas. Since horses were no longer needed, the stables where the water horses were fed and allowed to rest were torn down. Even though there were officials still working in the palace and given that the water supply lines were not repaired, the amount of water pumped in was not sufficient for the kitchens' needs. Many considered Terkos water to be an alternative; as such, water pipes were laid down along the existing coal gas line by the Istanbul Water Company in 1918. The document mentions that the water pump was temporarily taken out of use and that during that time, the Terkos water supply line worked in place of the Kırkçeşme only (BOA, 1344). According to Tahsin Öz, Topkapı Palace Museum's former director (1928–1952), Kırkçeşme water was pumped from the wells using a motor. Later on, both Kırkçeşme and Terkos water supply lines would be used together for the museum's fire extinguishing system (Öz, 1991). The *Dolap Ocağı* – where wells and water wheels were present – remained intact until 1979 (Tezcan, 1989).

FOUNTAINS

Today, there is one fountain inscription and three fountains (still) in Topkapı's kitchen. That inscription (dated 1603) belongs to the Mısırlı Osman Ağa Fountain which is not extant today and is located on the kitchen's walls (Tanışık, 1943). The first fountain is referred to as the hot water fountain and connects to the water tank where the cauldron of the cooks' bath is located. One can make out an inscription of the hot water fountain in a photograph dated between 1940 and 1943 from the Archive of the Institute of Ekrem Hakkı Ayverdi alas, it no longer exists today. The second one is the cooks' bath and has a marble basin. The fountains and baths were built in 1722 by Nevşehirli Damat İbrahim Pasha during the reign of Sultan Ahmet III (Sakaoğlu, 2002). Considering the architecture of a bath, having more than one fountain is necessary. The water from the wells should first reach the water tank; next, the heated water in the furnace should then be transmitted to the fountains of the bath. The third fountain (dated 1767) is located at the entrance of the Confectionery on the right side. The flower motifs in the vase at its basin reflect the traces of Westernisation; neither of these motifs do not exist (Figure 6). This fountain would have been added to the confectionery after the 1766 earthquake (Genç & Mazak, 2000). One more fountain is located in a dorm restroom, next to the cooks' bath, and was set for the museum exhibition only.

However, there were more than four fountains in the kitchen complex. Some were fed by the water towers and are included in a document dated 1509 according to Necipoğlu (Necipoğlu, 2013). Another document from 1825 shows how the kitchen fountains are arranged; the floor in front of the fountain was dilapidated, and later paved (BOA, 1240). Yet

[5] The water extracted from the wells was distributed without accumulating. However, the extracted water was gathered in a tank situated atop the Dolap Ocağı gate (according to a Topkapı Museum Guide dated 1933) (Topkapı Sarayı Müzesi Rehberi, 1933). As there is no entrance to the tank, it is impossible to research it further.

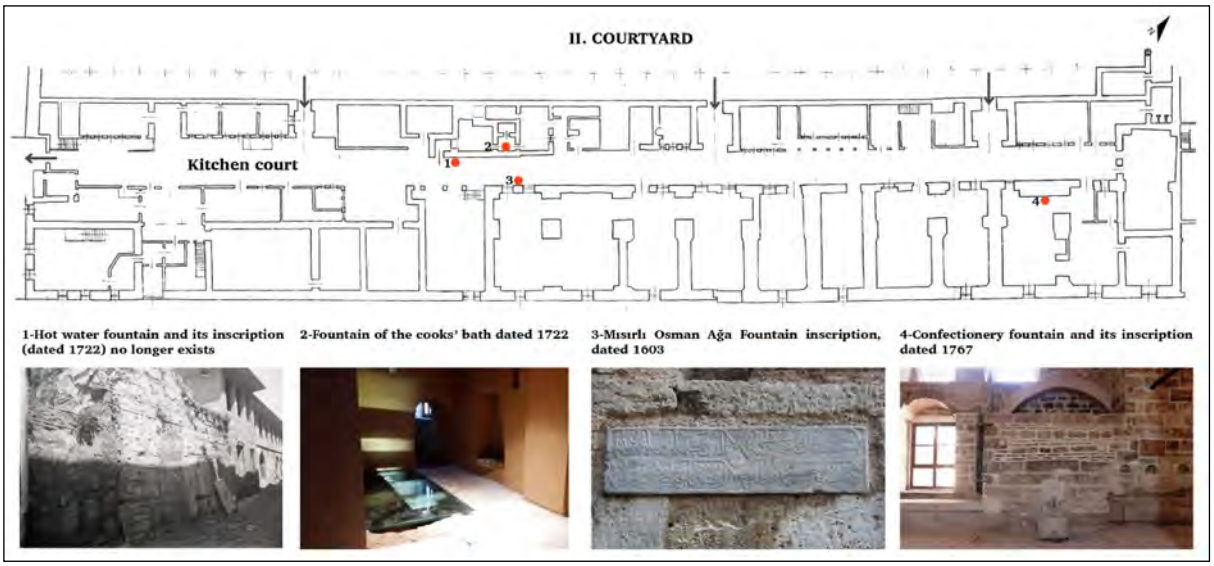

Figure 6. Complete fountains of the kitchen complex on an anonymous plan (Anonymous, 1894-1912) shown by Ece Uysal Engüdar. No 1: hot water fountain and its inscription (dated 1722); it no longer exists (EHAEA, 1940-1944). No 2: the fountain of the cooks' bath dated 1722 (Uysal Engüdar, 2017). No 3: Mısırlı Osman Ağa Fountain inscription, dated 1603 (Uysal Engüdar, 2021). No 4: confectionery fountain and its inscription, dated 1767 (Altınbıçak, 2012).

another document, this time from 1868, shows that the wall side of the kitchen's vegetable pantry was removed. Water was carried by placing walls, using existing fountain faces and faucets on the land-side, and laying lead pipes from the old location of the fountains to the newly built area. On the other side sits a covered sewer with walls on both sides, for dirty dishwater to flow into. In that same document, the wall side may, in fact, refer to the intermediate wall separating the kitchen units, while the land side may refer to the courtyard side (BOA, 1285). Likewise, another document refers to the seaside walls of the kitchens facing the Marmara Sea (BOA, 1323). It is not clear which unit in the kitchen served as the vegetable pantry at that time. That noted, the only part that fits the description in a contemporary context seems to be the fountain along the courtyard side, located next to the Confectionery; of that, only the marble fountain face remains (Figure 7). Three things show us that the number of fountains had increased: (1) removing the old fountains from their places in 1825, (2) transferring the water to a new place, and (3) adding a fountain in 1868. The location of the sewer cover on the other side cannot be determined because there is no clear description; however, it must be connected to the canal passing through the kitchen court (Figure 8).

Another fountain on the kitchen facade would have been used for ablution. Since there is no shadirvan in the kitchen complex, the kitchen staff would have performed their ablution using the fountains scattered throughout the courtyard. According to a document from 1874, a lead-covered new porch eave was built with the wooden painted ceiling above the ablution fountains of the confectionery (BOA, 1291). During restoration work in the 1940s, there was (still) a fountain on the court side of the confectionery – just as the 1874 document mentions (Figure 9). The

Figure 7. Fountain face located at the kitchen unit, next to the confectionary (Altınbıçak, 2012).

Figure 8. Vaulted drainage underground channel at the kitchen court (Özbersan İnşaat ve Ticaret Ltd. Şti., 2013).

Figure 9. The fountain assumed to be used for ablution on the kitchen main wall (TSMA, 1940). Traces of the porch are obvious.

Mısırlı Osman Ağa Fountain (dated 1603) might have been used for the same purpose, due to its location as well. Furthermore, Penzer also describes (1939) the presence of ablution fountains (Penzer, 1967). Traces of the porch are still visible today (Figure 10). The other probable fountains must have existed in the restrooms of the dorms, which one can detect from their plan that they date to the beginning of the 20th century (Figure 12).

RESTROOMS

There are two restrooms in the palace kitchens that can still be identified today. The first one is located in the bath; the wastewater from it would have been disposed of via a tile drain to a vaulted underground channel beneath the kitchen courtyard.[6] The second one facing the qibla[7] is located at the dorm next to the bath and would have been built for decoration during 1940's restorations (Figure 11 – Restroom 2). On the other hand, the other restrooms were located in the dorms where kitchen servants lived – at least, according to the design. The space referred to as the control

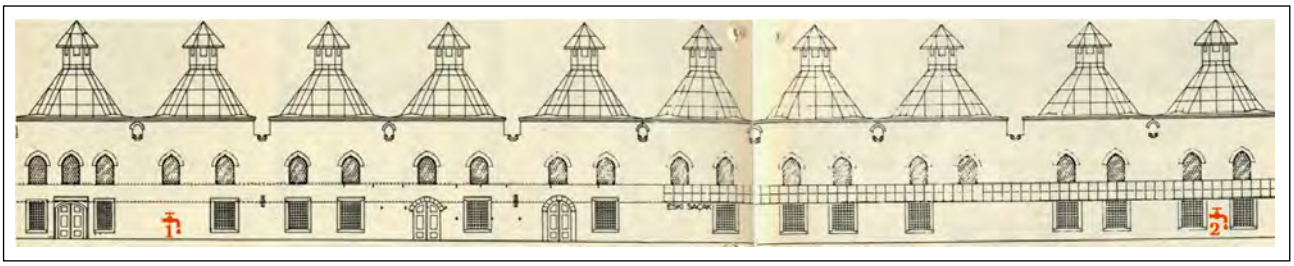

Figure 10. Demonstration of the fountains on the kitchen main wall assumed to be used for ablution on the elevation of Eldem's restitution (Eldem & Akozan, 1982); 1 for the fountain which is currently not existing, 2 for the Mısırlı Osman Ağa fountain dated 1603 revised and edited by Ece Uysal Engüdar.

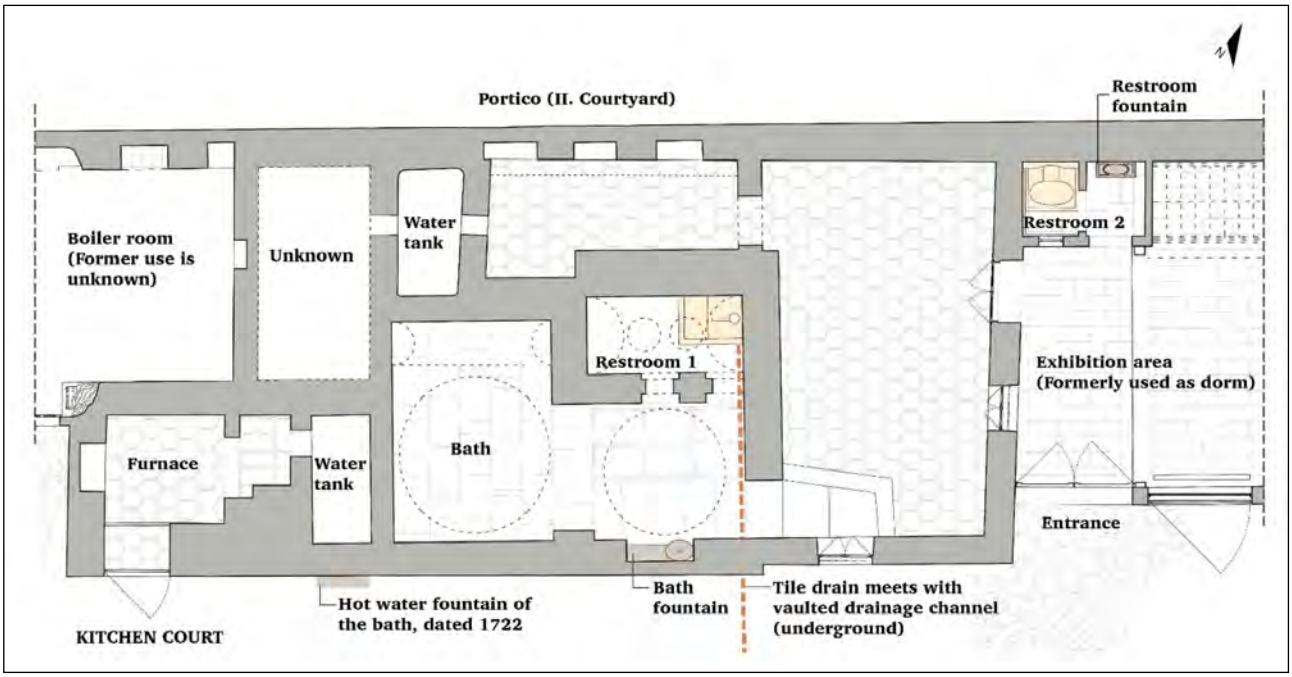

Figure 11. The cooks' bath on the partial plan of TURES Turizm Planlama ve Restorasyon San. ve Tic. Ltd. Şti. revised and edited by Ece Uysal Engüdar.

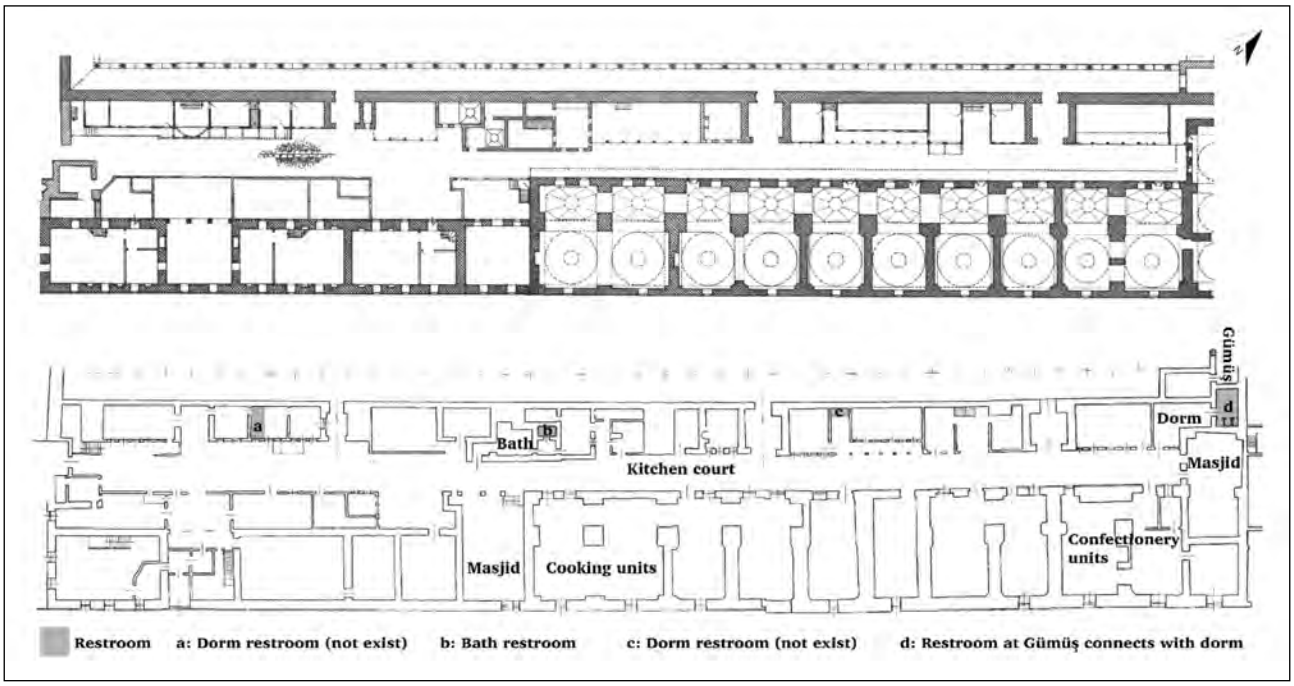

Figure 12. The restrooms of the kitchen complex are demonstrated both on the elevation of Eldem's restitution above (Eldem & Akozan, 1982) and an anonymous design below (Anonymous, 1894-1912) revised and edited by Ece Uysal Engüdar.

tower – in a document from 1509 (Necipoğlu, 2013) – was converted into a water distribution centre. Half of it was used as storage, while the other half was used as a restroom for visitors at an unknown date. Referred to as Gümüş (Çeçen & Kolay, 1997), the second half was connected to the dorm. This restroom sits next to the Confectionery Masjid, and would also have been used for ablution purposes. Beyond that, such a dual cellar-restroom feature placed next to the Cooks' Masjid is very unique – given that there were also restrooms for each ward unit (Figure 12).

A document of repair costs from 1840 mentions the repairs of the restrooms (BOA, 1255). Another document from 1868 highlights repair work done on the roof of the restrooms around the cooks' dorms; it involved removing old tiles and panels, renewing the rafters and panels, and replacing the old tiles with new ones (BOA, 1285). According to a document from 1884, the rotten roof of the confectionary dorm restrooms had collapsed. It was rebuilt out of its own debris; repairs were also made inside using plaster and white wash, marble paving stones were also laid down, and the old door was refurbished (BOA, 1291). The roof of the restrooms under the kitchen was also repaired with French bricks; however, the kitchens lack a lower floor. The stone pavement of the restrooms in the Kilerli Masjid (in the first courtyard) no longer exists, as it was eventually changed later on. Another document from 1884 (BOA, 1302) indicates that panels beneath the lead of the restrooms of the Confectionery dorms were removed and replaced as well.

DISPOSING WASTEWATER

Various sources tell us that the wastewater from the kitchen and the palace would have been pumped under the sea wall around the Sinan Pasha Kiosk.[8] A little further onwards, palace rubbish was thrown into the sea through a hole (Kömürciyan, 1988; İnciciyan, 1956). In that case, the wastewater of the kitchen complex should have been collected in a single centre and disposed of to the sea via channels separate from the palace. Jean-Claude Flachat stated (around 1740–1755) that the drainage channels of the kitchen were easy to use and clean (Flachat, 1766). French diplomat Pouqueville, upon describing the palace's gardens (1798–1800), wrote that the wastewater from the palace kitchens accumulated in a sewer to be thrown into the sea. He noted that the sewer started at the bottom of a road connecting the hospital in the first courtyard with the fortification walls, and ended at the western wall (Pouqueville, 1805). The only available information we have about the wastewater path from the kitchens is the

[6] Detected on-site during the restorations in 2017.

[7] In Ottoman architecture, restrooms do not face the qibla direction due to the requirements of Islam.

[8] People used to parse the waste in the hope of finding gold, silver, precious stones, rings and earrings from the seaside; some even sold what they found. The parsed waste would have been transported on midden boats to an offshore dump (Pul, 2008).

vaulted channel in the kitchen courtyard. Yet, where the channel connected and continued to before it ended up at the Marmara Sea still remains unknown; surveys and excavations are needed to clarify this. Moreover, another point to consider is the addition of Kennedy Street outside the sea walls which complicates the research.

UNKNOWN ARCHITECTURAL ELEMENTS

All of the kitchen units are supported by a retaining wall featuring buttresses, as there is an elevation difference between the upper courtyard and the lower seaside gardens where they are located. Similarly, there also are still traces of barbicans that would have prevented the retaining wall from taking on an additional load of rain water that may accumulate, and that would have helped filter the water from the soil, without being collected under the kitchen (Figure 13).

There is a photograph from the Archive of the Institute of Ekrem Hakkı Ayverdi, which houses the personal works of Ayverdi, the person in charge of the restorations of the palace kitchens in the 1940's. In the photograph, we can see an architectural element of which only the top part is visible. It could possibly be vaulted adjacent to the retaining wall, and it extends towards the Cooks Masjid. Alternatively, it might be a water tank or used as a warehouse due to its proximity to the cellar. Whether it belongs to the Ottoman or the Byzantine era is debatable, given that Topkapı was built over Byzantine structures (Figure 14).

Figure 13. Left: general view of the kitchen complex's retaining wall with buttresses facing the Marmara Sea. Right: a barbican located on the retaining wall (Uysal Engüdar, 2021).

Figure 14. Left: the kitchen complex's retaining wall facing the Marmara Sea where the unidentified vaulted element is located. Right: a close-up view unidentified vault element (EHAEA, 1940-1944).

In another photograph from the Archive of Ayverdi, we see a vault at the bottom of the retaining wall continuing towards the palace bath next to the kitchen might and this may have been used to dispose of wastewater from the palace bath.[9] Despite that, similar channels do not exist on the same level of the kitchen alignment (Figure 15). In that case, the wastewater of the kitchens should have been collected in a single channel extending towards the hospital, and then extending out towards the sea, as Pouqueville suggested (Pouqueville, 1805). As it stands, the slope direction of the vaulted channel at the kitchen courtyard already extends towards the palace hospital. The drainage channels of the kitchens and palace bath should have been separate, as Kömürciyan (Kömürciyan, 1988) and İnciciyan (İnciciyan, 1956) mentioned.

There is a masonry mass – presumably a water tank – in the palace garden between the retaining wall and the sea wall (Figure 16). However, it is overgrown with wild flora, and thus not suitable for architectural examination at the moment. The same point is also demonstrated in Rocque's map (dated 1752) (Figure 17); he, too, claimed that it is a water tank supplying water to the entire palace (Rocque, 1752). However, this mass is located at least 15 m below the kitchen's level. Pumping water from a lower-level water tank to upper-level buildings is not convenient; hence, this water tank – if it, indeed, is one – may very well have been used for irrigation.

Another water tank that is difficult for us to analyse is located in the kitchen courtyard next to the main wall of the portico. As has been mentioned above, one of Beylik water supply line maps (1584) is ripped (Bilge, 1969) and there is no information about kitchen sections on the maps from 1607 or 1748 (Çeçen & Kolay, 1997). We can thus infer the water should have been supplied from the Kırkçeşme water supply lines via wells leading to the water tank. This water tank is located on the ground floor of the wooden dorms for kitchen staff (Eldem & Akozan, 1982) which no longer exists. All units of the palace had a function; therefore,

Figure 15. Left: A presumed vaulted drainage channel under the bath's retaining wall, facing the Marmara Sea, next to the kitchens. Right: a close-up view of the channel (EHAEA, 1940-1944).

Figure 16. The remain assumed as a water tank is located at the palace garden behind the kitchens. The photo on the left was taken by Ayverdi in 1940's (EHAEA, 1940-1944). The photo on the right shows its current condition (Uysal Engüdar, 2021).

[9] Topkapi Palace was built on Byzantine structures (Müller-Wiener, 2001), hence, these canals could also be the continuation of another structure.

Figure 17. Rocque, the Seraglio & Gardens of the Grand Seignior, 1752 (Rocque, 1752). Number 10 is marked in red square.

Figure 18. The brick arch on the kitchen's wall during restoration between 1940 and 1944 (EHAEA, 1940-1944).

this one, too, should have been used until the palace was converted into a museum. Although there is no trace of an exit point for *lüles*, there are some small niches presumably for glasses (Figure 5). However, we have no information about this water tank in any studies.

Another photo from Ayverdi Institute depicts a brick arch located by the wall of the kitchen units that was partially buried in the ground under the ashlar – it hailed from the Mehmed II period (r.1451–1481) (Figure 18). This arch, too, might be related to the water supply line. The wastewater may have been disposed of from the arch to the vaulted drainage channel in the kitchen courtyard.

CONCLUSIONS

The Topkapı Palace kitchens were located in the palace's second courtyard; but, their annexes overflow into the first courtyard (Eldem & Akozan, 1982). In sum, the water was used for drinking, cooking, and cleaning purposes.

The water had been pumped into kitchens from the Beylik water supply line by a water tower (one *lüle*) until the fire of 1574 (Necipoğlu, 2013). Sinan the Architect added two and a half *ziras* from the second courtyard into kitchens; at that point, the water tower may have been removed, leaving the water to come from wells instead – also repaired by Sinan during the *Kanûnî* period (Tezcan, 1989) – fed from the Kırkçeşme water supply line (Çeçen & Kolay, 1997). The water tower might have been replaced with a possible water tank located on the ground floor of the wooden dorms; it too, no longer exists (Necipoğlu, 2013). According to a document from 1886, four *lüles* worth of water was supplied from wells to the kitchen (BOA, 1303). The Dolap Ocağı used to have a horse-drawn water wheel until the 1800's; it was converted into a water pump after the palace was hooked up to electricity (BOA, 1336). Coal gas was partially used to pull up the water from wells given that the perished Kırkçeşme water supply line between Hagia Sophia and the

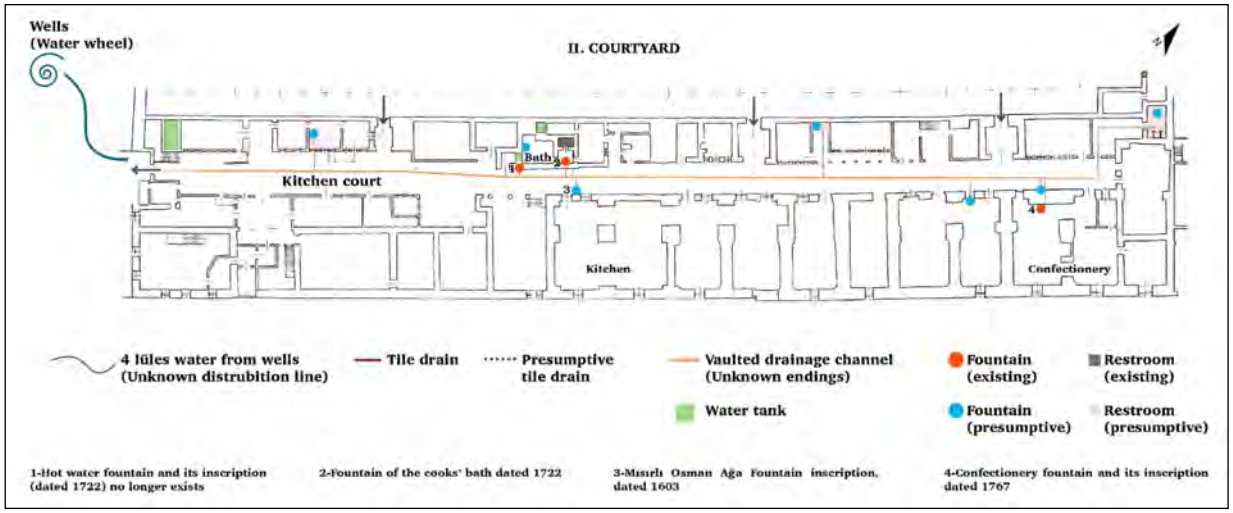

Figure 19. Complete water way elements of the kitchen complex on an anonymous plan (Anonymous, 1894-1912) shown by Ece Uysal Engüdar.

Dolap Ocağı was left in disrepair around the beginning of the 20th century. The *ocak* was taken out of order between 1918 and 1925 (Öz, 1991); during that time, Istanbul Water Company pumped water to the palace from the city of Terkos. After the water supply lines were eventually repaired, the water pump was used again, feeding directly from the Kırkçeşme water supply line (BOA, 1344). Back when Tahsin Öz ran the museum, the system was reused to extinguish fires and dually drew from the Terkos water supply line as well via a pump (Öz, 1991).

The water supplied from wells was transferred to the cooks' bath (on-site), alongside a hot water fountain, the inner fountain, a water tank of the bath, and the inner fountain of the kitchen. It also was pumped into the ablution fountains outside the kitchen (BOA, 1291) and the inner fountains of the kitchen dorms (Eldem & Akozan, 1982).

Wastewater from the kitchen units was disposed of via a vaulted underground channel beneath the kitchen court (Figure 19). It may have poured out into the sea from a different channel via the palace hospital. The varied channel ways are mentioned in multiple sources (Pouqueville, 1805).

The photos from the archives demonstrate that the channels beneath the bath (adjacent to the kitchen sections) do not continue under them. Additionally, we have also identified an architectural element whose top is visible only next to the retaining wall, a masonry mass in the garden and a brick arch (EHAEA, 1940-1944). The function of the architectural element is unknown but may be a vault. The masonry mass is most likely a water tank that might have been used for irrigation, instead of supplying the water to the whole palace (Rocque, 1752). It seems impossible to allocate the water towards up. As we have mentioned already, it is unclear whether the mass belongs to the Byzantine or Ottoman eras. Lastly, the brick arch might have been built as a discharging arch to carry a wall load, with a bare chance, or as an exit point for one of the channels to dispose of wastewater.

Before arriving at any conclusion in the evaluation, one should keep in mind that Topkapı Palace was founded in a Byzantine region (Müller-Wiener, 2001); moreover, the palace has been repaired multiple times throughout its life (Eldem & Akozan, 1982), and restoration work still continues to this very day. This study can only offer inferences upon compiling the findings. Excavations and surface surveys still need to be carried out in the working area. Likewise, more research needs to be done to study how each of the underground spaces were related to another, as well as to analyse when they would have been built, in order to offer any straightforward conclusion. The palace has undergone multiple changes. As such, even if we do not expect to arrive at a clear result, future fieldwork will help us confirm our data/findings, or even propose a different – possibly contrary – hypothesis altogether.

ETHICS: There are no ethical issues with the publication of this manuscript.

PEER-REVIEW: Externally peer-reviewed.

CONFLICT OF INTEREST: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

FINANCIAL DISCLOSURE: This journal article was derived from PhD thesis and funded by Yıldız Technical University's Scientific Research Projects Coordination (General Research Project coded FBA-2021-4083).

REFERENCES

Âlî, G. M. (1997). Kayseri Raşid Efendi Kütüphanesi'ndeki 901 ve 920 No.'lu nüshalara göre Kitâbü't -Târîh-i Künhü'l-Ahbâr. (A. Uğur, Ed.) Kayseri: Erciyes University.

Altınbıçak, Y. (2012). Topkapı Sarayı mutfaklarının koruma projesi (Master's thesis). Graduate School of Sciences and Engineering. İstanbul: Yıldız Technical University.

Anonymous. (1875). Constantinople: vue du Bosphore et de Scutari. Accessed September 11, 2020, from Online Archive of California: https://oac.cdlib.org/findaid/ark:/13030/kt038nd8h9/dsc/?query=et%20de%20scutari;dsc.position=1#hitNum1.

Anonymous. (1894–1912). TASUDOC1048, Plan of Topkapı Palace. Accessed December 27, 2020, from SALT Research: https://archives.saltresearch.org/handle/123456789/81932.

Ayverdi, E. H. (1953). Fâtih Devri mimarisi. İstanbul: İstanbul Fethi Derneği.

Bayrak, M. (1996). Topkapı Sarayı. İstanbul: Sümer Kitabevi.

Bilge, A. (1969). Fatih zamanında Topkapı Sarayı suyu. Türk Sanatı Araştırma ve İncelemeleri. 216–222.

BOA. (1240, Zilhicce 29). HH.d 15511. İstanbul: Turkish Republic Presidency State Archives, Ottoman Archives.

BOA. (1255, Zilhicce 29). TS.MA.d 9917/34. İstanbul: Turkish Republic Presidency State Archives, Ottoman Archives.

BOA. (1285, Cemâziyelâhir 20). HH.d 21450. İstanbul: Turkish Republic Presidency State Archives, Ottoman Archives.

BOA. (1291, Cemâziyelevvel 20). TS.MA.d 449. İstanbul: Turkish Republic Presidency State Archives, Ottoman Archives.

BOA. (1302, Safer 29). HH.d 19202. İstanbul: Turkish Republic Presidency State Archives, Ottoman Archives.

BOA. (1303, Zilhicce 28). TS.MA.e 629/78. İstanbul: Turkish Republic Presidency State Archives, Ottoman Archives.

BOA. (1312, Cemâziyelevvel 30). HH.İ 95/67. İstanbul: Turkish Republic Presidency State Archives, Ottoman Archives.
BOA. (1316, Şaban 24). İ.PT 9/51. İstanbul: Turkish Republic Presidency State Archives, Ottoman Archives.
BOA. (1323, Teşrinievvel 01). ML.EEM 625/11. İstanbul: Turkish Republic Presidency State Archives, Ottoman Archives.
BOA. (1325, cemâziyelâhir 19). TS.MA.e 1179/4. İstanbul: Turkish Republic Presidency State Archives, Ottoman Archives.
BOA. (1336, Ramazan 07). TS.MA.e 1299/97. İstanbul: Turkish Republic Presidency State Archives, Ottoman Archives.
BOA. (1344, Cemâziyelevvel 24). TS.MA.e 1108/1. İstanbul: Turkish Republic Presidency State Archives, Ottoman Archives.
Bozkurt, F. (2016). III. Mustafa dönemine ait bir kadınefendinin masraf defteri. İstanbul: Okur Kitaplığı.
Çeçen, K. and Kolay, C. (1997). Topkapı Sarayı'na su sağlayan isale hatları. İstanbul: İSKİ.
Çelebi, E. (2003). Günümüz Türkçesiyle Evliyâ Çelebi Seyahatnâmesi. (S. Koz, Ed., S. A. Kahraman, and Y. Dağlı, Trans). İstanbul: Yapı Kredi Yayınları.
EHAEA. (1940–1944). [Unclassified photo album]. Archive of the Institute of Ekrem Hakkı Ayverdi.
Eldem, S. H. and Akozan, F. (1982). Topkapı Sarayı bir mimari araştırma. İstanbul: Kültür ve Turizm Bakanlığı.
Engin, V. and Gülsoy, U. (2016). Osmanlı'dan Cumhuriyet'e İstanbul'da elektrik. İstanbul: İETT Yayınları.
Flachat, J. C. (1766). Observations sur le commerce et sur les arts d'une partie de l'Europe, de l'Asie, de l'Afrique, et Même des Indes Orientales. Lyon: Jacquenod Père & Rusand.
Genç, M. and Mazak, M. (2000). İstanbul depremleri fotoğraf ve belgelerde 1894 depremi. İstanbul: İGDAŞ Kültürel Yayınları.
Hezârfen, H. E. (1998). Telhîsü'l-Beyân Fî Kavânîn-i Âl-i Osmân. (S. İlgürel, Ed.) Ankara: Türk Tarih Kurumu.
İnciciyan, P. Ğ. (1956). XVIII. asırda İstanbul. İstanbul: İnstanbul Fethi Derneği İnstanbul Enstitüsü Yayınları.
Kömürciyan, E. Ç. (1988). İstanbul tarihi XVII. asırda İstanbul. İstanbul: Eren Yayıncılık.
Kritovoulos and Riggs, C. T. (1954). History of Mehmed the Conqueror. New Jersey: Princton University Press.
Kuban, D. (1996). İstanbul bir kent tarihi Bizantion, Konstantinopolis, İstanbul. İstanbul: Türkiye Ekonomik ve Toplumsal Tarih Vakfı.
Mazak, M. and Kon, K. (1999). Osmanlı'dan günümüze havagazının tarihçesi. İstanbul: İGDAŞ Genel Müdürlüğü.
Müller-Wiener, W. (2001). İstanbul'un tarihsel topografyası. İstanbul: Yapı Kredi Yayınları.
Necipoğlu, G. (2007). 15. ve 16. yüzyıllarda Topkapı Sarayı, mimarî, tören ve iktidar. İstanbul: YKY.
Necipoğlu, G. (2013). Virtual archaeology in light of a new document on the Topkapı Palace's waterworks and earliest buildings, circa 1509. Muqarnas (30):315–350.
Nişancı, M. P. (1983). Nişancı Mehmed Paşa tarihi ve Osmanlı tarihi zeyli hadisat. (E. Yaşarbaş, Trans.) İstanbul: Kamer Yayınları.
Özbersan İnşaat ve Ticaret Ltd. Şti. (2013). Vaulted drainage underground channel at the kitchen court. Özbersan İnşaat ve Ticaret Ltd. Şti. Archive.
Öz, T. (1991). Hayatım. İstanbul: Topkapı Sarayı Müzesi.
Özkan Aygün, Ç. and Kaçan, M. (2014). İstanbul'un birinci tepesindeki sarnıç, kuyu, galeriler ve su dağıtımına ilişkin yeni bulgular. İSTYAM International Istanbul Historical Peninsula Syposium 1–5 October 2013. 258–279.
Özkan Aygün, Ç. and Eğilmez, A. H. (2015). Lost Constantinople: subterranean water structures-application of speleology techniques in the archaeological research. HYPOGEA 2015: International Congress of Speleology in Artificial Cavities. Rome, pp. 1–17.
Penzer, N. M. (1967). Harem: an account of the institution as it existed in the Palace of the Turkish Sultans with a history of the Grand Seraglio from its foundation to the present time. London: Spring Books.
Pouqueville, F. (1805). Voyage en Morée, à Constantinople, en Albanie et dans Plusieurs Autres Parties de l'Empire Ottoman Pendant les Années 1798, 1799, 1800 et 1801. Paris: Chez Gabon e Comp, Libraires, Place de l'École de Médecine. Retrieved from Gallica Bnf.
Pul, A. (2008). Osmanlı sosyal hayatı figüranlarından arayıcı esnafı. Tarih İncelemeleri Dergisi 23:211–238.
Rocque, J. (1752). The Seraglio & Gardens of the Grand Seignior. Accessed December 24, 2021, from Harvard Map Collection: https://curiosity.lib.harvard.edu/scanned-maps/catalog/44-990107793030203941.
Sakaoğlu, N. (2002). Tarihi, mekanları, kitabeleri ve anıları ile Saray-ı Hümayun. Topkapı Sarayı. İstanbul: Denizbank.
Seçkin, N. (1990). Topkapı Sarayı'nın biçimlenmesine egemen olan tasarım gelenekleri üzerine bir araştırma (1453–1755) (Phd Thesis). Graduate School of Science And Engineering. İstanbul: İstanbul Technical University.
Selânikî. (1999). Tarih-i Selânikî. (M. İpşirli, Ed.) Ankara: Türk Tarih Kurumu Yayınları.
Sönmez. (1997). Osmanlı dönemi yapı ve malzeme terimleri sözlüğü. İstanbul: YEM Yayın.
Tanışık, İ. H. (1943). İstanbul çeşmeleri. İstanbul: T. C. Maarif Vekilliği Antikite ve Müzeler Müdürlüğü.
Tezcan, H. (1984). Topkapı Sarayı Müzesi kurşunluk hafri-

yatı. Kemal Çığ'a armağan 203–215.
Tezcan, H. (1989). Topkapı Sarayı ve Çevresinin Bizans Devri Arkeolojisi. İstanbul: Türkiye Turing ve Otomobil Kurumu.
Topal, M. (2001). Silâhdar Fındıklılı Mehmed Ağa, Nusretnâme, tahlil ve metin (1106-1133/1695-1721) (PhD thesis). Institute of Turkish Studies. İstanbul: Marmara University.
Topkapı Sarayı Müzesi Rehberi. (1933). Topkapı Sarayı Müzesi. İstanbul: İstanbul Asarıatika Müzeleri.
TSMA. (1940, May 13). 55/36. İstanbul: Topkapı Palace Museum Archive.
TURES Turizm Planlama ve Restorasyon San. ve Tic. Ltd. Şti. (2009), Topkapı Sarayı Avluları Çevre Düzenlemeleri-II. Avlu. TURES Turizm Planlama ve Restorasyon San. ve Tic. Ltd. Şti. Archive.
Ürekli, F. (1990). İstanbul'da 1894 depremi. İstanbul: İletişim Yayınları.
Yurdakul, İ. (2010). Aziz şehre leziz su Dersaadet (İstanbul) Su Şirketi 1873–1933. İstanbul: Kitabevi.

Megaron, Vol. 17, No. 4, pp. 617–628, December 2022

Megaron
https://megaron.yildiz.edu.tr - https://megaronjournal.com
DOI: https://doi.org/10.14744/MEGARON.2022.67625

Article

An important parameter in concert hall design: Determination of directivity for instruments

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ARTICLE INFO

Article history
Received: 08 November 2022
Revised: 19 December 2022
Accepted: 19 December 2022

Key words:
Architectural acoustics; instrument directivity; semi-anechoic chamber; sound physics; stage design

ABSTRACT

Instrument sound directivity is of great importance when defining the sound source for research in architectural acoustics. When it comes to the topic of instrument directivity, whereas there are various studies on Western music instruments, only a few studies could be found on the directivity information of Eastern music instruments. For this reason, during architectural acoustic design processes in concert halls, rehearsal rooms, music studios and other Turkish music performance areas, there may be insufficient approaches in terms of defining the sound source. Directivity measurements of the qanun, oud, tanbur and clarinet, which are important instruments of Turkish music, were carried out within the scope of the study. These measurements for all octave band regions were carried out by designing a measurement setup with 20 microphone measurement points in the hemispherical area created in the semi-anechoic room at TÜBİTAK UME. The effect of the tonal spread characteristics of the instruments on the directivity was taken into account and a total of 143 measurements were carried out for all the note regions in the octave ranges of the relevant instruments. The directivity differences among the instruments and the acoustic propagation characteristics of different octave bands for each instrument are interpreted at the end of the study. The obtained values and results will make an important contribution to source modelling in architectural acoustic simulations of concert halls and concert hall stages; and in relation to this, in musician stage arrangements and all the other musical acoustics research.

Cite this article as: Özgencil Y, Yüğrük Akdağ N. An important parameter in concert hall design: determination of directivity for instruments. Megaron 2022;17(4):617–628.

INTRODUCTION

The directivity of performers and musical instruments in music halls such as concert halls, operas, recording studios, etc. is an important topic that needs to be taken into consideration for both performers and listeners when designing such halls. In halls where the directivity of sound sources is not evaluated, there may be a much different acoustic setting than predicted. Therefore, it is necessary to define the directivity information of sound sources as data in the acoustic design of halls and in simulation programs created with the aim of obtaining much more accurate results. An acoustic approach that correctly establishes the relationship between the sound source, volume and receiver will make it easier for the architectural area to be designed to serve its purpose (Sabine, 1964; Benade, 1976).

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Therefore, the designs and approaches to be created in the field of musical architectural acoustics cannot be considered separately from instruments with musical sound sources.

There are many studies in the literature that musical instruments are reviewed from different perspectives. (Meyer, 1993; Causse, Derogis & Waresful, 1995; Fletcher & Rossing, 1997; Rossing, Moore & Wheeler, 2002). However, the research on instrument directivity is quite little. It is obvious that the directivity of the symphony orchestra has been taken into consideration in the studies dating back to the 1970s and performed by Meyer (1978). Although these studies provide insights about instrument directivity, they do not provide detailed information about the measurement methods. In the later years, it could be seen that Fletcher and Rossing (1997) conducted extensive research on the acoustics of musical instruments. However, these studies do not provide a detailed methodology and results about instrument directivity (Rossing, Moore & Wheeleri, 2002). Although sound propagation of musical instruments has received more attention recently, most of the published research has still concentrated on the physical properties of instruments, and instrument performances have been carried out with mechanical setups (Patynen & Lokki, 2010). Although this approach is correct, it ignores the human factor (Wang & Vigeant, 2004). Later on, research taking into account the musician factor started to be carried out, and instead of using a mechanical device, instruments have been performed by musicians. Studies of directivity measurements with the help of microphones positioned horizontally in the middle plane have contributed to the literature (Otondo & Rindel, 2004). Examples of vocal or wind orchestral instruments are seen in this two-dimensional approach, and these studies include a directivity research approach based on different tones. However, it is observed that most studies focus on average values during performances and fall short in focusing on relevant frequency regions that are important during performances (Causse, Derogis & Waresful, 1995). Although it can be observed that different frequency regions of instruments show different directivity patterns in these studies since measurements are performed only on a horizontal plane, the approaches within the scope of research may be insufficient (e.g., resource descriptions in concert hall simulations). In later research, different studies were conducted that evolved to three-dimensional measurements in the form of a sphere with increasing microphone numbers and placement points that varied between 22 and 64 (Patynen & Lokki, 2010). Cook and Truman (1998) used 12 microphones in an icosahedron experiment setup for the directional impulse response of string instruments. Conducting research on symphony orchestra instruments, Patynen (2010) designed a study in which he examined different octave bands by creating a spherical measuring instrument with 22 microphones. This study is an elaborate resource for understanding how directivity changes for different instruments and how the same instrument acts for different octave bands. The values obtained as a result of directivity research taking musician factors into consideration can be simulated within a concert hall or similar buildings. In research in this field, the variability of the directivity of instruments in room acoustic simulations and auditory simulations can significantly affect the "perceived sound" associated with the acoustic quality in the room (Dalenback, Kleiner & Svensson, 1993; Vigeant, Wang & Rindel, 2007). Studies have shown the effect of incorporating the directivity of the sound source into computer models both in terms of the objective values in the acoustic parameters and the subjective values of the auralizations (L. M. Wang, M. C. Vigeant). Musical instruments owe part of their acoustic characters to differences in tone varying in different directions. (Pollow, Behler & Masiero, 2009). This confirms the effect of source type and performance type on acoustics (Weinreich, 1997). In addition, recent studies have shown that the movements of the musicians during the performance affects the spread of the sound in the medium (Ackermann, Böhm, Brinkman & Weinzierl, 2018). Last research has also shown this allows computerised testing of the resource and space relationship at the design stage for purpose-oriented architectural structures. It is clear that these studies give more reliable results in sources defined by accurate instrument acoustic properties and directivity information. It is seen that the studies carried out in the literature so far have been mainly focused on Western music instruments (Martin, 1942; Berg & Stork, 2005). On the directivity of the instruments of Eastern music, there is no detailed study in which the musician factor is also taken into account. Studies in the literature mostly consist of mechanically designed measuring devices and investigate instrument vibration modes and propagation motion in the instrument body (Erkut, Tolonen, Karjalainen & Valimaki, 1999; Degirmenli, 2017).

This study aims to find out the directivity characteristics of qanun, oud, tanbur and clarinet which are Turkish music instruments with different characteristics. Measurements were performed in an accredited laboratory and results were evaluated in accordance with the relevant standard. First of all, a semi-anechoic chamber, microphones, calibration and methods related to measurements are designed. Within the scope of the study, directivity measurements were performed for Turkish music instruments of qanun, oud, tanbur and clarinet, and the results were evaluated. These measurements were made in the semi-anechoic chamber in line with the relevant measurement standard. The measuring device designed as a hemisphere has 20 measuring points consisting of the same types of microphones. Measurements for all instruments were carried out using the same microphones. The musicians who performed were professional.

METHODOLOGY

The steps listed below were followed in the study.

- Selection of Turkish music instruments whose directivity would be found out,
- Directivity measurements in an accredited laboratory environment,
- Demonstration of measurement results in tables and graphs,
- Comparative evaluation of the results.

Selection of Turkish Music Instruments

The differences between Turkish music and Western music are quite a few. Basically, both music styles have 8 notes. However; in Western music, these 8 notes are divided into 12 equal parts, while in Turkish music they are divided into 24 unequal parts. Whereas 1 note is divided into 2 equal parts in Western music, 1 whole note is divided into 9 separate parts called "comma" in Turkish music (Açın, 1998). The genres and modes of the two styles vary because of all these differences. For this reason, there are also differences in the instruments used to perform these music styles. Both music style approaches have their own instruments. Within the scope of the project, 4 different instruments were selected, which are respectively qanun, clarinet, tanbur and clarinet. To select these instruments, Turkish music performance examples were examined and experts with conservatory education on the subject were consulted. The acoustic characteristics and octave ranges of these four instruments are different from each other, and this difference provides diversity when comparing the sources (Figure 1).

Directivity Measures

The directionality measurements of musical instruments were carried out in a semi-anechoic room at TÜBİTAK UME (The Scientific and Technological Research Council of Turkey National Metrology Institute) in accordance with the relevant standard (ISO Standard 3745:2003, 2003). The semi-anechoic room is 7.6 m in length, 9.8 m in width and 10.3 m in height. For directivity measurements, a hemispherical area with a radius of 2.7 m was created, meeting the relevant standard. The person playing the musical instrument was placed in the center of the hemisphere with the instrument. Measurements were performed by placing microphones at 20 points on the hemispherical surface. Microphones were positioned at angles of 22.5 degrees, 45 degrees, 67.5 degrees and 90 degrees from the center in the vertical direction and 60 degrees from the center in the horizontal plane, respectively (Figure 2).

The G.R.A.S. 40AF type capacitive microphones and Brüel & Kjaer type 3560 D Pulse multichannel analyser system were used for directivity measurements. Sound pressure level measurements were carried out at 1/3 octave band centre frequencies in the frequency range of 31.5–16000 Hz. Carried out as 2 sets by using 20 microphones, the measurements were repeated twice. In sets of 10 microphones, measurements at each microphone position were made simultaneously. The measurement system was

Figure 1. Selected instruments (Oud, Tanbur, Clarinet, Qanun, respectively).

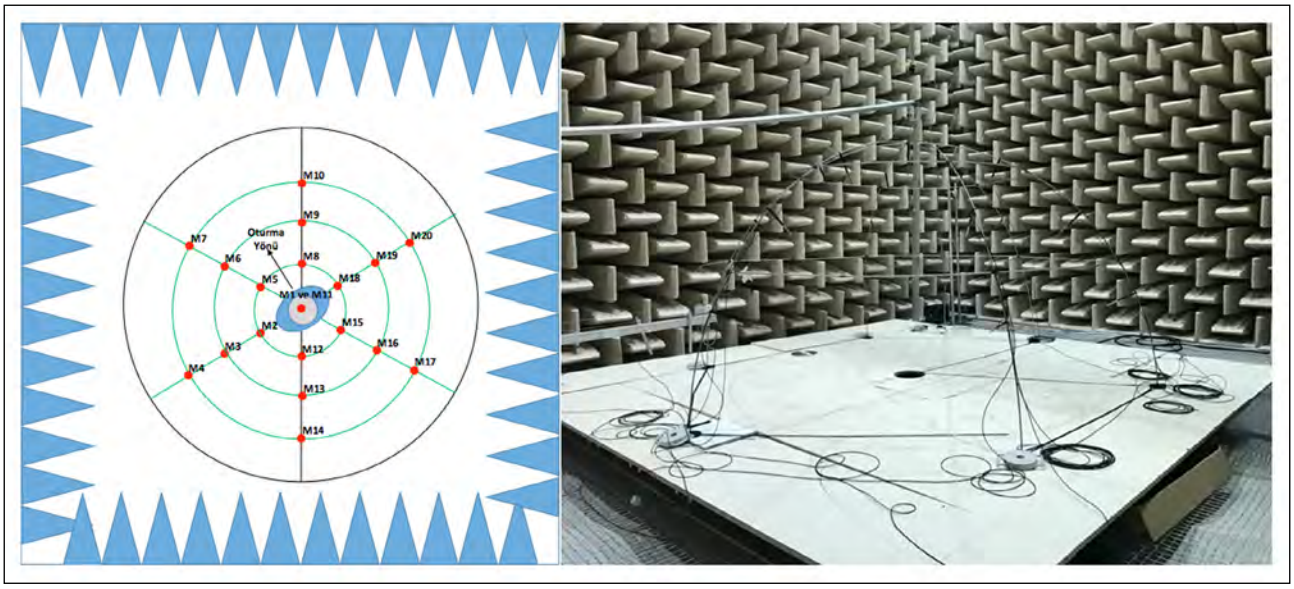

Figure 2. Microphone array of full non-anechoic room recordings.

checked with a Brüel & Kjaer type 4231 Acoustic Calibrator before and after the measurements. The system used in the measurements meets the requirements of the IEC 61672 standard, type 1 and the sound calibrator meets the requirements of the IEC 60942 standard, class 1. Figure 3 shows the equipment used in the measurements.

All musicians were positioned in the centre of the hemisphere and performed in the same position (Figure 4). At this stage, all note regions between the lowest sound and the highest sound according to the octave range of the instruments were analysed for tonal directivity. Thus, a detailed frequency analysis according to octave band ranges could be carried out. For example, for the clarinet instrument, the 3rd octave B note (246.94 Hz) was taken as the centre for the 250 Hz octave band region, but the tonal spreads of the 3rd octave B flat (233.08 Hz) and 4th octave C note (261.63 Hz) were also taken into consideration for the average values. Sample measurement value results are shown in Table 1. As in the example, results for all octave bands were obtained for all notes.

As seen in Table 1, when making a tonal measurement, the data for sound pressure levels in all octave bands were obtained and the propagation information within the hemisphere was obtained numerically. In order to focus on frequency regions tonally, according to the sample table, the 250 Hz region was taken into consideration to proceed. To reach the directivity distribution data of the 250 Hz region, one lower and one upper-frequency note was also taken into consideration and their data were analysed. Table 2 shows the data of 3 notes in the relevant frequency region tonally. This table was created by examining all octave band values for the related notes and taking 250 Hz values into account in the related note measurement.

Examining the Table, we can see the 3rd octave B flat (233.08 Hz), 3rd octave C note (246.94 Hz) and 4th octave C note (261.63 Hz) measurement data for the clarinet instrument for all microphone points. After this phase, the directivity data of the clarinet in the hemisphere in the 250 Hz region is obtained by averaging these values.

Within the scope of this study, these procedures were carried out for all instruments and octave bands. In brief, reduced values were created by taking the average of the tonal region measurements for the relevant octave bands into account. Aspiring to obtain the measurement results of all octave bands, the tables are averaged out according to the relevant frequency regions as in the example narrative. Table 3 shows the average measurement results for all octave bands of the clarinet.

Figure 3. TÜBİTAK's full non-anechoic room recording equipment.

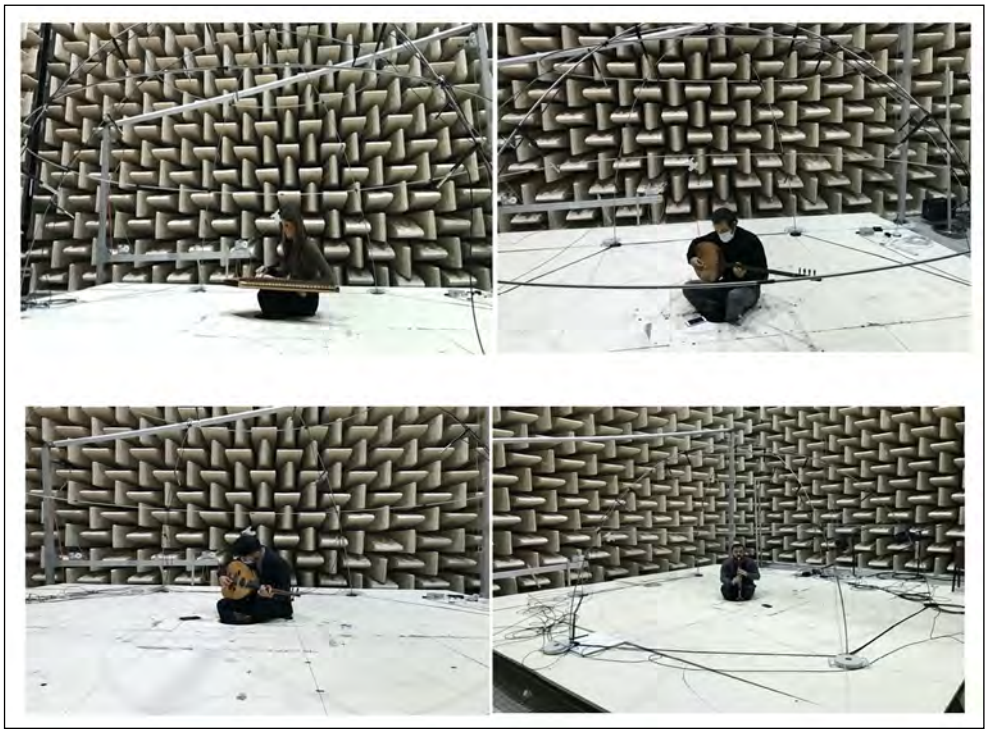

Figure 4. Directivity measurements of instruments.

Table 1. Effect of energy consumption on the LCC

Frequency (Hz)	Sound Pressure Level, dB Ref. 20 µPa									
Microphone Points	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**
31.5	18.9	20.7	21.8	22.8	20.8	21.0	21.5	24.1	25.6	15.5
63	14.0	15.6	15.1	14.7	14.5	15.4	16.1	22.4	23.7	15.1
125	11.6	13.4	13.3	13.2	12.0	12.3	10.9	19.9	20.4	10.6
250	71.8	69.6	71.3	75.7	68.0	71.4	76.3	69.7	68.3	75.5
500	50.1	49.1	42.5	39.9	42.4	52.1	41.6	49.7	46.1	38.6
1000	53.6	59.7	51.1	62.5	63.0	58.0	61.0	59.9	60.8	61.9
2000	61.0	59.2	56.2	54.9	60.0	55.6	54.4	57.5	60.7	59.3
4000	52.0	49.6	52.7	44.2	54.7	57.3	53.2	58.4	55.5	46.5
8000	30.3	30.8	30.3	34.5	34.1	37.4	35.6	35.1	32.4	35.0
16000	25.0	25.5	26.9	31.5	26.5	30.4	30.0	30.2	29.9	31.3
A	73.7	71.6	71.7	79.1	74.4	78.6	80.0	77.0	73.4	75.3
L	75.4	73.2	74.2	80.1	74.9	79.1	81.0	77.4	74.1	77.8
Frequency (Hz)	**Sound Pressure Level, dB Ref. 20 µPa**									
Microphone Points	**M11**	**M12**	**M13**	**M14**	**M15**	**M16**	**M17**	**M18**	**M19**	**M20**
31.5	17.1	18.8	19.0	19.4	19.8	20.0	21.6	32.4	43.2	15.4
63	18.1	19.2	19.9	20.3	18.4	18.2	18.8	30.1	37.9	15.8
125	12.4	13.7	12.2	14.9	13.3	11.4	12.7	26.6	36.2	13.3
250	73.1	71.3	67.7	70.7	69.7	65.8	72.0	70.2	68.2	74.7
500	51.9	52.1	50.4	42.2	51.3	49.2	38.7	51.1	52.3	43.5
1000	55.7	55.8	57.6	63.0	55.2	59.0	59.1	59.6	62.6	63.2
2000	60.2	53.9	53.6	55.5	52.7	48.1	50.1	55.1	57.7	57.8
4000	43.7	39.6	39.6	28.4	38.9	36.7	30.2	43.6	44.2	34.5
8000	25.9	24.9	20.3	14.0	24.6	17.7	8.9	21.3	22.8	21.9
16000	19.2	17.6	15.5	10.3	16.7	12.2	7.0	17.4	19.1	16.9
A	72.3	70.0	69.2	69.4	70.6	65.0	67.3	69.2	71.2	73.2
L	75.5	73.6	71.5	72.7	73.4	68.0	72.9	72.7	73.2	76.5

Table 2. Measurement results of the relevant tonal regions of the clarinet instrument

Frequency (Hz)	Sound Pressure Level, dB Ref. 20 µPa									
Microphone Points	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**
250	69.9	68.1	70.1	74.1	67.5	71.1	74.8	69.5	67.3	74.6
250	71.8	69.6	75.7	75.7	68.0	71.4	76.3	69.7	68.3	75.5
250	73.5	72.4	77.9	77.9	72.1	71.8	78.5	72.4	71.1	78.3
Frequency (Hz)	**Sound Pressure Level, dB Ref. 20 µPa**									
Microphone Points	**M11**	**M12**	**M13**	**M14**	**M15**	**M16**	**M17**	**M18**	**M19**	**M20**
250	72.2	68.8	68.2	71.3	68.8	67.6	73.1	71.4	68.4	74.0
250	73.1	71.3	67.7	70.7	69.7	65.8	72.0	70.2	68.2	75.7
250	71.3	70.4	67.5	72.1	71.3	71.3	72.1	69.0	70.3	74.4

Table 3. Average directivity sound pressure level measurement results for all octave bands of the clarinet instrument

Frequency (Hz)	Sound Pressure Level, dB Ref. 20 µPa									
Microphone Points	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**
125	72.1	72.4	72.1	71.6	73.4	73.6	73.5	73.6	73.1	73.3
250	71.4	69.6	71.3	75.7	68.0	71.4	76.3	69.7	68.3	75.5
500	79.0	75.5	63.6	74.5	75.6	78.5	80.4	77.8	76.6	78.0
1000	74.2	85.1	77.5	88.3	90.4	86.1	93.3	88.3	86.6	90.9
2000	85.4	83.6	82.5	78.9	82.4	82.8	77.6	82.7	85.7	85.7
4000	73.7	66.6	71.3	61.8	78.2	80.5	69.1	78.8	78.6	75.3
8000	60.5	56.4	55.6	58.9	62.3	61.2	59.5	61.5	56.9	60.4
Frequency (Hz)	**Sound Pressure Level, dB Ref. 20 µPa**									
Microphone Points	**M11**	**M12**	**M13**	**M14**	**M15**	**M16**	**M17**	**M18**	**M19**	**M20**
125	71.6	71.1	70.2	69.1	70.8	69.8	69.2	70.1	71.1	68.6
250	73.1	71.3	67.7	70.7	69.7	65.8	72.0	70.2	68.2	74.7
500	79.2	77.0	68.4	75.5	76.8	71.1	73.5	62.9	75.4	77.0
1000	61.5	77.7	83.7	88.5	73.1	77.3	80.7	82.8	83.5	86.3
2000	83.4	73.6	61.6	75.9	65.3	65.5	71.4	73.3	81.8	78.2
4000	69.0	61.7	65.6	60.1	61.2	61.8	54.5	66.7	62.4	63.2
8000	53.1	43.8	43.1	41.7	42.1	34.8	30.2	46.2	42.7	46.2

RESULTS AND DISCUSSION

Average Sound Pressure Levels According to Frequency of Directivity Measurements of Instruments

Considering the octave ranges of the instruments, a total of 143 measurements (43 for the qanun, 40 for the clarinet, 25 for the tanbur and 38 for the oud) were performed from 20 different points. For the qanun, the lowest note is "C" in the first octave, while the highest note is "G sharp" in the fourth octave; for the clarinet, the lowest note is "B" in the second octave and the highest note is "Re" in the sixth octave; for the tanbur, the lowest note is "A" in the second octave and the highest note is "A" in the fourth octave; for the oud, the lowest note is "C sharp" in the second octave and the highest note is "D" in the fifth octave. The average sound pressure level values of 20 different points obtained from the averages for the sample octave band (246.94 Hz) are shown in Table 4 and the schematic representations of the directivity of all results obtained according to octave bands are shown in Figures 5–9, respectively.

When the measurement results are evaluated;

- The qanun generally demonstrates an inhomogeneous directivity characteristic, as seen in the measurement results. For the 2000 and 4000 Hz octave bands, the instrument reaches the highest sound pressure levels, and the directivity is more prominent at these frequencies.
- For the clarinet, the highest sound pressure values are observed in the 1000 Hz and 2000 Hz octave bands. It shows a more homogeneous and unclear propagation of

Table 4. Average directivity sound pressure level measurement results for all octave bands of the instruments

Frequency (Hz)		Sound Pressure Level, dB Ref. 20 µPa									
Microphone Points		**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**
Qanun	125	36.9	38.8	42.6	46.0	36.5	40.5	46.0	33.7	38.6	44.2
	250	61.0	58.5	53.7	58.8	59.3	54.2	57.0	59.4	53.6	57.3
	500	62.2	59.7	57.8	54.2	55.5	53.5	49.8	58.5	60.3	55.2
	1000	61.6	58.5	58.0	48.3	57.7	56.1	47.4	54.5	53.2	52.7
	2000	64.5	62.4	62.8	56.8	58.2	59.6	60.1	63.0	59.8	52.4
	4000	61.6	62.3	60.4	57.2	61.0	59.4	58.8	58.7	55.9	49.2
	8000	45.2	42.0	42.9	35.4	45.1	41.4	33.2	42.2	39.9	33.6
Clarinet	125	72.1	72.4	72.1	71.6	73.4	73.6	73.5	73.6	73.1	73.3
	250	71.8	69.6	71.3	75.7	68.0	71.4	76.3	69.7	68.3	75.5
	500	79.0	75.5	63.6	74.5	75.6	78.5	80.4	77.8	76.6	78.0
	1000	74.2	85.1	77.5	88.3	90.4	86.1	93.3	88.3	86.6	90.9
	2000	85.4	83.6	82.5	78.9	82.4	82.8	77.6	82.7	85.7	85.7
	4000	73.7	66.6	71.3	61.8	78.2	80.5	69.1	78.8	78.6	75.3
	8000	60.5	56.4	55.6	58.9	62.3	61.2	59.5	61.5	56.9	60.4
Tanbur	125	31.7	28.8	26.3	26.2	32.0	33.4	33.5	32.1	31.2	27.3
	250	48.8	49.6	42.5	50.8	49.1	43.4	52.3	48.9	44.5	48.9
	500	59.6	57.1	54.5	47.0	57.7	49.0	50.7	60.9	56.5	49.9
	1000	55.9	57.0	58.5	54.1	56.4	61.6	53.8	57.7	60.0	56.2
	2000	30.4	26.6	28.8	28.8	31.9	31.7	28.3	34.9	27.5	31.5
	4000	27.1	25.7	24.8	26.0	27.1	27.0	26.6	25.2	24.6	17.1
	8000	24.2	25.2	28.6	27.7	28.1	29.5	28.1	27.1	27.6	27.6
Oud	125	57.3	57.9	59.1	58.9	59.1	60.6	60.9	59.5	60.9	61.5
	250	55.5	56.2	61.2	62.8	59.7	64.8	66.3	61.7	64.2	68.3
	500	60.6	58.7	50.3	48.0	61.1	54.6	59.2	62.5	57.8	61.3
	1000	51.5	49.8	38.8	33.8	53.3	52.2	45.3	53.3	48.1	50.6
	2000	32.2	27.7	34.2	30.1	31.2	28.8	34.7	31.1	35.7	36.4
	4000	27.8	26.5	28.4	23.3	28.0	25.0	20.6	24.9	23.3	28.8
	8000	26.0	26.9	27.6	29.3	26.9	23.7	27.3	27.4	23.7	25.8
Microphone Points		**M11**	**M12**	**M13**	**M14**	**M15**	**M16**	**M17**	**M18**	**M19**	**M20**
Qanun	125	26.6	30.6	37.5	40.0	28.8	34.7	40.5	28.6	28.5	39.8
	250	58.0	55.3	48.0	52.0	55.6	49.6	52.6	56.2	51.4	56.5
	500	57.6	57.7	55.5	49.3	58.0	52.9	45.1	56.7	47.8	39.9
	1000	58.7	56.7	53.2	47.7	54.2	50.3	46.8	52.0	53.0	43.3
	2000	64.7	59.9	58.1	59.7	59.0	53.8	59.4	60.9	51.5	52.8
	4000	59.1	56.8	50.9	50.5	48.8	51.6	48.8	54.2	55.0	48.9
	8000	44.2	38.6	37.0	36.6	42.1	40.4	34.6	42.3	44.1	42.3
Clarinet	125	72.1	72.4	72.1	71.6	73.4	73.6	73.5	73.6	73.1	73.3
	250	71.8	69.6	71.3	75.7	68.0	71.4	76.3	69.7	68.3	75.5
	500	79.0	75.5	63.6	74.5	75.6	78.5	80.4	77.8	76.6	78.0
	1000	74.2	85.1	77.5	88.3	90.4	86.1	93.3	88.3	86.6	90.9
	2000	85.4	83.6	82.5	78.9	82.4	82.8	77.6	82.7	85.7	85.7
	4000	73.7	66.6	71.3	61.8	78.2	80.5	69.1	78.8	78.6	75.3
	8000	60.5	56.4	55.6	58.9	62.3	61.2	59.5	61.5	56.9	60.4
Tanbur	125	31.9	31.6	34.1	37.1	36.7	41.2	43.8	35.3	37.6	39.2
	250	52.1	53.0	46.2	49.7	45.2	39.5	41.2	48.2	45.6	45.4
	500	61.8	60.7	57.2	52.3	61.0	55.0	51.7	62.9	59.2	44.7
	1000	58.0	55.1	56.0	44.6	53.0	56.6	56.0	55.7	55.8	52.2
	2000	38.5	31.7	26.4	28.7	34.6	38.7	32.5	36.3	44.6	32.5
	4000	14.2	14.5	13.2	18.1	17.2	16.7	19.5	16.1	19.7	15.8
	8000	14.2	13.1	11.9	12.3	10.3	9.7	10.7	14.1	14.2	15.8
Oud	125	54.3	54.2	54.8	55.7	55.1	56.6	57.5	57.7	56.2	57.9
	250	53.7	55.4	57.9	61.4	56.9	58.8	64.3	62.6	58.1	67.2
	500	56.9	52.4	50.3	42.6	52.3	43.7	39.9	53.2	56.0	50.5
	1000	44.9	38.3	30.6	40.5	41.4	44.1	43.8	45.8	47.4	46.4
	2000	24.1	25.6	21.8	22.1	24.6	20.9	22.2	23.0	27.3	28.1
	4000	24.2	19.7	17.0	18.6	19.1	17.9	22.7	22.4	23.8	21.5
	8000	21.3	20.1	19.6	21.6	14.9	18.4	19.4	25.8	21.5	22.4

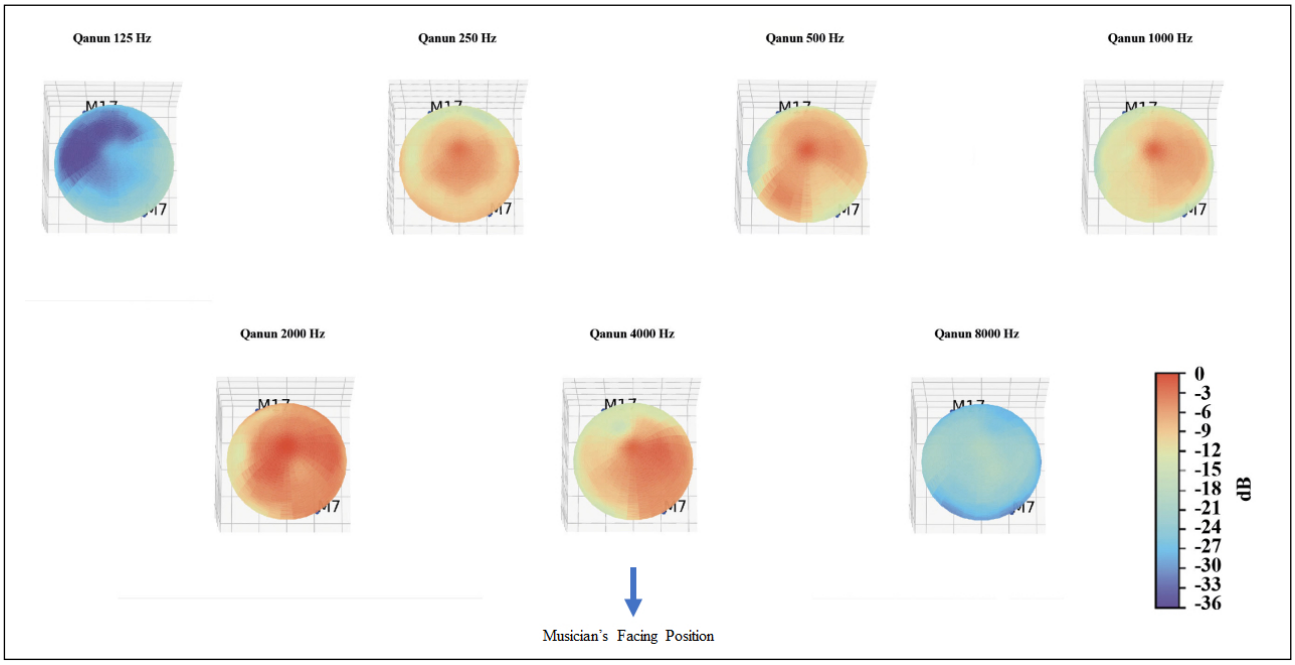

Figure 5. Measurement results for the qanun at each measurement point and octave band.

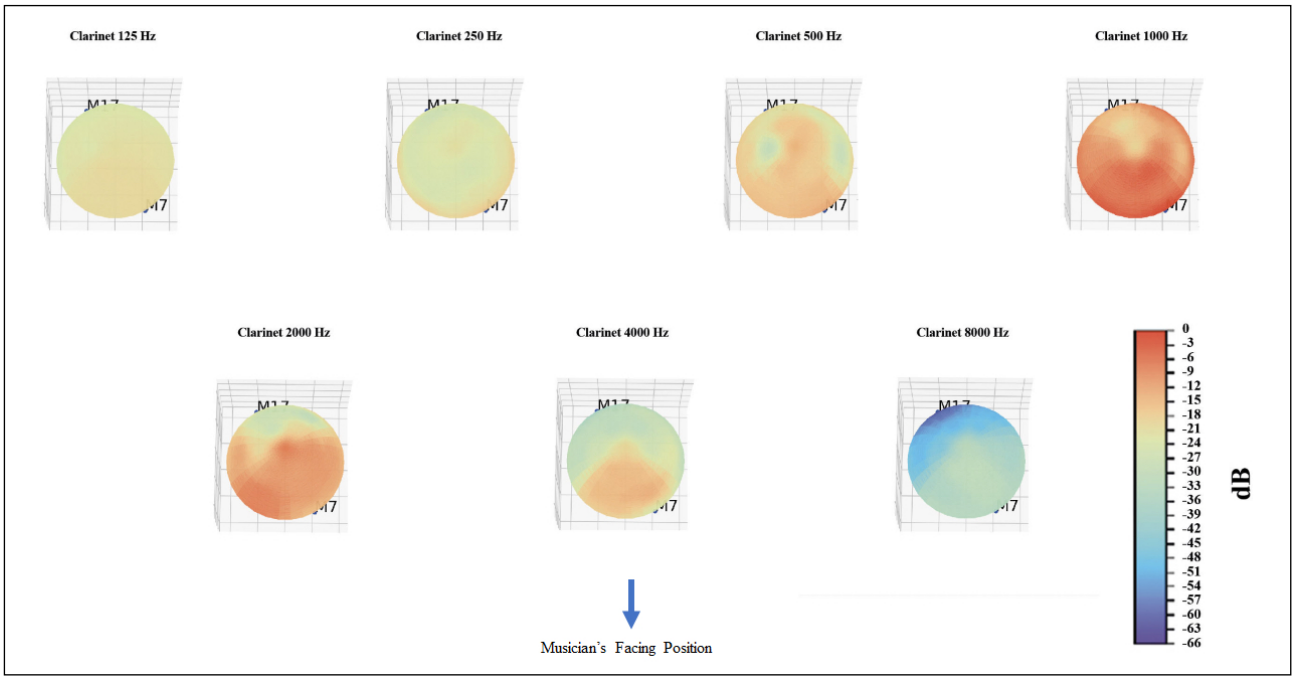

Figure 6. Measurement results for the clarinet at each measurement point and octave band.

directivity at low frequencies, while at high-frequencies there is a more prominent directivity as expected.

- The most obvious directivity information for the tanbur is observed at 4000 Hz and 8000 Hz although it has low sound pressure levels. This makes a difference as against other instruments. The highest sound pressure level values are around 500 Hz and 1000 Hz, and the propagations in this octave band are homogeneous.
- The oud reaches the highest sound pressure levels in low-frequency bands, while it creates a lower sound pressure level at high-frequencies. For all octave bands, it could be observed that there is ambiguous and similar directivity information.
- When examining the differences between the instruments according to octave bands, the qanun shows a non-homogenous propagation at 125 Hz, while other

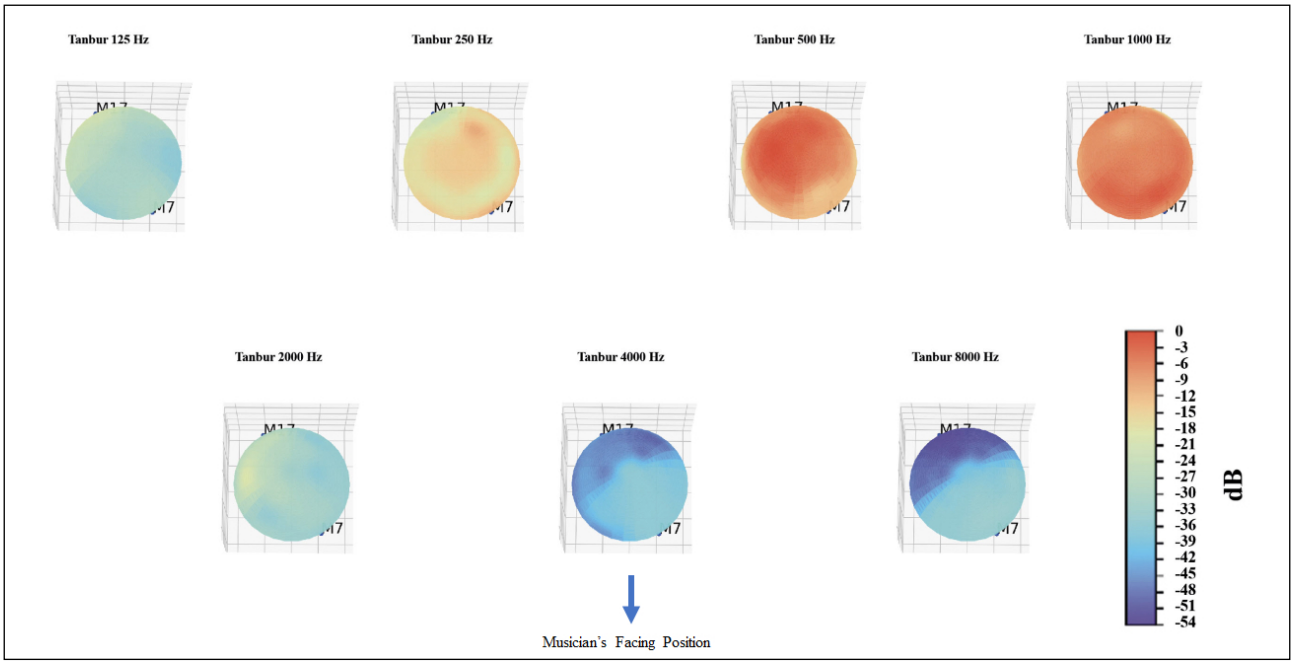

Figure 7. Measurement results for the tanbur at each measurement point and octave band.

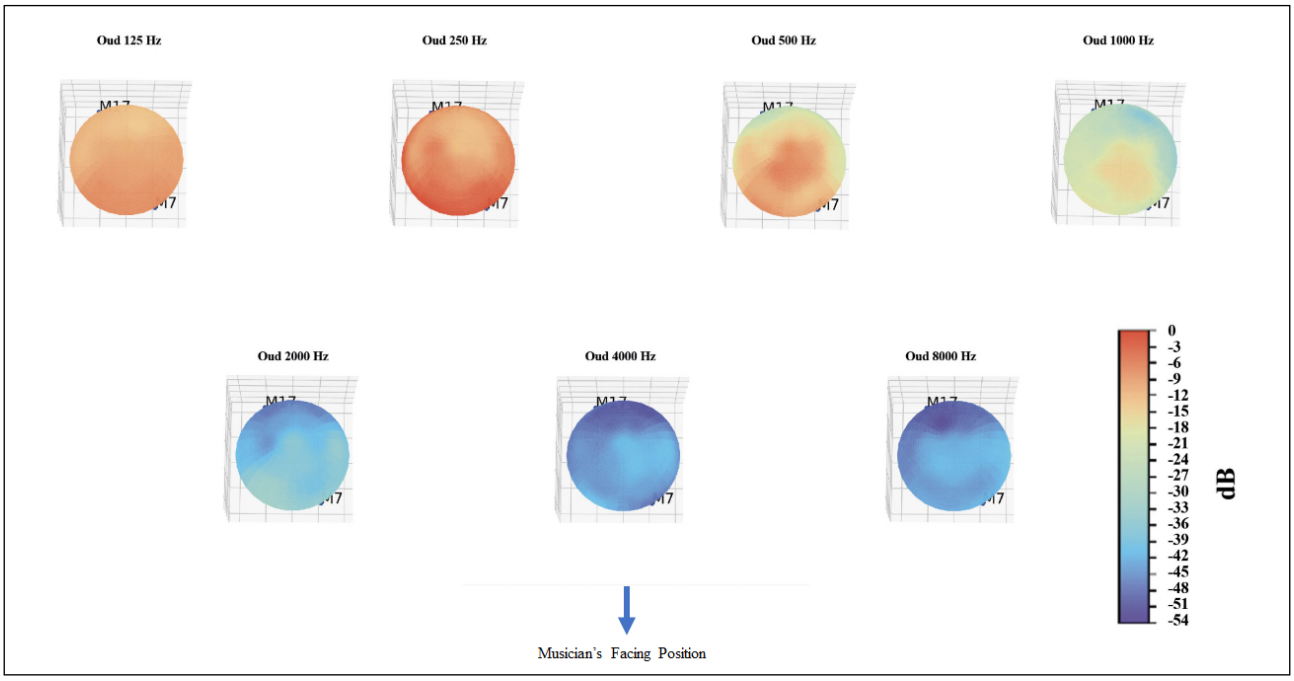

Figure 8. Measurement results for the oud at each measurement point and octave band.

instruments show a propagation close to homogeneous. The oud has the highest sound pressure level of around 125 Hz.

- The frequency zone in which the oud characteristically reaches the highest sound pressure levels is 250 Hz. The clarinet demonstrates a fairly homogeneous propagation. The qanun and tanbur have similar directivity compared to other instruments.
- The frequency region where the tanbur reaches the highest sound pressure values is 500 Hz, and it shows a propagation close to homogeneous. Other instruments reflect more prominent information of directivity and could be stated to be demonstrating similar characteristics.
- They are frequency regions where the clarinet and tanbur reach the highest sound pressure levels. While

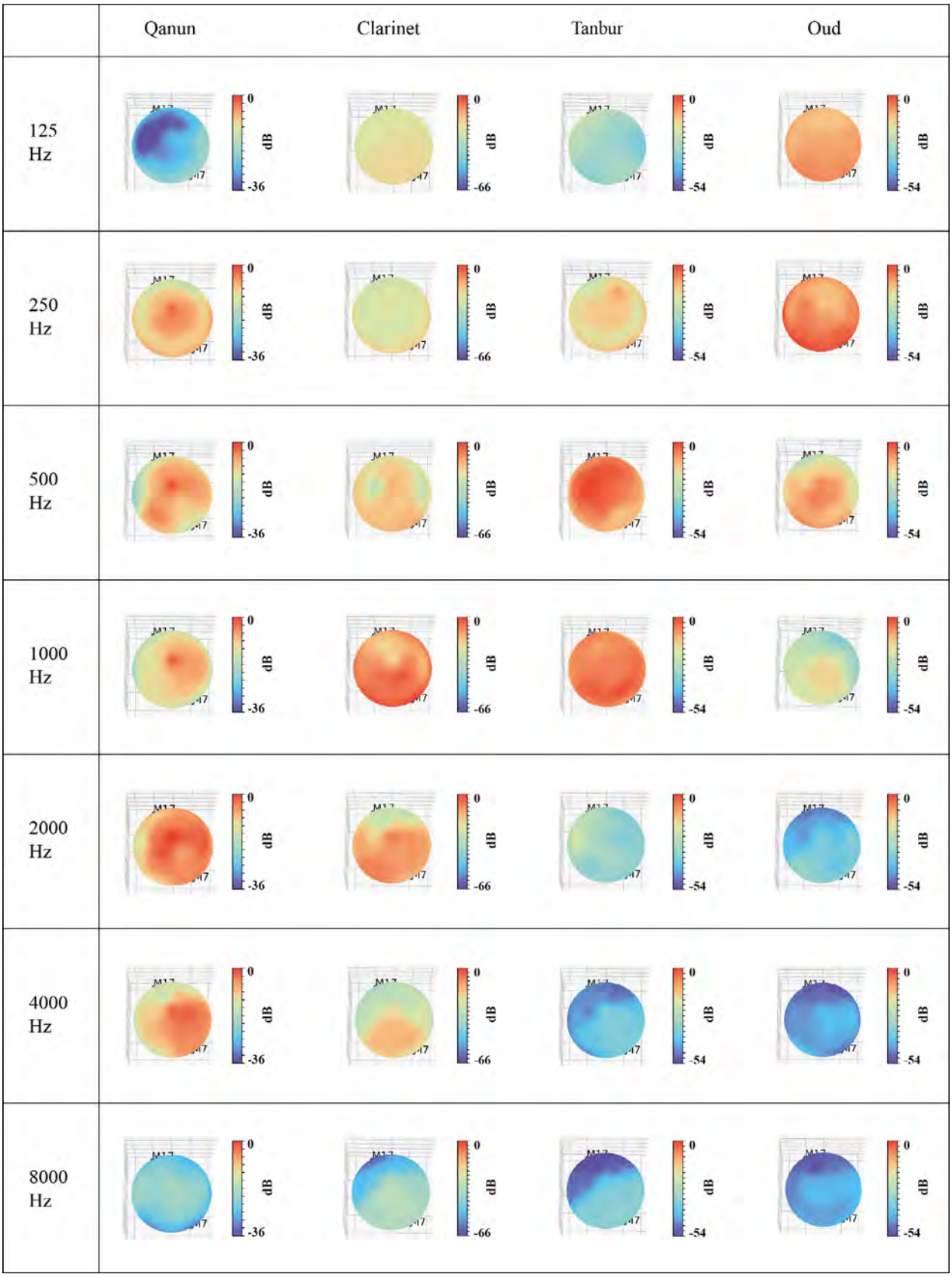

Figure 9. Measurement results for all instruments at each measurement point and octave band (All scales are separate for each instruments).

directivity information for tanbur is homogeneous, regional concentrations are observed in other instruments. For example, it is possible to refer to a prominent propagation in the direction of view for the oud.

- There is a significant decrease in sound pressure levels for the tanbur and oud compared to other low-frequency regions. The clarinet shows a prominent sound propagation characteristic towards the point of view at this frequency. The oud also shows similar propagation characteristics as the clarinet. The qanun has reached the highest sound pressure level in frequency zone measurements within itself.
- Propagation characteristics for all instruments have been sharper than for lower frequencies. Although the sound pressure levels of oud and tanbur decrease to lower and medium frequencies, the propagation zones are clearly visible. Clarinet and qanun demonstrate sharp propagations but in different directions.

The propagation characteristics of clarinet and tanbur are quite similar. The qanun has a homogeneous propagation, although it demonstrates a high-frequency zone that does not have propagating characteristics. Although the oud shows characteristics close to homogeneous, it is possible to demonstrate a distinct area for the propagation zone.

CONCLUSION

For the acoustic performance of the halls, it is extremely important to consider the directivity characteristics of the sound sources during the stage and orchestra design. This topic which has been studied for most Western music instruments has unfortunately not been discussed in detail for Turkish music instruments until today. In the study, the directivity information of four different Turkish music instruments has been obtained. According to the findings, it has been determined that instruments with different acoustic properties show different directivity behaviours. In addition, the directivity behaviour of the same instrument also varies in different octave bands. Considering the musician factor, whether the low-, medium- and high-frequencies have similar or different general behaviours for different instruments can be interpreted within the scope of the study. With this approach, it is obvious that instrument type, positioning and placement are very important for acoustic performance places with different purposes. It can be said that instrument directivity is a very important parameter especially in designing concert halls. In addition, this study aims to contribute to the development of measurement approaches required for directivity research of Eastern music instruments. With future studies, determining the directivity characteristics of other Turkish music instruments that are not discussed within the scope of the study is important in terms of the contribution to the literature.

Acknowledgments
This study was created from the doctoral dissertation supported by Yıldız Technical University Scientific Research Projects Coordination Unit with the FDK-2019-3681 project. The author would like to thank the YTU BAP Coordination Unit.

- *This article is based on the PhD Dissertation entitled as An Approach to Determining the Acoustic Characteristics of Turkish Music Instruments and Evaluating Their Effect on Hall Design by Yalın Özgencil and continues under the supervision of Prof. Dr. Neşe Yüğrük Akdağ at Yildiz Technical University, Department of Architecture in 2022.*

ETHICS: There are no ethical issues with the publication of this manuscript.

PEER-REVIEW: Externally peer-reviewed.

CONFLICT OF INTEREST: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

FINANCIAL DISCLOSURE: The authors declared that this study has received no financial support.

REFERENCES

Ackermann, D., Böhm, C., Brinkmann, F., and Weinzierl, S. (2018). The acoustical effect of musicians' movements during musical performances. Acta Acustica United with Acustica 105(2019):356–367.

Açın, C. (1994). Enstrüman Bilimi. Yenidogan Basımevi.

Benade, A. H. (1976). Fundamentals of Music Acoustics. 1st ed. London: Oxford University Press.

Berg, R. E. and Stork, D. G. (2005). The Physics of Sound. San Francisco: Pearson Education, Inc.

Causse, R., Derogis, P., and Waresful, O. (1995). Radiation of musical instruments and improvement of the sound diffusion techniques for synthesized, recorded or amplified sounds. Proceedings of the International Computer Music Conference. Banff, Canada, 359–360.

Cook, P. and Trueman, D. (1998). A database of measured musical instrument body radiation impulse responses, and computer applications for exploring and utilizing the measured filter functions. Proceedings of the International Symbiosis Musical Acoustics. Leaven-Worth WA, USA, 303–308.

Dalenback, B. I., Kleiner, M., and Svensson, P. (1993). Audibility of changes in geometric shape, source directivity, and absorptive treatment - Experiments in auralization. Journal of Audio Engineering Society 41:905–913.

Değirmenli, E. (2017). Türk Müziği Telli Çalgılarının Akustik Analizlerinde Kullanılan Yöntemler. Gazi Üniversitesi Fen Bilimleri Dergisi Part C: Tasarim ve Teknoloji 5(2):23–35.

Erkut, C., Tolonen, T., Karjalainen, M., and Valimaki, V. (1999). Acoustical Analysis of Tanbur, a Turkish Long -Necked Lute. Paper presented at the International Congress on Sound and Vibration, Denmark.

Fletcher, N. H. and Rossing, T. D. (1997). The Physics of Musical Instruments. New York: Springer-Verlag.

ISO Standard 3745:2003. (2003). Acoustics - Determination of sound power levels of noise sources using sound pressure — Precision methods for anechoic and hemi-anechoic rooms. International Standards Organization.

Martin, D.W. (1942). Directivity and the acoustics spectra of brass wind instruments. Journal of Acoustics Society of America 13:309–313.

Meyer, J. (1978). Acoustics and the Performance of Music. Frankfurt/Main: Verlag Das Musikinstrumenter.

Meyer, J. (1993). The sound of the orchestra. Journal of Audio Engineering Society 41:203–213.

Otondo, F. and Rindel, J. H. (2004). The influence of the directivity of musical instruments in a room. Acta Acustica United with Acustica 90:1178–1184.

Patynen, J. and Lokki, T. (2010). Directivities of symphony orchestra instruments. Acta Acustica United with Acustica 96:138–167.

Pollow, M., Behler, G., and Masiero, B. (2009). Measuring directivities of natural sound sources with spherical microphone array. Proceedings of Ambisonics Symposium 2009, Graz, Austria, 25–27.

Rossing, T. D., Moore, R. F., and Wheeler, P. A. (2002). The Science of Sound. Third edition. Prentice Hall.

Sabine, W. C. (1964). Collected Papers on Acoustics. Reprinted by Dover Publications, Inc.

Vigeant, M. C., Wang, L. M., and Rindel, J. H. (2007). Investigations of multichannel auralization technique for solo instruments and orchestra. 19th International Congress on Acoustics, Madrid.

Wang, L. M. and Vigeant, M. C. (2004). Objective and subjective evaluation of the use of directional sound sources in auralizations. 18th International Congress on Acoustics, Kyoto, Japan. IV:2711–2714.

Weinreich, G. (1997). Directional tone color. Journal of the Acoustical Society of America 101:2338.

Megaron, Vol. 17, No. 4, pp. 629–643, December 2022

Megaron
https://megaron.yildiz.edu.tr - https://megaronjournal.com
DOI: https://doi.org/10.14744/MEGARON.2022.53386

Article

The influence of learning space colours on students within attention, emotional and behavioural

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ARTICLE INFO

Article history
Received: 08 October 2022
Revised: 25 October 2022
Accepted: 06 December 2022

Key words:
8–9-years-old children; attention, emotional response; behavioural response; colour effects; learning spaces

ABSTRACT

Environmental colours can affect users in terms of performance, aesthetics, emotion, etc., and can play a role in their actions. Previous studies have shown that environmental colours are effective on user perception. This research aims to find out how wall colours can impact students in the learning environment by manipulating their attention, emotion, and behavioural reactions. An experiment was conducted with students aged 8–9 years in a real classroom painted in twelve colours. The students have taken the courses within a classroom having different wall colours (red, yellow, green, blue, purple, orange, green–yellow, blue–green, purple–blue, red–violet, white and grey) for twelve consecutive weeks during the experiment. In this process, various measurements and evaluations were conducted for each different colours regarding attention, emotion, and behaviours. The results show that learners' attention notably increased in the red–purple and yellow wall colours and decreased in the orange, purple, red, and blue wall colours. The students mostly preferred green–yellow, blue–green, orange, purple, and blue wall colours, and the least preferred ones were grey, yellow, and red–purple colours. The red, orange, green, green–yellow, blue–green, blue, and purple wall colours were perceived as positive by students. From behavioural point of view, they were more active in red, orange, yellow, and blue–green, whereas they were calmer in purple, red–purple blue, and green. In the grey wall colour environment, students were observed as bored and distracted, and there was a slight decrease in their attention in the course.

Cite this article as: Duyan F, Ünver FR. The influence of learning space colours on students within attention, emotional and behavioural. Megaron 2022;17(4):629–643.

INTRODUCTION

There are various studies about colour effects on users regarding attention, emotional and behavioural, in the literature. Studies on the effects of environmental colour have developed in parallel with the effects of space and environmental evaluations on users. Pressey found that there was no difference in the responses of warm and cold colours on the autonomic nervous system, whereas luminance increased performance speed (Pressley, 1921). Birren focused on the psychological and emotional areas of colour, especially on the tangible benefits of colour and lighting in interior spaces requiring performance (Birren, 1973).

In the literature, interior colour studies were carried out

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for different functions such as living room, office and classroom. The studies for the effects of the interior colours on the users can be exemplified as follows.

Ainsworth et al. assessed the work performance and the responses of the subjects (18–24-years-old) to anxiety, depression and arousal in red, blue–green and white-coloured experimental settings organised as office spaces. It was concluded that there was no difference between the rooms painted in different colours in terms of both performance and affective reactions (Ainsworth et al., 1993). Kwallek et al. investigated the effects of office wall colours on people's colour preferences, mood, and work performance (Kwallek et al., 1996). Although there was no significant relationship found between mood and office colours in the study, participants were more satisfied with working in rooms with low-value and high-saturation colours. Subjects made more mistakes in the white room than in the red and blue room, and in terms of work performance, subjects made high-scores in rooms with high-saturated wall colour room than in rooms with low saturated walls.

Küller et al. conducted three different experiments to assess the affective and neurophysiological effects of office colours on users aged 17–54 years. In the first experiment, a visually complex room with colours and patterns was created and in the second and third experiments, a red room and a blue room were compared. The results showed that saturated colours and complexity, red and similarly coloured rooms activated the brain whereas the blue room have a calming effect. In terms of colour effects on performance, the results of the experiment show that for the subjects who had inward and negatively oriented personalities, the red colour had an enhancing effect on performance. According to the results of all three experiments, it was concluded that individuals with a high-level of attention performed better in the red office, and adult individuals with lower attention capacity performed better in the blue room (Küller et al., 2009). In the study realised by Manav et al., the emotional effects of colour and lighting on adult individuals who created office spaces in a lab were investigated. The results of the study, in which both high-and low-saturation of blue and yellow wall colours were evaluated under different lighting scenarios, confirm that space colour perception is closely related to quantitative and qualitative properties of light. Besides, it has been found that even when the colour hue remains constant, environmental evaluations change as the saturation of the same hue changes (Manav et al., 2009).

In another study performed by Yıldırım et al., two separate living room images visualised on the computer were shown to the adult subjects on a projection screen. On the walls of the living rooms, which were furnished in two different ways, three different colours were applied: red, blue and grey (monochromatic). The participants aged 18–24 years found the warm (red) hue as "highly stimulating" and "exciting", and the cold (blue) hue as "spacious", "relaxing" and "peaceful". Grey space was generally defined with adjectives that resulted in the colour being negatively characterised (Yıldırım et al., 2011). Park's study examined the living room colour preferences of children aged between 7 and 11 years and the relationship between these preferences and colour components via the 1:12 scale room model. Forty-five colours were applied to the walls of the model, and were asked to the children, and which one they prefer most. Children preferred the red colour in medium value and saturation, the yellow colour in high-value and medium saturation, the green colour in medium value and saturation, and the blue colour, respectively. In terms of gender, it was found that girls preferred red and purple colours more in terms of hues whereas boys preferred less saturated colours within both red and purple hues (Park, 2013).

Al-Ayash et al.'s one of studies on the colour effect in learning environments assessed the moods and performances of the subjects aged between 20 and 38 years using high-saturation and high-value versions of blue, yellow and red colours and low saturation and high-value versions of the same hues in an experiment room. The results of the study showed that blue colours had a relaxing effect, whereas high-saturated hues significantly increased the performance scores (Al-Ayash et al., 2016). Tikkanen, on the other hand, studied the effects of changes in colour and lighting on emotions around the school environment with students aged 16 years. The students associated warm with pleasantness and cold with unpleasantness for both light and colour (Tikkanen, 1976). In a study conducted at an architectural studio of a university by Baytin et al., the wall with the blackboard was painted with thirty-four different colours each week. The effects of wall colours on the undergraduate students' tastes and moods as well as their performance were evaluated during this period. Purple and green–blue were the most preferred colour types, which the students stated as having soft, positive and relaxing effects. The colours which increased the students' attention in terms of academic efficiency were orange and purple, and the colours that decreased attention the most were yellow and yellow–green wall colours (Baytin et al., 2005).

The purpose of Wang and Russ's study was to investigate the relationship between computer lab wall colour preferences and undergraduate students' personality types. In the study, a classroom with computers was visualised and the wall with the blackboard was painted with 15 different colours. Purple, blue and blue–purple were the most preferred colours by undergraduate students (Wang and Russ, 2008). Yildirim et al. evaluated students' perceptual performance by showing university students the images of a digitally visualised classroom with walls painted with high-value yellow (cream), blue and pink colours. According to the results, it was found that blue-coloured classrooms were perceived more positively than yellow and pink-coloured classrooms (Yildirim et al., 2015).

Learning spaces in other words classrooms within which students spend a large part of their lives from early childhood to adolescence play an important role in their physiological, social, and cognitive development of them. Functionally expectations from these spaces are to provide suitable and efficient studying conditions for students. In a classroom, that has form and size are generally defined by standards and physical environment properties (materials, textures, patterns, lighting features, surface colours, etc.) can have an impact on students throughout their education. One of the physical components that affect students as environmental stimuli is wall colours that occupy a large part of the classroom surfaces. Students take courses under the effect of the colour stimuli reflected from the walls. These colour stimuli can influence students by manipulating their attention on the lesson, emotional or behavioural outputs.

In this context, this research was planned to find out how wall colours can impact students in the learning environment by manipulating their attention, emotion, and behavioural reactions. The research was conducted with students aged 8–9 years in a real classroom painted in twelve colours throughout the academic term and the students continued their courses under red, yellow, green, blue, purple, orange, green–yellow, blue–green, purple–blue, red–violet, white, and grey wall colours during the experiment. In this process, various measurements and evaluations were realised for each different colour within the scope of attention, emotional effects, and behaviours.

The majority of predecessor studies carried out on colour effects are mainly focused on adult users, and they have been conducted through visualisations and laboratory experiments. The most significant aspect that distinguishes our research from similar studies is that the experiment takes place in a real classroom environment throughout the academic term with children. The main purpose of this study is to determine the environmental colour conditions that should be supported learning in classrooms and to reach useful results in the colour design of the learning environment. On the way to this goal, the research has been planned in line with the fact that each different wall colour can create different effects, and the effects of these colours on students are evaluated in three attitudes such as attention, emotional, and behavioural response. Details of the in-site experimental research are given below as materials, methods, and results.

MATERIALS AND METHODS

The research was planned to determine the attention, affective and behavioural effects of the colours on the walls of a primary school classroom on students. The stages of the study are as follows;

- Determination of classroom wall colours,
- Arranging the classroom as an experimental space,
- Determination of methods of attention, affective and behavioural response to environmental wall colour,
- Evaluation of results.

PARTICIPANTS

Jean Piaget who has described learning according to the "theory of individual's mental development" and has accepted it as an age-related process, has described the period of 7–11 years as the period of concrete processing in which individuals can bring logical solutions to problems. So, the reason for concrete models and their reactions to environmental stimuli would be in this direction (Brainerd, 1978). The learning speed of individuals in the cognitive concrete operational thinking period is very high between 7 and 11-years-old. In parallel, the emotional and behavioural responses of students in this age group to the environment differ from adults. For this reason, students from the 8–9-year-old age group, who are within the period of concrete operational thinking were preferred for the study as subjects. A total of 35 students (22 females, and 13 males) participated in the study.

DETERMINATION OF WALL COLOURS

Twelve wall colours, using the Munsell Colour System were determined in the experiment. The chromatic colours are ten hues with equal perceiving steps (red, orange, yellow, green–yellow, green, blue–green, blue, purple–blue, purple, red–purple) and achromatic colours are white and grey. Every hue has the same value (7) and saturation (8) in order to create a similar perception for all colour hues. Table 1 demonstrates Munsell Colour System symbols for wall colours chosen for the study. Figure 1 shows equal steps of hues (Value: 7, Chroma: 8) of the Munsell Colour System (Munsell, 1971; Munsell, 2016; Luke, 1996). The ceilings

Table 1. Notations of Munsell colour system for wall colours

WALLS	Hue	Value/ Saturation	Color Sample
RED	5R	7/8	
ORANGE	5YR	7/8	
YELLOW	5Y	7/8	
GREEN-YELLOW	5GY	7/8	
GREEN	5G	7/8	
BLUE-GREEN	5BG	7/8	
BLUE	5B	7/8	
PURPLE-BLUE	5PB	7/8	
PURPLE	5P	7/8	
RED-PURPLE	5RP	7/8	
WHITE	N	9/o	
GREY	N	7/o	

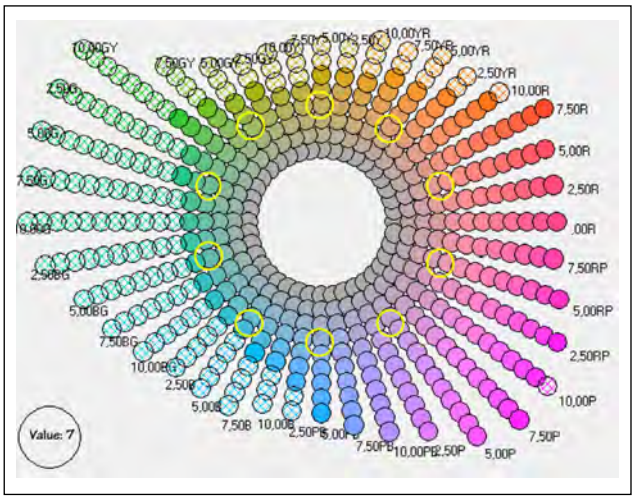

Figure 1. Ten chromatic colours determined from Munsell colour system in equal step (Value: 7, Chroma: 8) (Munsell, 2016).

of the experimental class were painted white (N 9/0). All furniture in the classroom was converted into grey in order to not decrease to wall colour effect. The students took their courses during the experiment.

MEASUREMENTS AND PROCEDURES

Colour Blindness: "Ishihara Colour Vision Test" was applied to all subjects to check their colour vision prior to the experiment. As a result of this control, it was determined that subjects had no colour vision defect (Ishihara, 1990).

Measurement of Attention Response: Within the scope of attention response, the "attention test" method was used to determine the extent to which classroom wall colour affects students' attention levels. The age and cognitive levels of the students were taken into consideration, it was picked a test they could comprehend easily and that would not take too long. Eventually, the letter form of the Bourdon Attention Test was found suitable for this study (Brickenkamp et al., 1975). The Bourdon Letter Test, which consists of 3 blocks and 660 letters was used as 2 blocks and 440 letters considering the age of the subjects. The 3-minute period given to the subjects in the three-block application was shortened to 2 minutes in this two-block application. Within 2 minutes, subjects were asked to find and mark the letters "a, b, d, g".

Measurement of Emotional Response: In order to evaluate the students' responses to classroom wall colours in terms of emotional effects, the "Environmental Colour Assessment (ECA)" form was prepared by using attitude scales which consist of two parts. In the first part of the form, on how the students perceive the classroom wall colour, the "Semantic Differential Scale (SDC)" consists of five levels and ten adjective pairs. In the second part, to determine the students' level of satisfaction with the classroom wall colours, "Likert Scale (LS)" with ten levels was prepared (Adams and Osgood, 1973; Küller, 1972; Küller, 1973; Osgood et al., 1957; Anderson, 1988; Groat and Wang, 2013; Joshi, 2015). The ECA test was applied to the students every week for each wall colour.

Measurement of Behavioural Response: The "Teacher Observation Form (TOF)" was prepared to determine the effects of classroom wall colours on students' behaviour. During the 12-week experiment period, the class teacher evaluated students' behaviour including class participation, concentration periods, students' mobility, talking, etc. in general throughout the week for each wall colour. In the first part of the Teacher Observation Form, which consists of two parts, the teacher evaluates her observations on students' behaviours according to a five-level scale and the second part includes her evaluation including written comments.

Experimental Settings

The study was carried out in a classroom with the dimensions of 7.15 m × 7.20 × 3.10 m as seen in Figure 2. On one wall of the classroom space, there are four windows directed to the Northwest. The current classroom layout was converted into the experiment space by making some arrangements.

Desks and panels on the walls were covered with medium grey fabrics, cabinets were covered with medium grey cardboards. Since the colour of the floor and curtain materials have high-value and low saturation, no new arrangements had been made. The white ceiling surface again was painted in white colour. The visual and written materials on the walls, which had the intensity to decrease the effect of the wall colour, had been reduced to the minimum number required for education.

Improvements have been made in the artificial lighting system to provide the values in the relevant standards. The lamp types changed while maintaining the positions of the luminaires. In this context, 36 W fluorescent lamps with

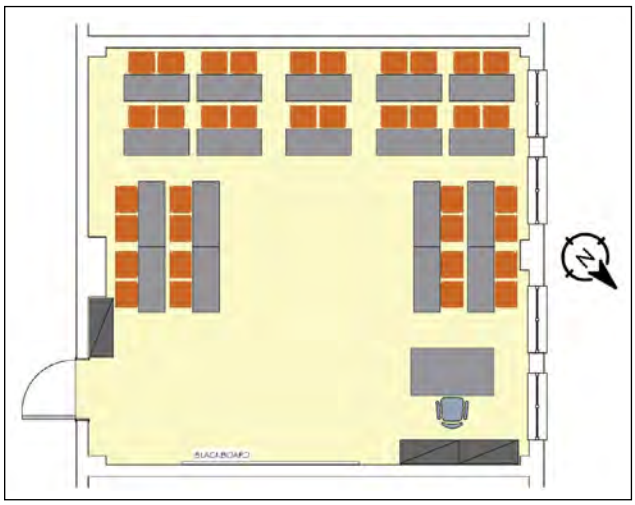

Figure 2. Classroom plan.

colour rendering index 1A (Ra> 80), colour temperature (Tc) 4000 K and light flux 3200 lm were used. By this way, the artificial illuminance realised on the desks had been minimum 300 lm/m^2 and it was made sure that all lamps were working properly.

There was no change in the natural lighting system, curtains were kept open, and both natural and artificial light was used together during the experiment. Since the windows were facing Northwest and the students were in class during the morning, the classroom was illuminated by sky light and artificial light.

The chosen wall surface colours were produced by a paint company in accordance with the specified Munsell Colour System and were applied after checking the accuracy of the colour properties. Class walls were painted during the weekend holidays. Education continued throughout the five weekdays with the wall colour applied for that week (Figures 3–6).

Figure 3. Red (5R 7/8), orange (5YR 7/8) and yellow (5Y 7/8) coloured wall class photos.

Figure 4. Green–yellow (5GY 7/8), green (5G 7/8) and blue–green (5BG 7/8) coloured wall class photos.

Figure 5. Blue (5B 7/8), purple–blue (5PB 7/8) and purple (5P 7/8) coloured wall class photos.

Figure 6. Red–purple (5RP 7/8), grey (N 7/0) and white (N 9/0) coloured wall class photos.

RESULTS

Attention Results

SPSS 10 (Statistical Program for Social Sciences) statistical program was used to analyse and evaluate attention results obtained by the Bourdon Attention Test (BAT) data. Furthermore, to control the reliability of the data, the "Test-retest reliability method" was used.

To find out whether there is a statistically significant difference between the first wall colour and the twelfth wall colour, two pre-tests and one post-test was applied. Thus, the experiments in the study continued for 15 weeks. The arithmetic mean results of the Bourdon Attention Test and the graphical representation are shown in Table 2 and Figure 7.

As the weeks progressed, attention test scores increased positively (Figure 8, Table 2). This positive rise in the scores revealed that "repeat-based learning" affects test scores, even though the order of letters in the attention test was changed every week. This is due to individuals' learning processes being based on repetition. No matter how influential the independent variables affecting attention are, the individual's test scores will increase by a certain amount each time when similar tests are applied. This situation is based on the repetition effect theory in the literature (Hebb, 1961; Szmalec et al., 2009; Johnson et al., 2017). Thus, it is important to obtain realistic results by subtracting the learning effect in order to assess correctly the effect of environmental stimuli on attention. Hereby, in this study, a method that eliminates the effect of repeat-based learning has been developed to accurately measure the effect of wall colour on attention. Accordingly, within the scope of the study, the procedure begins firstly with "determining the increase in students' scores learning due to repetition", in other words, determining the learning styles of the students. Then the assessment procedure is followed by subtracting these determined results from the Bourdon Attention Test values.

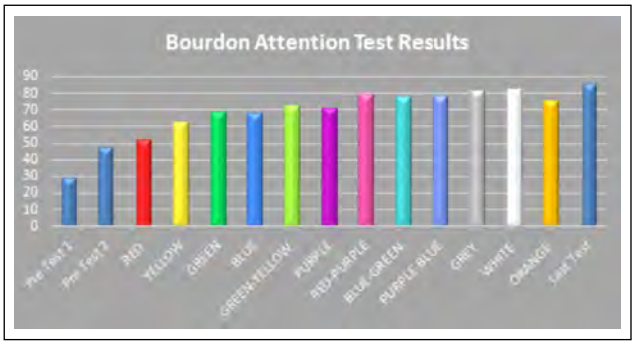

Figure 7. Bourdon attention test results graphic.

Each person or group has a way of learning and a function that demonstrates it (Carlson, 1973; Jaber and Guiffrida, 2004; Jaber, 2011; Pusic et al., 2015, 2016). In order to determine the increase in attention points in repeat-based learning, it is necessary to determine the function type of the students' learning styles. For this reason, the primary aim was to find out the "functional learning structure" of "Bourdon Attention Test scores obtained via repeat-based" for each student. An investigation was carried out to indicate which of the 10 functions "Linear, Logarithmic, Inverse, Quadratic, Cubic, Compound, Power, S, Growth,

Table 2. Arithmetic average of Bourdon attention test results

Week	Wall Colour Number	Wall Colours (Munsell colour system; Hue value/Chroma)	Bourdon Test Result (Average)
1st Week		Pre-test 1 (yellow–3Y 8/2)	29.26
2nd Week		Pre-test 2 (yellow–3Y 8/2)	47.91
3rd Week	1	Red (5R 7/8)	51.85
4th Week	2	Yellow (Y 7/8)	62.27
5th Week	3	Green (5G 7/8)	68.86
6th Week	4	Blue (5B 7/8)	68.13
7th Week	5	Green–Yellow (5GY 7/8)	72.65
8th Week	6	Purple (5P 7/8)	70.70
9th Week	7	Red–Purple (5RP 7/8)	79.30
10th Week	8	Blue–Green (5BG 7/8)	77.71
11th Week	9	Purple–Blue (5PB 7/8)	78.24
12th Week	10	Grey (5N 7/0)	81.31
13th Week	11	White (9N 0/0)	82.46
14th Week	12	Orange (5YR 7/8)	75.15
15th Week		Last test (Orange – 5YR 7/8)	85.40

and Exponential" were suitable for the functional structure of Bourdon Test scores. The best learning function was determined Cubic function as a result of the investigation by using the "Curve Estimation" module in the SPSS program. In the other words, the students' repeat-based Bourdon test scores are mostly in accordance with the "Cubic Function". The "deviations" within this function were assumed as "the effect of classroom wall colours on attention" and the evaluation was performed accordingly.

Bourdon Attention Test scores (raw scores) of students as shown in Table 2 were modelled according to "Cubic function" by regression analysis and colour effect data representing the differentiation of real values from theoretical values were prepared. Equivalence of the average effect of each colour on students to "0" was tested using the "One Sample T-Test". Since the number of samples was over 30, a non-parametric test was not used. Assuming that "each deviation" in the resulting cubic functions was "the wall colour effect on attention", it has been evaluated with the logic of "the wall colour with a greater standard deviation, had affected the attention more".

The Elimination of the Learning Effect (ELE Method)

With the elimination of the learning effect (ELE) method, the rise in attention scores due to repeat-based learning was eliminated from the test results via the cubic function. ELE was calculated by subtracting the theoretical values expected from the learning function from the estimated values. In other words, the mean of deviations in the learning function was tested to see if they were significant.

The "p" values of the significance level obtained from the "One Sample T-test" results were evaluated when the values were $p<0.01$ (99% significant), $p<0.05$ (95% significant), and $p<0.1$ (90% significant). It was determined that the average effect score obtained from the wall colours having "p" values satisfying these conditions had a positive (increasing points) or negative (decreasing points) effect according to the value. Table 3 shows the results of "one sample T-test with eliminated repeat-based learning effect (no learning effect)" for all students.

The numerical values showing the relationship between the twelve wall colours applied to the classroom walls and their

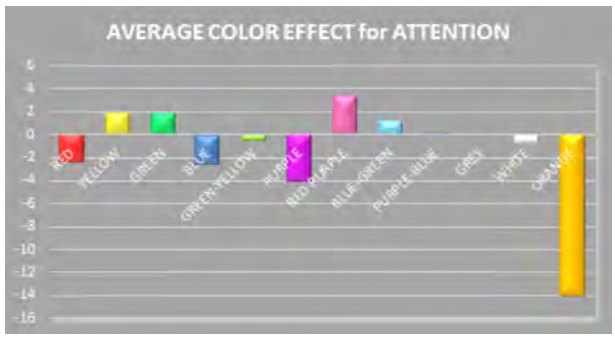

Figure 8. Average wall colours effect for attention (without learning effect).

Table 3. The results of "One Sample T-Test" with eliminated repeat-based learning effect

Colours	Test Value = 0						
	t	Df	Significant (2-tailed)	Average Effect	95% Confidence Interval of the Difference		Effect Size
					Lower	Upper	
Pre-test 1	-2.662	33	0.012**	-2.08630	-3.6810	-0.4916	2.55
Pre-test 2	3.930	33	0.000***	+3.67195	1.7710	5.5730	3.93
Red	-1.985	33	0.056*	-2.35473	-4.7685	0.0590	1.98
Yellow	1.871	33	0.070*	+1.88568	-0.1653	3.9367	1.87
Green	1.444	33	0.158	+1.84021	-0.7521	4.4325	1.44
Blue	-2.366	33	0.024**	-2.58352	-4.8048	-0.3623	2.37
Green–Yellow	-0.362	33	0.720	-0.49289	-3.2650	2.2792	0.36
Purple	-3.678	33	0.001***	-4.03176	-6.2619	-1.8016	3.68
Red–Purple	2.942	33	0.006***	+3.39955	1.0482	5.7509	2.94
Green–Blue	1.029	33	0.311	+1.23101	-1.2040	3.6661	1.03
Blue–Purple	0.189	33	0.852	+0.16465	-1.6112	1.9405	0.19
Grey	0.076	33	0.940	+0.07867	-2.0307	2.1881	0.08
White	-1.121	33	0.271	-0.72255	-2.0342	0.5892	1.12
Orange	-6.429	32	0.000***	-14.00910	-18.4476	-9.5706	6.43
Last test	-3.359	29	0.002***	-13.32443	-21.4384	-5.2105	3.36

It displays significance at *90%, **%95, ***99% confidence level.

Table 4. Ranking of Bourdon Attention test arithmetic average results (Raw Scores-with learning effect)

Week	Bourdon Test Colour Ranking According To Raw Scores		Bourdon Test Results (Raw score)
11st Week	1st	White (11)	82.46
10th Week	2nd	Grey (10)	81.31
7th Week	3th	Red–purple (7)	79.30
9th Week	4th	Purple–blue (9)	78.24
8th Week	5th	Blue–green (8)	77.71
12th Week	6th	Orange (12)	75.15
5th Week	7th	Green–yellow (5)	72.65
6th Week	8th	Purple (6)	70.70
3rd Week	9th	Green (3)	68.86
4th Week	10th	Blue (4)	68.13
2nd Week	1th	Yellow (2)	62.27
1st Week	12th	R`ed (1)	51.85

Table 5. Ranking of Bourdon Attention test results after ELE method (Reliable Scores-without learning effect)

Week	Colour ranking independent from time effect		Average effect scores (Clear Scores)
7th Week	1st	Red–purple	3.399***
2nd Week	2nd	Yellow	1.885*
3rd Week	3th	Green	1.840
8th Week	4th	Blue–green	1.231
9th Week	5th	Purple–blue	0.164
10th Week	6th	Grey	0.078
5th Week	7th	Green–yellow	-0.492
11st Week	8th	White	-0.722
1st Week	9th	Red	-2.354*
4th Week	10th	Blue	-2.583**
6th Week	1th	Purple	-4.031***
12th Week	12th	Orange	-14.009***

It displays significance at *%90 (p<0.1), **%95 (p<0.05), ***%99 (p<0.01) confidence level.

effects on attention are presented in Table 3. According to these values, six colours (red, yellow, blue, purple, red–purple and orange) among the applied colours showed a significant effect (p<0.1). Among these six colours, yellow and red–purple had a significantly increasing average attention effect, while red, blue, purple, and orange wall colours had a decreasing average attention effect. The other six colours (green, green–yellow, blue–green, purple–blue, grey, and white) were ineffective, i.e. had greater values as "p>0.1". In this case, it can be stated that "six colours did not have a statistically significant effect".

As seen in Tables 4 and 5, the values in the Bourdon Attention Test obtained by application of the ELE method give only the results of the effects of wall colours on attention regardless of the repeat-based learning effect. After the application of ELE method, the highest score was reached with "red–purple" wall colour (p<0.01). In other words, the red–purple colour has had the significant most positive effect on students' attention. This colour is followed by "yellow" colour with an increase of 1.885 points (statistically p<0.1). On the other hand, the "green" wall colour, which shows a very close score similar to the yellow colour with an increase of 1.84 points, does not give a statistically significant (p>0.1) result. After application of the ELE method, red, blue, purple, and orange colours have had negative values in terms of average effect without learning effect (reliable scores). These wall colours can be identified as colours that negatively affect student attention (Figure 8).

EMOTIONAL RESULTS

The students' responses to classroom wall colours in terms of emotional effects were determined by the "Environmental Colour Assessment (ECA)" form. It has "Semantic Differential Scale (SDS)" for adjectives and "Likert Scale (LS)" for preference of wall colours. Findings of the emotional response are given in Tables 6 and 7, as an arithmetic mean and standard deviation values in terms of SDS and LS.

Semantic Differential Scale findings: The data on the Semantic Differential Scale (SDS) were evaluated by the arithmetic mean method on all subjects ignoring the gender difference. The result of semantic profiles of twelve colours was divided into three graphics for clearer perception. The first graphic involves the main five colours (red, yellow, blue, green, and purple), the latter graphic involves five mid-colours (Orange, Green–Yellow, Blue–Green, Purple–Blue, Red–Purple) and the third graphic involves two achromatic colours (white and grey).

According to the arithmetic means of the Semantic Differential Scale (SDS), users' semantic responses to variables for each wall colour are shown in Figure 9a (red, yellow, green, blue, purple), Figure 9b (orange, green–yellow, blue–green, blue–purple, red–purple) and Figure 9c (grey, white). In this scale, where each variable is evaluated with two opposing adjectives and five intervals, the adjective pairs are graded from -2 to +2. The areas below the "0" axis define the negative references given by the users about the wall colour for each adjective and the areas above the "0" axis define the positive references.

The red, orange, green, green–yellow, blue–green, blue, and purple wall colours were perceived as "positive" for all

Table 6. Mean (M) and standard deviation (SD) values of semantic differential scale (SDS)

COLOURS		Adjectives / SDS									
		Ugly/ Beautiful	Boring/ Interesting	Unpleasant/ Pleasant	Dark/ Light	Lifeless/ Alive	Passive/ Active	Sour/ Sweet	Cold/ Hot	Heavy/ Light	Dirty/ Clean
Red	M	1.29	0.71	1.29	1.15	1.38	1.35	0.91	1.06	0.76	0.71
	SD	1.09	1.38	0.94	1.18	1.02	1.04	1.36	1.28	1.33	1.57
Yellow	M	0.59	0	0.71	0.88	0.56	0.56	0.41	-0.18	-0.44	-0.21
	SD	1.35	1.44	1.4	1.41	1.58	1.48	1.44	1.53	1.48	1.57
Green	M	1.18	0.56	1.06	0.68	0.85	0.97	1.18	0.65	0.35	1.06
	SD	1.27	1.42	1.28	1.34	1.48	1.14	1.14	1.39	1.5	1.35
Blue	M	1.38	0.91	1.12	1.38	1.35	1.03	1.24	0.85	0.59	1.06
	SD	0.99	1.31	1.2	1.1	1.1	1.19	1.16	1.26	1.54	1.28
Purple	M	1.09	0.82	0.97	1.09	0.91	0.76	1.24	0.74	0.74	0.52
	SD	1.44	1.47	1.49	1.31	1.4	1.37	1.28	1.48	1.48	1.58
Orange	M	1.22	0.91	1.01	0.88	1.15	0.69	1.01	0.58	0.54	1.27
	SD	1.13	1.16	1.26	1.3	1.26	1.41	1.3	1.48	1.42	1.15
Green–yellow	M	1.29	1.06	0.93	1.1	1.17	0.8	1.09	0.51	0.75	0.97
	SD	1.04	1.08	1.18	1.19	1.24	1.33	1.2	1.36	1.28	1.34
Blue–green	M	1.22	0.86	1.14	0.91	1.01	0.81	1.06	0.59	0.78	0.87
	SD	1.06	1.3	1.1	1.26	1.38	1.37	1.15	1.45	1.43	1.84
Purple–blue	M	0.78	0.22	0.51	0.09	0.22	0.21	0.35	-0.04	0.31	0.31
	SD	1.3	1.49	1.32	1.54	1.63	1.41	1.53	1.34	1.51	1.54
Red–purple	M	0.42	0.18	0.29	0.11	0.21	0.03	0.58	0.12	0.39	0.33
	SD	1.41	1.52	1.61	1.62	1.67	1.51	1.5	1.49	1.63	1.54
Grey	M	-0.15	-0.39	-0.45	-0.52	-0.7	-0.61	-0.64	-0.64	-0.61	-0.97
	SD	1.7	1.77	1.7	1.7	1.61	1.66	1.67	1.6	1.52	1.43
White	M	0.18	-0.18	0.13	0.22	0.21	0.09	-0.01	-0.19	0.06	0
	SD	1.47	1.51	1.58	1.56	1.73	1.49	1.58	1.56	1.4	1.78
Total	M	0.87	0.49	0.71	0.63	0.69	0.52	0.7	0.32	0.4	0.54
	SD	1.34	1.46	1.42	1.47	1.54	1.46	1.45	1.49	1.5	1.61

Table 7. Arithmetic mean (M) and standard deviation (SD) values of Likert scale (LS)

		Red	Yellow	Green	Blue	Purple	Orange	Green–yellow	Blue–green	Purple–blue	Red–purple	Grey	White	Total
Satisfaction (LC)	Mean	7.82	6.47	8.12	7.91	7.91	7.7	7.86	9.43	6.06	6.3	4.72	5.43	7.16
	SD	2.94	3.52	2.65	2.52	3.07	2.76	2.65	12.38	2.98	3.02	3.77	3.29	5.17

adjectives. While purple–blue and red–purple wall colours were also perceived as "positive", they were not as much as the others. The yellow (5Y 7/8) wall colour was perceived as bright, vivid, and energetic but in contrast, it was also perceived as dirty by the students.

The students characterised the white (N 9/0) colour around the zero axis and did not give a clear definition for it. Students' approach to this wall colour was slight as light, alive and active, but can be overall described as "indecisive" or "neutral" (Figure 9c). As seen from the graph in Figure 9c, the students found the grey (N 7/0) wall colour negative for each adjective and evaluated it to be particularly lifeless and dirty.

Likert Scale Findings: According to the arithmetic average results of the Likert scale given in Table 8, the student's favourite colour was the green–yellow (5GY 7/8) wall colour (90.88 points). The blue–green (5BG 7/8) wall colour followed as the second (89.41 points) and the orange (5YR 7/8) wall colour (84.55 points) came next. Students' least favourite colour for the classroom wall was medium grey

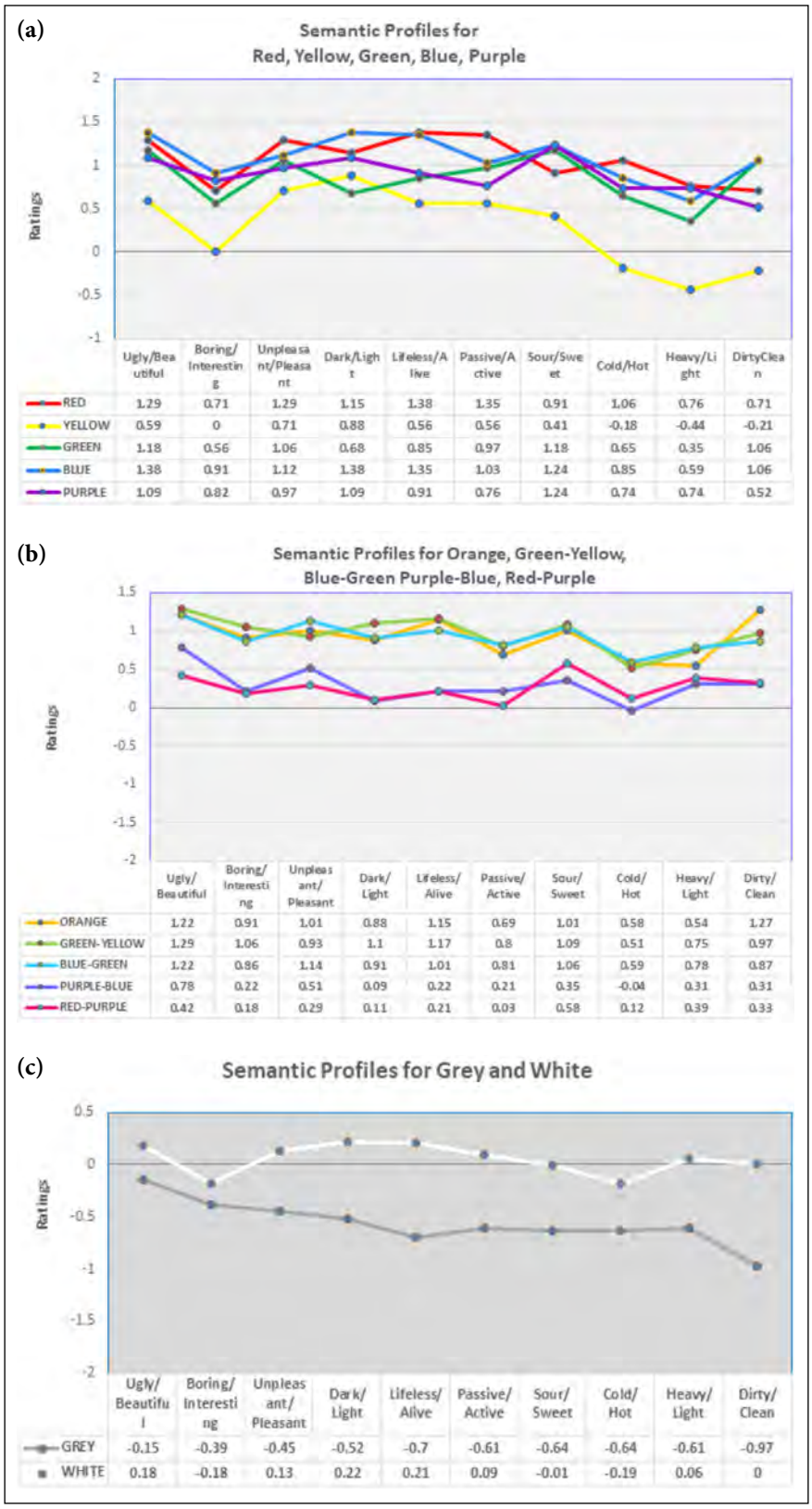

Figure 9. **(a)** Results of semantic differential scale (SDS) of red, yellow, green, blue, purple colours. (b) Results of semantic differential scale (SDS) of orange, green–yellow, blue–green purple–blue, red–purple colours. (c) Results of semantic differential scale (SDS) of achromatic (grey and white) colours.

Table 8. Likert scale satisfaction levels (%) of wall colours

	Wall Colour	Satisfaction Level (%)
1st	Green–yellow (5GY 7/8)	90.88
2nd	Blue–green (5BG 7/8)	89.41
3th	Orange (5YR 7/8)	84.55
4th	Green (5G 7/8)	81.18
5th	Purple (5P 7/8)	82.35
6th	Blue 5B 7/8)	80.88
7th	Red (5R 7/8)	76.47
8th	White (N 9/0)	67.00
9th	Purple–blue (5PB 7/8)	65.00
10th	Red–purple (5RP 7/8)	66.18
11th	Yellow (5Y 7/8)	64.41
12th	Grey (N 7/0)	47.27

Figure 10. Likert scale satisfaction level (%) result as graphic.

(N 7/0) colour with 47.27 points. The scores were graded out of 100. A graphical representation of the Likert scale findings according to colour is presented in Figure 10.

BEHAVIOURAL RESULTS

Behavioural responses were evaluated according to the class teacher observation forms. This investigation is a qualitative assessment and was carried out to support the research. The evaluation of the information in the Teacher Observation Form can be summarised as follows:

Red (5R 7/8) Wall Colour: In the red wall environment, substantial fidgetiness was observed among the students. The students had been stimulated, their movements were more intense and disturbing than ever. They had trouble focusing on lectures and practices and talked among themselves without raising their hands. As a result, the teacher had difficulty in establishing discipline and the students were adversely affected by this classroom wall colour.

Yellow (5Y7/8) Wall Colour: The review of the teacher for the yellow wall colour was that this colour energised and cheered the students but also caused an increase in their attention to the lessons.

Green (5G 7/8 Wall Colour: For this wall colour, the teacher stated that the students were calmer when compared to their behaviours for the red and yellow wall colours, and their transition from an energetic activity to a more focused one was fast and they were surprisingly quick in adapting to the lesson. The teacher also underlined the observation of the students' noticeable calmness in this colour environment.

Blue (5B 7/8 Wall Colour): In the blue environment, the students were more compliant with the classroom and school rules. They took the warnings into consideration more quickly and they did their work efficiently.

Purple (5P 7/8) Wall Colour: The teacher stated that the students were stagnant, especially when they needed to study alone, but they generally talked a lot. In the blue environment, the course contents of the students were moderate.

Orange (5YR 7/8) Wall Colour: The orange wall colour made the students' energies surge in a positive way, they were cheerful and loving, and they participated in the lesson more.

Green–yellow (5GY 7/8) Wall Colour: In the green–yellow wall colour environment, the focus of students on the lesson increased, their complaints were reduced, they looked peaceful and the noise they made even while studying on their own was reduced, but the female students specifically were a little restless.

Blue–Green (5BG 7/8) Wall Colour: For the blue–green wall colour, the teacher stated that there was chaos in the classroom and it turned into a noisy environment in a very short time. In addition, the complaints and fights within the classroom had increased and she defined these observations as puzzling.

Purple–Blue (5PB 7/8) Wall Colour: The teacher stated that the overall processes and the courses were run as normal in the classroom. The usual changes were observed, there was no significant behavioural difference and there was no shift to the extremes in either a positive or a negative sense when compared with other wall colours.

Red–Purple (5RP 7/8) Wall Colour: In the week in which the red–purple wall colour was painted, a lot of activities had taken place in parallel with the children's day celebrations. The teacher reported that the students could concentrate on the subjects and activities very much and did not make any noise while studying on their own. After the completion of the experimental research, the teacher emphasised that she was most satisfied with the red–purple wall colour in terms of students' behaviour and attention.

Grey (5N 7/0) Wall Colour: The teacher noticed that, with the grey colour, the students were looking a bit numb and bored, their perception had slowed down, they did not

Table 9. General evaluation of responses towards wall colours

	Attention	Emotional		Behavioural
	Bourdon Attention Test	**Semantic Differential Scale**	**Likert Scale**	**Teacher Observation**
RED	Students' attention level scores (p<0.1, significant) decreased by an average of 2.3547	Red wall colour was found pleasant, lively, bright, active and warm, and "effective"	Ranked 7th out of 12 by 74.47 scores	The students stimulated and were fidgety, their movements have become more uncontrolled and intense than ever, and have had difficulty in focusing, the teacher has had difficulty in discipline
		Attention ↘ Emotional ↗ Behavioural ↘↘		
YELLOW	Students' attention level scores (p<0.1, significant) increased by an average of 1.8856	Students described the colour yellow light, lively and alive, but also somewhat dirty	Ranked 11st out of 12 by 64.41 scores	The students have elicited active and cheerful behaviour and their attention to the lessons increased
		Attention ↗ Emotional ↘ Behavioural ↗		
GREEN	Students' attention level scores (p>0.1, p=0.158) increased by an average of 1.8402	Green colour is described as "positive" for all adjectives	Ranked 5th out of 12 by 81.18 scores	Students were calm and focused swiftly to the lesson
		Attention – Emotional ↗ Behavioural ↗		
BLUE	Students' attention level scores (p<0.05, significant) declined by an average of 2.5835	Blue colour is described as "positive" for all adjectives	Ranked 6th out of 12 by 80.88 scores	They were calm, disciplined and have done their work efficiently
		Attention ↘ Emotional ↗ Behavioural ↗		
PURPLE	Students' attention level scores (p<0.01, significant) declined by an average of 4.03176	Purple colour is described as "positive" for all adjectives	Ranked 4th out of 12 by 82.35 scores	Students were stagnant, but generally talked a lot. The course contents of the students were moderate
		Attention ↘ Emotional ↗ Behavioural ↘		
ORANGE	Students' attention level scores (p<0.01, significant) declined by an average of 14.0091	Orange colour is defined as clear, beautiful and positive for other adjectives	Ranked 3th out of 12 by 84.55 scores	Students' energies have surged in a positive way, they were cheerful and loving, and they participated in the lesson more
		Attention ↘ Emotional ↗ Behavioural ↗		
GREEN–YELLOW	Students' attention level scores (p>0.1) decreased by an average of 0.4928	Green-yellow colour is called as "positive" for all adjectives	Ranked 1st out of 12 by 90.88 scores	The focus of students on the lesson increased, their complaints were reduced, they looked peaceful and calmer, but also the female students specifically were a little restless
		Attention ↗ Emotional ↗ Behavioural ↘		
BLUE–GREEN	Students' attention level scores (p>0.1) surged by an average of 1.2310	Blue-green colour is described as "positive" for all adjectives	Ranked 2nd out of 12 by 89.41 scores	There was chaos in the classroom, the complaints and fights within the classroom have had increased as puzzling
		Attention ↗ -- Emotional ↘ Behavioural ↗		
PURPLE–BLUE	Students' attention level scores (p>0.1, p=0.852) surged by an average of 0.1646	The colour is found to be "less positive" at close values for each adjective	Ranked 10th out of 12 by 65 scores	The overall processes and the courses were run as normal in the classroom. There was a balanced situation in the classroom
		Attention ↘ -- Emotional ↘ Behavioural -- ↗		
RED–PURPLE	Students' attention level scores (p<0.01, significant) increased by an average of 3.3995	The colour is found to be "less positive" at close values for each adjective	Ranked 9th out of 12 by 66.18 scores	The students could concentrate on the subjects and activities very much and did not make any noise while studying on their own
		Attention ↗ Emotional ↘ Behavioural ↗		
GREY	Students' attention scores (p>0.1, p=0.94) increased on average 0.0786, meaningless and insignificant	Grey colour is described as "negative" for all adjectives	Ranked 12th out of 12 by 66.18 scores	The students were looking a bit numb and bored, their perception have had slowed down, not make a lot of noise, and their communication capabilities have decreased
		Attention ↘ -- Emotional ↘ Behavioural ↘		
WHITE	Students' attention scores (p>0.1, p=0.271) decreased on average 0.7225	White colour is described as neither negative nor positive for all adjectives	Ranked 8th out of 12 by 67 scores	The students have not behaved consistently, they could focus studying on their own, but also even a small event that developed could suddenly has pushed the students into uncontrolled behaviours
		Attention ↘ -- Emotional ↘ Behavioural ↘		

make a lot of noise, and their communication capabilities decreased.

White (5N 9/0) Wall Colour: The teacher stated that the most remarkable point about the students was that they did not

behave consistently, they were focused even while studying on their own, and even a small event that developed could suddenly eliminate all the calmness and control, and pushed the students into uncontrolled behaviours. The teacher also stated that during the first few days with the white wall colour, while the students were concerned about the cleanness of the wall, they were not stable about keeping the wall clean, yet the wall remained less dirty than normal.

COMPARATIVE EVALUATION OF RESPONSES TOWARDS WALL COLOURS

The results of the study show that the effects of each wall colour on students occur differently in terms of attention, emotional and behavioural. In this sense, the responses of three different attitudes given by students to twelve different colours were evaluated collectively and comparatively summarised in Table 9.

DISCUSSION

In this study, in a primary school classroom painted in twelve different colours, one each week, students completed attention tests and environmental colour assessments throughout twelve weeks. In this process, the classroom teacher made evaluations by observing the behaviours of the students. Many significant results were obtained from the study in terms of attention, emotional and behavioural response. These outcomes have exposed similar but sometimes contradictory results to the other literature studies.

According to the environmental colour studies in the literature is that cold colours having shorter wavelengths such as blue and purple have a calming effect on people, while warm colours having longer wavelengths such as red, orange, and yellow have a stimulating effect on people (Thönes, 2018). The behavioural results of this study also show that the red wall colour stimulated the students and negatively affected their classroom behaviours. Similarly, the calming effect of the blue colour in the literature was also observed in this colour environment during the experimental process.

Al Ayashi et al. found that the performance of subjects increased in the red, blue and yellow environments (Al Ayashi et al., 2016). However, for our study, the participants' attention decreased in red and blue colour but increased with yellow colour. In contrast to the study of Küller, in our study, performance in the red environment decreased (Küller, 2009). Contrary to our research, in the study by Baytin et al. in the week when the yellow and green–yellow wall colour was applied, a decrease in the level of attention of the subjects/students was observed (Baytin et al., 2005).

The results of our research showed that the blue wall colour was satisfied by the students but this colour environment significantly reduced their attention. On the other hand, Kwallek et al. found that the blue colour decreased the attention, but in the study by Küller et al. on offices and in Al-Ayashi et al.'s experimental studies, it was observed that the subjects became calmer but their performance had increased in the blue wall-coloured environment (Kwallek et al., 1996; Küller et al., 2009; Al-Ayashi et al., 2016).

In contrast to the results of this study, subjects preferred orange wall colour as the least favourite colour in the studies of Kwallek and Wang. However, the preference for the orange wall colour as one of the most admired colours for the design studio by students in Baytin is parallel with this study (Kwallek et al., 1996; Wang, 2008). As in Yıldırım's study, grey was the least admired, boring and cold wall colour in this study, as well. Purple wall colour, which is one of the favourite colours, was the most admired wall colour for the class in Baytin's study (Baytin et al., 2005; Yildirim et al., 2007).

According to the study realised by Kwallek, the result that purple environment colour reduces attention is parallel with our study. In the study by Baytin et al., it was concluded that the students preferred the purple wall colour the most, and also there was an increase in the attention level of the students during the week when the purple, and orange wall colour was applied. In terms of attention, this study does not give the same result as Baytin's study (Kwallek et al., 1996; Baytin et al., 2005).

Evaluation of the behavioural attitude towards classroom colours was limited only to the observation of the classroom teacher. This evaluation was qualitative and it could not possible to analyse the result statistically. In addition, behavioural responses may change depending on the mood of the subjects during the observation period. In this context, the reason for including this evaluation in the study was to gather more detailed information and to support the overall study. The results of the qualitative assessment in this study may also help to form the hypotheses of other studies.

While determining the effects of wall colour on students' attention, the results of the study could be tested with a control group. In this case, the learning function of the control group should also be determined and its suitability with the learning function of the experiment group should be compared. It was not possible to test the results with an experimental group in this study.

CONCLUSIONS

The results of our study showed that come forward red-purple is the most positive colour within the scope of attention and behavioural response, and this wall colour has produced the highest increase in attention scores in

the relevant age group. In this wall colour environment, it was seen that there was a positive and parallel relationship between the attention and behaviours of the students. After the experiment was completed, the class teacher emphasised that she was most satisfied with the red–purple wall colour in terms of classroom behaviour and attention. Despite all these positive results in terms of cognitive (attention) and behavioural aspects, students were not satisfied with this colour in terms of the affective aspect.

The most negative colour in terms of impact on attention is the "orange (5YR 7/8)" wall colour, which has the lowest result in attention test scores. On the other hand, this wall colour was highly appreciated by the students and their behavioural attitudes also increased positively. The results of the study indicate that the most negative wall colour effective in both affective and behavioural contexts is grey (N 7/0). For the grey wall colour, the affective effects shifted slightly to a more negative area, as the students did not like the wall colour, they also became numb and silent, and their communication skills declined. This wall colour's results show that it was the least preferred colour in terms of affective aspects, it received negative responses for all the adjectives in the semantic assessment, and in terms of behavioural aspects, the students were tired, distressed, and had difficulty focusing.

The repetition of the Bourdon Attention Test, which was administered many times including the pre- and post-test, has led to positive increasing test score results. Since the main purpose of measuring the attention effect in the experiment was to assess the effect of the wall colour only, the "increasing scores due to repeat-based learning" were subtracted from these scores and obtained more reliable scores. For this purpose, the ELE (Elimination of the Learning Effect) method which was specifically developed for this study was used by utilising the existing statistical methods. This approach may guide other studies to obtain more accurate results in eliminating the repeat-based learning effect while measuring the effects of multiple dependent variables on attention, especially if there is no control group.

Within the scope of the effects of space colours on individuals, a study-specific method was applied in this field experiment research on the effect of classroom wall colour on 8–9-year-old students. In the context of the effects of classroom wall colour in educational spaces, this study was conducted to determine student attitudes that will support learning positively and it is aimed to contribute to the education sector. Apart from this research in which classroom wall colours and 8–9-year-old students were taken into consideration, planning of studies for different age groups, different socio-cultural levels and interiors with different functions will contribute to architectural colour science in terms of determining the indoor surface colours.

This article is based on the PhD Dissertation entitled İlköğretim Okullarında Sınıf Duvar Renginin Öğrencilerin Duyuşsal, Bilişsel ve Davranışsal Tepkilerine Etkisinin Saptanması by Fazıla Duyan and completed under the supervision of Prof. Dr. Rengin Ünver at Yıldız Technical University, Department of Architecture in 2016.

Acknowledgement
The authors gratefully wish to thank the Yıldız Technical University Scientific Research Projects Coordination Unit (Grant Number: 2013-03-01-DOP01), the students participated to the experiment, Ömer Bilen who contributed to statistical evaluations, and the class teacher Zeynep Karipçin for supporting this research.

ETHICS: There are no ethical issues with the publication of this manuscript.

PEER-REVIEW: Externally peer-reviewed.

CONFLICT OF INTEREST: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

FINANCIAL DISCLOSURE: This study is supported financially by Yıldız Technical University Scientific Research Projects Coordination Unit.

REFERENCES

Adams, F. M. and Osgood, C. E. (1973). A cross-cultural study of the affective meaning of colour. Journal of Cross Culture Psychology 14(2):135–156. [Google Scholar].

Ainsworth, R. A., Simpson, L., and ve Cassell, D. (1993). Effects of three colour in an office interior on mood and performance. Perceptual and Motor Skills 76:235–241.

Al-Ayash, A., Kane, R. T., Smith, D., and Green-Armytage, P. (2016). The influence of colour on student emotion, heart rate, and performance in learning environments. Colour Research and Application 41(2):196–205. https://doi.org/10.1002/col.21949.

Anderson, L. W. (1988). Attitudes and their Measurement. Keeves, J. P. (Ed.), Educational research, methodology and measurement: An international handbook. New York: Pergamon Press.

Baytin, C., Kiran, A., and Tunbis, M. (2005). Colour preferences in architectural design studios. Architectural Science Review 48(4):317–328. DOI: 10.3763/asre.2005.4839.

Birren, F. (1973). The practical application of light and colour to human environments. Proceeding, Aıc Colour 1973, London, pp. 179–189. https://www.aic-color.org/resources/Documents /aic1973proc-reduced.pdf.

Brainerd, C. J. (1978). Piaget's theory of intelligence. Englewood Cliffs (NJ): Prentice-Hall. Google Scholar.

Brickenkamp, R., Bleck, I., Dzida, W., Heinrich, P., Hellwig, H. J., Krüger- Naumann, R., Rothe, R., Speck,

D., Speck, R., and Thiede, L. (1975). Handbuch psychologischer und paedagogischertests. Göttingen: Verlag für Psychologie.

Carlson, J. (1973). Cubic learning curves: Precision tool for labor estimating. Manufacturing Engineering and Management 67(11):22–25.

Groat, L. and Wang, D. (2013). Architectural Research Methods. Published by John Wiley, 2013, ISBN: 978-0-470-90855.

Hebb, D. (1961). Distinctive features of learning in the higher animal. In Brain mechanisms and learning, Edited by: Delafresnaye, J. F. 37–46. Oxford, UK: Blackwell. Google Scholar.

Ishihara, S. (1990). İshihara's Tests for Colour Blindness, 38 Plates Edition.

Jaber, M. Y. and Guiffrida, A. L. (2004). Learning curves for processes generating defects requiring reworks. European Journal of Operational Research 159(3):663–672. DOI:10.1016/S0377-2217(03)00436-3.

Jaber, M. Y. (2011). Learning Curves, Theory, Models, and Applications. CRC Press, Taylor & Francis Group. International Standard Book Number: 13:978-1-4398-0740-8 (eBook-PDF).

Johnson, A. J., Dygacz, A., and Miles, C. (2017). Hebb repetition effects for non-verbal visual sequences: determinants of sequence acquisition. Memory 25(9). https://proxy.dogus.edu.tr:2071/10.1080/09658211.2017.1293692.

Joshi, A., Kale, S., Chandel, S., and Pal, K. D. (2015). Likert scale: Explored and explained. Current Journal of Applied Science and Technology 7(4):396–403. DOI: 10.9734/BJAST/2015/14975.

Küller, R. (1972). A semantic Model for Describing Perceived Environment. National Swedish Institute for Building Research, Document D12, Stockholm.

Kuller, R. (1973). Beyond Semantic Measurement, Architectural Psychology, ed. R. Küller. Lund Procedings of 2. International Architectural Psychology Conference, Stroudsburg, Pa., Dowden, Hutchinson & Ross, 181-97.

Küller, R., Mikellides, B., and Janssens, J. (2009). Colour, arousal, and performance. A comparison of three experiments. Journal of Colour Research and Application 34(2):141–152. https://doi.org/10.1002/col.20476.

Kwallek, N., Lewis C. M., Lin-Hsiao, Jw., and Woodsoon D. H., (1996). Effects of nine monochromatic office interiors. Colour Research and Application 21(6). Google Scholar.

Luke, J. T. (1996). The Munsell Colour System a Language for Colour. NY, New York: Fairchild Publications.

Manav, B., Kutlu, R., and Küçükdoğu, M. Ş. (2009). An Experimental Study on the Appraisal of an Office setting with Respect to Illuminances and Wall Colors. 11th European Lighting Conference, Lux Europa 2009, İstanbul.

Munsell conversion software. 2016 version. http://wallkillcolor.com/Munsell16/index.htm.

Munsell, A. H. (1971). A Colour Notation, Munsell Colour Company, Baltimore, ABD.

Osgood, C. E., Suici, G. J., and Tannenbaum, P. H. (1957). The Measurement of Meaning. Chicago and London: Urbana University of Illinois Press.

Park, J. G. P. (2013). Correlations between colour attributes and childrens' colour preferences. Colour Research and Application 39(5):452–462. https://doi.org/10.1002/col.21801.

Pusic, M., Boutis, K., Hatala, R., and Cook, D. (2015). Learning curves in health professions education. Journal of the Association of American Medical Colleges 90(8):1034–1042. doi:10.1097/ACM.0000000000000681.

Pusic, M. V., Boutis, K., Pecaric, M. R., Savenkov, O., Beckstead, J. W., and Jaber, M. Y. (2016). A primer on the statistical modelling of learning curves in health professions education. Advantages in Health Sciences Education. 22(3):741–759. doi:10.1007/s10459-016-9709-2.

Pressey, S. L. (1921). The influence of colour upon mental and motor efficiency. American Journal of Psychology 32:327–356. doi: 10.2307/1413999.

Szmalec, A., Duyk, W., Vandierendonck, A., Barberá, A., and Mata & Mike P. A. (2009). The Hebb repetition effect as a laboratory analogue of novel word learning. The Quartely Journal of Experimental Psychology 62(3):435–443. https://proxy.dogus.edu.tr:2071/10.1080/17470210802386375.

Thönes, S., Castell, C. V., Iflinger, J., and Oberfeld, D. (2018). Colour and time perception: Evidence for temporal overestimation of blue stimuli. Scientific Reports 8:1688. https://www.nature.com/articles/s41598-018-19892-z.

Tikkanen, K. T. (1976). A study of emotional reactions to light and colour in a school environment. Lighting Research & Technology 8(1). https://doi.org/10.1177/1477153576008001010.

Wang, H. and Russ, R. R. (2008). Computer classroom wall colour preference and the relationship with personality type of college students. Colour: Design & Creativity 4(2):1–13.

Yıldırım, K., Hid Küller, Hidayetoğlu, M. L., and Çapanoğlu, A. (2011). Effects of interior colors on mood and preference: Comparisons of two living rooms. Perceptual and Motor Skills 112(2): https://doi.org/10.2466/24.27.PMS.112.2.509-524.

Yıldırım, K., Çağatay, K., and Ayalp, N. (2015). Effect of wall colour on the perception of classrooms. Indoor and Built Environment 24 (5):607–616.

Megaron, Vol. 17, No. 4, pp. 644–657, December 2022

Megaron
https://megaron.yildiz.edu.tr - https://megaronjournal.com
DOI: https://doi.org/10.14744/MEGARON.2022.23356

Article

Determining the impact of horizontal and vertical fins of office facades on visual and thermal comfort

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ARTICLE INFO

Article history
Received: 05 October 2022
Revised: 08 October 2022
Accepted: 11 November 2022

Key words:
horizontal fin; solar control; thermal comfort; vertical fin; visual comfort

ABSTRACT

A high degree of transparency is customary in modern building design, and horizontal or/and vertical fins are often employed for shading the building envelope. This study proposes a method to limit horizontal and vertical fin ranges according to current visual and thermal comfort standards. The study was carried out considering a module office room, which is assumed to be located in an office building, and one long wall is transparent. The minimum and maximum fit ranges were determined for four glazing types and seven directions the transparent wall faces (a total of 112 cases). The criteria suggested in the standard EN 17037 have been considered for visual comfort. In the first stage of providing thermal comfort, solar control was implemented to limit the fin range, that is, the annual shading need and solar gain were identified depending on the direction. Afterward, the adaptive comfort method recommended for naturally ventilated spaces in the ASHRAE 55-2017 standard was applied to evaluate the comfort conditions of the fit ranges. The detailed analysis revealed that the optimum direction regarding thermal and visual comfort is south, and the fin type in this direction is horizontal. Vertical fins in the west, east, northwest, and northeast directions provide positive outcomes. The performance of the horizontal and vertical fins is close to each other in the southwest and southeast directions. The results for the module office room can be used to take principle decisions for fit design.

Cite this article as: Süt G, Dokuzer Öztürk L. Determining the impact of horizontal and vertical fins of office facades on visual and thermal comfort. Megaron 2022;17(4):644–657.

INTRODUCTION

The design of a comfortable building consuming energy at a minimal level is a complex process involving a large number of interdependent variables. In a complex system consisting of criteria that often contradict each other, it is essential to make an integrated design. Determining the limitations that meet the minimum conditions of comfort criteria provides a great deal of convenience to the designer. Solar control, in other words, benefiting from the sun and/or avoiding the sun depending on the conditions, is a passive design strategy that directly affects thermal and visual comfort. Solar radiation affects the illuminance generated by natural light, and therefore the energy to be consumed in electric lighting. In addition, depending on climatic and seasonal conditions, it also affects the heating and/or

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Published by Yıldız Technical University Press, İstanbul, Turkey
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cooling load. The main parameters affecting the heating and cooling loads are the transparency ratio and shading property of the building envelope. In recent years, a high transparency ratio is quite common in modern building design. Transparent areas in the building envelope are the most sensitive element of the structure and create the greatest effect on the heat flow balance (Olgyay & Olgyay, 1957). Increasing the transparency ratio in the building envelope increases the daylight illuminance level and solar gain indoors, while it may also cause unwanted solar gains and glare. One of the most effective ways to reduce the solar load in transparent areas is to block direct incoming solar radiations before they reach the glazing (ASHRAE, 2013). However, in the design of shading elements, it is important to establish a balance between "benefiting from daylight and solar energy" and "unwanted solar gain and glare control". For this reason, building energy consumption can be reduced with an effective passive solar design approach which will be used at the early design stage and will benefit from solar energy and daylight while avoiding their negative effects (DeKay & Brown, 2013).

The most up-to-date standard for the assessment of visual comfort in interiors is "EN 17037: Daylight in Buildings". In the standard, the criteria for the assessment of daylight are listed as *"daylight provision, protection from glare, exposure to sunlight, and view out (i.e., visual connection with the external environment)"* (European Committee for Standardization, 2018, 2022). The studies carried out within the scope of this standard basically cover the assessment of sample spaces based on daylight criteria (Paule et al., 2018; Yılmaz, 2019). As a different approach, in his study, Schouws (2022) investigated how much influence the European standard in question had on the energy consumption of a typical office building and whether BREEAM and LEED requirements could still be met (Schouws, 2022). Rasmussen and Pedersen (2019), on the other hand, showed the difficulties that designers face when trying to simulate building performance by taking into account daylight, indoor climate, and landscape.

There are many standards for indoor thermal comfort such as ISO 7730, ASHRAE 55, EN 15251, and CIBSE (ASHRAE, 2013; CIBSE, 2006; EN 15251, 2007; ISO, 2005). In these standards predicted mean votes (PMV) thermal comfort model and adaptive comfort model are included. Based on the temperature of the indoor environment, air movement speed, average radiative temperature, relative humidity, activity level of people, and clothing insulation values, Fanger created the PMV model in which he transferred the satisfaction states of individuals to numerical data (Fanger, 1970). The PMV thermal comfort model, created with a limited number of users in an air-conditioned laboratory environment, was designed for use in buildings that do not have natural ventilation. Therefore, in buildings with different climate types or natural ventilation, it can determine the level of thermal comfort as colder or warmer than it is (Nicol, 2004; Rijal et al., 2017; Wu et al., 2017). On the other hand, the Adaptive Comfort model proposed by Dear and Brager was created by making 21000 measurements in 160 buildings, most of which are offices. In this model, indoor temperatures or acceptable temperature ranges are associated with outdoor meteorological or climatic parameters. This method defines acceptable thermal environments for areas that are naturally ventilated only by user control and do not have any mechanical cooling and heating systems operating (de Dear and Brager, 1998). Since there is no mechanical heating and cooling system, passive climate-based design approaches are more applicable (Nicol et al., 2012; Parkinson et al., 2020). Passive design approaches can be carried out using traditional design tools or climate-based computer programs. "Solar Path Diagrams" and "Shading Masks", which are among the traditional design tools, have created a framework in terms of passive design strategies, analysis, and calculations for shading elements in buildings and minimising overheating (Olgyay & Olgyay, 1957; Mazria, 1979). Thanks to the development of technology, climate-based software can combine climate data with traditional design tools and translate them into meaningful graphics.

In recent years, different design approaches have been developed, especially regarding shading and shaping fins for facade aesthetics (Kuhn, 2017). The most common method used for evaluating the fins made for shading purposes in terms of different criteria is the genetic algorithm. Genetic algorithms are the most advanced improvement method that works using mechanisms similar to evolutionary mechanisms observed in nature (Zitzler, 1999). Design alternatives are calculated based on different criteria and offer the most appropriate solution from a large number of options. The optimisation studies carried out in this direction have been usually limited to a single space (Manzan, 2014; Manzan & Padovan, 2015; Khoroshiltseva et al., 2016; Settino et al., 2020; Mangkuto et al., 2021; Luca et al., 2022; Noorzai et al., 2022). However, since the exposure to sunlight states of rooms facing in different directions are also different, the solution sets that meet the requirements for various criteria will also differ. Examining the literature, a study that takes into account all the criteria in the EN 17034 daylight standard along with thermal comfort was not found.

In this study, an approach was developed to determine the optimum fin range, providing visual and thermal comfort for offices facing in different directions. In this context, by taking into account also facade alignment, horizontal and vertical fins were considered separately in the rooms that receive light from one facade and two facades. The effect of obstacles outside the building was excluded from the scope of the study. In this article, the results obtained related to the rooms that receive light from only one facade are presented.

VISUAL AND THERMAL COMFORT CRITERIA

In the study, in terms of visual comfort criteria, it benefited from the European Standard "TS EN 17037". In the standard, the criteria for using daylight are specified as daylight provision, protection from glare, exposure to sunlight, and assessment for view out. The minimum, medium and high levels recommended in the standard for these four criteria are given in Table 1. It is important to meet the requirements for these criteria when determining the ranges of fins.

In this standard, the minimum requirement in terms of daylight illuminance is recommended as ≥ 300 lx. For spaces with vertical windows, it is expected that ≥ 300 lx illuminance will be provided at ≥50% of the reference plane of the room and that an illuminance of 100 lx will occur in 95% of the same plane. It is stated that these illuminances should be provided at ≥50% of daylight hours throughout the year. For the three levels of protection from glare, the recommended daylight glare probability (DGP) values are shown in Table 1. The criterion of exposure to sunlight is expressed by the number of hours the space receives direct sunlight on a cloudless reference day to be selected between February 1st and March 21st. The assessment of view out is performed based on the horizontal sight angle, the distance of external obstacles from the building, and the number of seen layers. The recommended values for these three magnitudes must be provided in at least 75% of the used area of the room.

In the study, two different methods were used to ensure thermal comfort. The first method is to conduct a solar control in order to limit the horizontal and vertical fin ranges; that is, the first method focuses on determining and limiting the annual need for shading and solar gain of the rooms under consideration. The second method used to assess the comfort conditions of fin ranges is adaptive comfort, which is recommended for naturally ventilated spaces in the ASHRAE 55-2017 standard. This method, which defines acceptable thermal environments for user-controlled naturally ventilated areas, includes the following restrictions:

- Any mechanical cooling or heating system is not working.
- The metabolic rate is between 1.0 and 1.3.
- The clothing insulation values are at least 0.5 clo and at most 1.0 clo.
- The average outdoor temperature should be at least 10°C (50°F) and no more than 33.5°C (92.3°F).

METHOD

There are many factors that determine the thermal and visual comfort of the interiors. In this study, the factors affecting visual and thermal comfort were grouped into two groups: constant and variable. The number of variable factors was limited in order to obtain interpretable and meaningful results. The approach followed in the study was to determine which values related to variable factors would be considered and to perform optimisation by determining the fin ranges that meet the requirements for thermal and visual comfort criteria. The decisions taken and the examinations carried out within the scope of the steps listed below the approach are explained in the following sections:

- Assumptions related to constant factors
- Assumptions related to variable factors
- Determination of the calculation method
- Process of conducting calculations

Assumptions Related to Constant Factors

The space considered within the scope of the study was designed as a module room for 24 people as a result of the examination of sample office rooms and design sources (Neufert& Neufert, 2012) (Figure 1). The assumptions made for the constant factors are listed below.

Constant factors related to the room:

- Location: Istanbul-Turkey
- Number of employees in the office: 24
- Length, width and ceiling height of the room: 15.00 m, 7.50 m, 3.00 m

Table 1. Assessment of daylight in interiors

Criteria for the assessment of daylight		Level of recommendation		
		Minimum	Medium	High
Daylight provision	Target illuminance	≥300 lx	≥500 lx	≥750 lx
	Minimum target illuminance	≥100 lx	≥300 lx	≥500 lx
Protection from glare		0.40<DGP≤0.45	0.35<DGP≤0.40	DGP≤0.35
Exposure to sunlight		1.5 h	3 h	4 h
Assessment for view out	Horizontal sight angle	≥14°	≥28°	≥54°
	Outside distance of the view	≥6 m	≥20 m	≥50 m
	Number of layers to be seen	1 layer	2 layers	3 layers

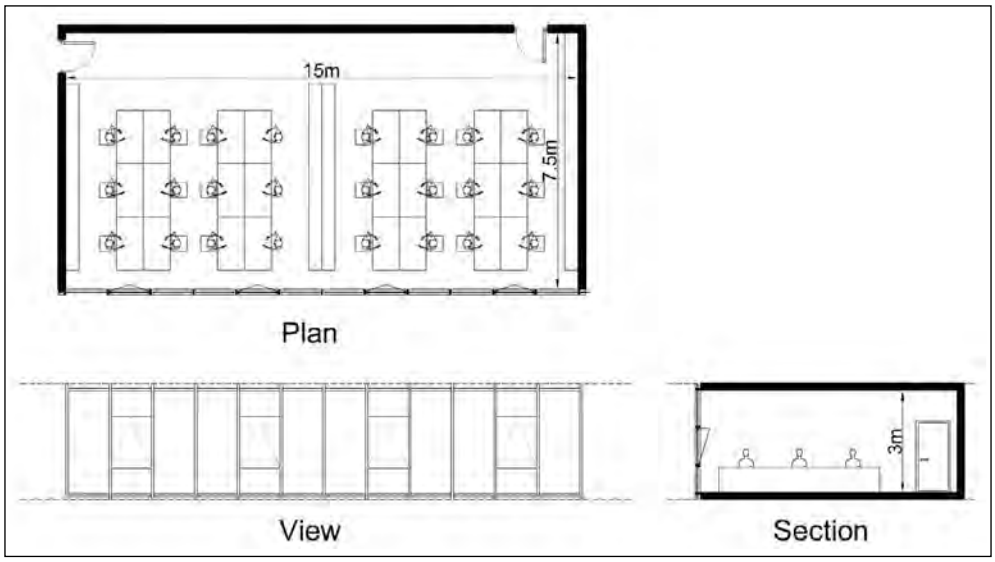

Figure 1. Module office room of 24 people.

- Window area: One long wall of the room
- Joinery dimensions and axle ranges in the window: 0.05 m × 0.15 m and 1.25 m
- Location of the joinery within the wall section: Outside the section
- Reflectance of wall, ceiling and floor of the room: 70%, 80%, 40%
- Days and times of the use of the room: five days a week, from 08:00 to 18:00
- The size, thickness and reflectance of the horizontal and vertical fins: 0.30 m, 0.025 m and 60%

Constant factors related to the light:

- Reference plane for illuminance calculations: Horizontal plane at a distance of 0.77 m from the floor and 0.50 m from the walls (table height: 0.75 m)
- Calculation points for horizontal viewing angle and glare: Eye-level at a distance of 1.20 m from the floor, at the middle level of the work table, and 10 cm from the table (Figures 2 and 4)
- Points considered related to exposure to sunlight: The closest point of the fins to the window glass (Figure 4)

Constant factors related to the heat:

- U value of the aluminium joinery: 3.3 W/m2K
- Number of people per area: 0.47 ppl/m2
- Metabolic rate: 1.0–1.3 met
- Occupants' clothing insulation: 0.5–1.0 clo
- Air speed: 0.2 m/s
- Natural ventilation settings: Minimum and maximum outdoor temperatures: 10°C and 33.5°C. Minimum and maximum indoor temperatures: 22°C and 24°C

Assumptions Related to the Variable Factors

In the study, the process was performed for four different types of window glazing and for the cases in which the window wall faces in seven different directions.

- The direction which the window wall is facing: South, east, west, southeast, southwest, northeast, northwest
- Glass type: 4 different glazing types (Table 2)

Determination of the Calculation Method

Various simulation programs were used to be able to provide optimisation between visual and thermal comfort criteria. The programs used and the path followed in the calculation are summarised below for light and heat.

Table 2. Types of glazing

#	Glazing type	Visible transmittance (%)	Solar heat gain coefficient	Thermal transmittance (W/m²K)
1	4 mm Low-E + 16 mm + 4 mm	79	0.64	1.3
2	4 mm Low-E + 16 mm + 4 mm	71	0.51	1.3
3	6 mm Solar Low-E + 16 mm + 6 mm	69	0.42	1.3
4	6 mm Solar Low-E + 16 mm + 6 mm	58	0.37	1.3

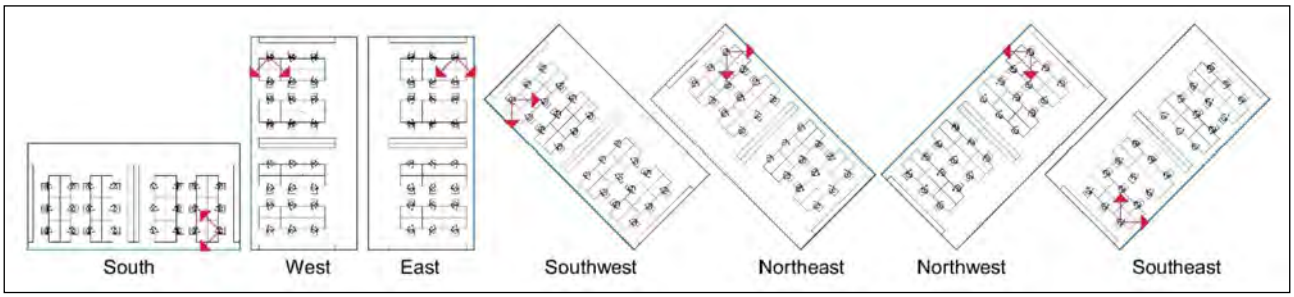

Figure 2. Change of camera position by directions in the glare calculation.

Simulation Programs Used for Light and the Assumptions

For the simulation analyses for daylight illuminance and glare analysis, Rhino 3D modeling tool, Grasshopper visual coding program, Honeybee, Ladybug plug-in programs, and Daysim and Radiance simulation engines were used. The assumptions within the scope of the study were processed into the program and the analysis of the fin ranges was performed. Climate data for Istanbul province was transferred from the EnergyPlus website by using the Ladybug plug-in program (https://energyplus.net/weather). Calculations of daylight illuminances were made at 10 cm interval points determined on the reference plane and the annual calculation results were analysed with daylight autonomy (DA) values. Daylight autonomy refers to the ratio of the time during which the targeted daylight illuminance is provided (or exceeded) at a certain point of the space to the duration of use of the space throughout the year in percentage terms (Illuminating Engineering Society, 2013).

In the EN 17037 standard, the daylight glare probability thresholds are allowed to exceed the referenced space by 5% of the annual period of use. Therefore, when performing glare analyses, it was taken into account that the degree of targeted daylight glare probability (DGP) could be exceeded by 130 hours per year (2600×0.05=130). The position of the person who would be most exposed to glare in the module office room was investigated, and the DGP was calculated for the person who would be most affected by the glare. The directions in which the person could turn his head to avoid glare depending on the conditions were accepted as ±45° with the direction of view. The change of the camera position based on the directions is shown in Figure 2.

To calculate the time for exposure to sunlight, the minimum altitude angle (γs, min) for the city of Istanbul and the day of March 21 was first investigated, and it was determined as 18.80° (EN 17037, 2018; Darula and Malikova, 2017). Then, using the SunCalc simulation program, the hours when the γs, min angle is in question for March 21 were determined as 8.51 and 17.33 (https://www.suncalc.org/). In more specific terms, the exposure to sunlight occurs between 8:51 and 17.33 hours on March 21. Taking the minimum altitude angle as a reference, horizontal and vertical fin ranges providing minimal, medium, and high degrees of sunlight exposure for seven different directions were determined.

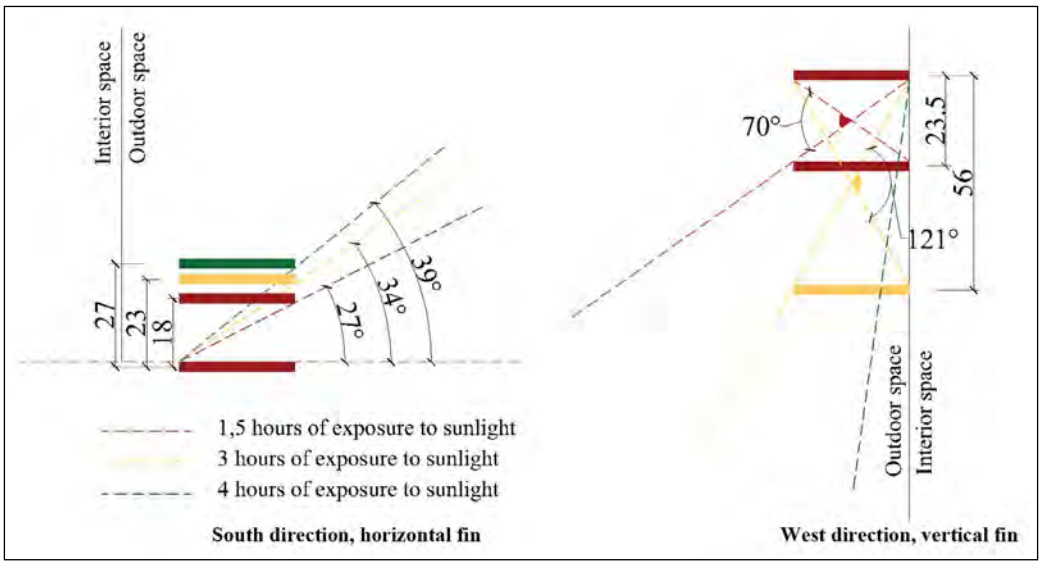

Figure 3. Horizontal and vertical fin ranges providing minimum, medium, and high level sunlight exposure.

These determined values were used in the optimisation related to visual and thermal comfort criteria. Horizontal fin ranges that provide minimal, medium, and high levels of sunlight exposure are shown as an example for the southern facade and vertical fin ranges are shown as an example for the western facade in Figure 3. In the southern direction, the horizontal fin ranges, which provide minimum (1.5 hours), medium (3 hours), and high (4.5 hours) exposures to sunlight, are 18 cm, 23 cm, and 27 cm, respectively. In the western direction, on the other hand, the vertical fin ranges, which provide minimal and medium sunlight exposures, are 23.5 cm and 56 cm, respectively; however, a high level of sunlight exposure can only be achieved without a fin.

Since obstacles outside the building were excluded from the scope of the study, only a horizontal viewing angle study was performed for the "view out" criterion. For each of the 24 users of the space, ranges that provided the minimum, medium and maximum level of horizontal viewing angle in the use of vertical fin were studied. Since the horizontal fins did not restrict the horizontal viewing angle, they were not considered. The observer's visual field was assumed to be a maximum of 124° horizontally (Panero & Zelnik, 1979). It was assumed that in rooms that receive light from a single facade where the line of sight was parallel to the window wall, the person will turn his head 90° towards the window to establish a visual connection with the external environment. Tangent rays were drawn from each observer's position to the vertical fins, and the horizontal viewing angle was determined by summing all the fin range angles located within the observer's visual field of 124° (±62°). The vertical fin ranges, which provided the minimum, medium, and high horizontal viewing angles at all observer points, were 12.5 cm, 23.44 cm, and 68.18 cm, respectively (Figure 4). These measures were used as data in determining the optimisation of visual and thermal comfort criteria.

Simulation Programs Used for Heat and Assumptions

For thermal comfort simulation studies, the Rhino 3D modeling tool, Grasshopper visual coding program, Honeybee, and Ladybug plug-in programs were used. The limitations of the adaptive comfort method and the assumptions determined for the office room were processed in the program and the analysis of the fin ranges was carried out. The climate data for the province of Istanbul were transferred from the EnergyPlus website by using the Ladybug plug-in program (https://energyplus.net/weather). By assuming that the module room is located in an office building, it was assumed that there was no heat exchange from the wall, floor, and ceiling components. These surfaces were defined as Adiabatic to the program. In accordance with the adaptive comfort approach, it was assumed that there was no heating, cooling, and mechanical ventilation system in the room.

In terms of solar control, in other words, for shading and solar gain, the Sun Shading Chart in the Climate Consultant program was used (https://www.sbse.org/resources/climate-consultant). In the program where Istanbul climate data was used and the adaptive comfort model was selected, the comfortable temperature range was expressed as 20°C-24°C. Based on this, the hours when it is >24°C throughout the year were evaluated as shading needs, and the hours when it is <20°C were evaluated as solar gain needs. In this context, the need for annual shading and utilisation of solar energy for each direction was obtained in hours. It is stated that when the dry thermometer temperature rises above 24°C degrees, thermal stress begins in the person (Matzarakis et al., 1999). By collecting the data in the winter-spring and summer-fall charts, which show the annual comfort conditions, the proportion of shading and solar gain for the direction and fin range was determined (Figures 5 and 6).

In order to determine and limit the annual shading needs and solar gains of the discussed rooms, a number of assumptions had to be made. The following assumptions, which vary by the sunlight exposure that depends on the direction and fin type, constituted data in terms of determining the optimal fin range.

- *The minimum horizontal fin range* is the range that provides maximum shading and allows maximum solar gain based on the sunlight exposure conditions of the building facade.
- *The minimum vertical fin range* is the range that allows solar gain at least at a rate of 50% (25% in the northwest and northeast directions).

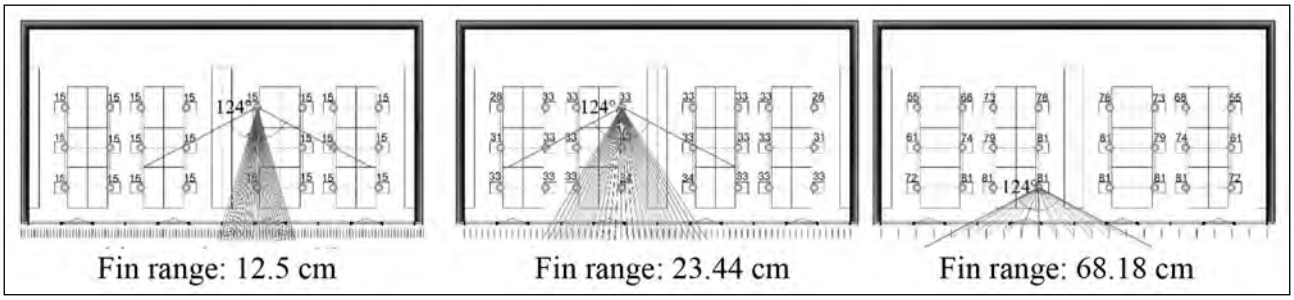

Figure 4. Vertical fin ranges providing minimum, medium and high level horizontal viewing angle.

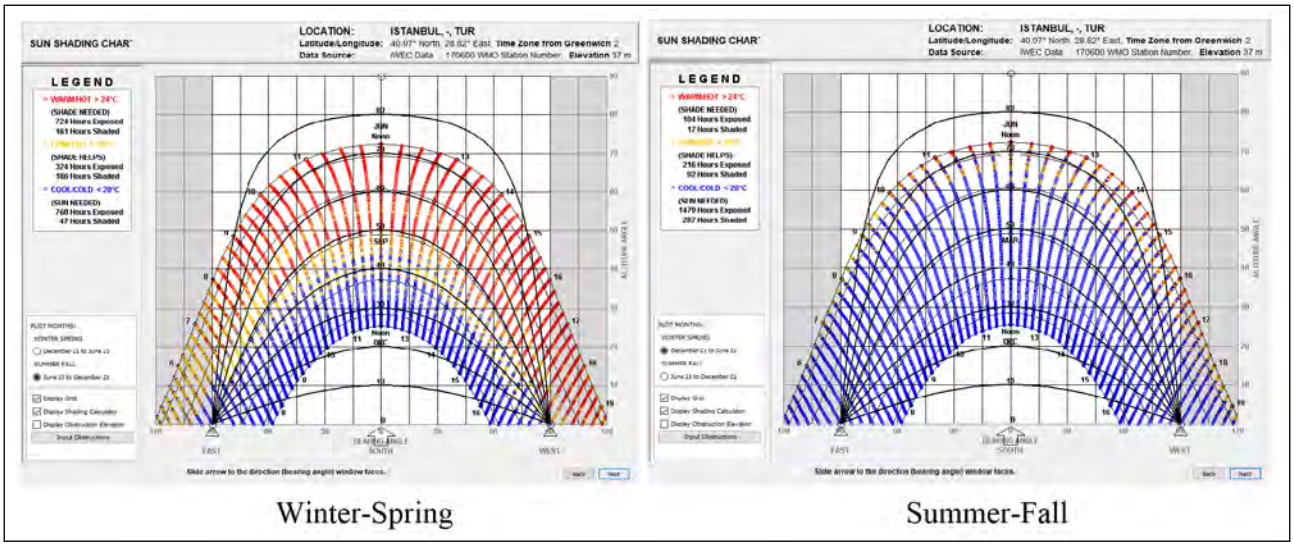

Figure 5. An example of solar control analysis with Sun Shading Chart: The situation of sunlight exposure without fin on the south facade.

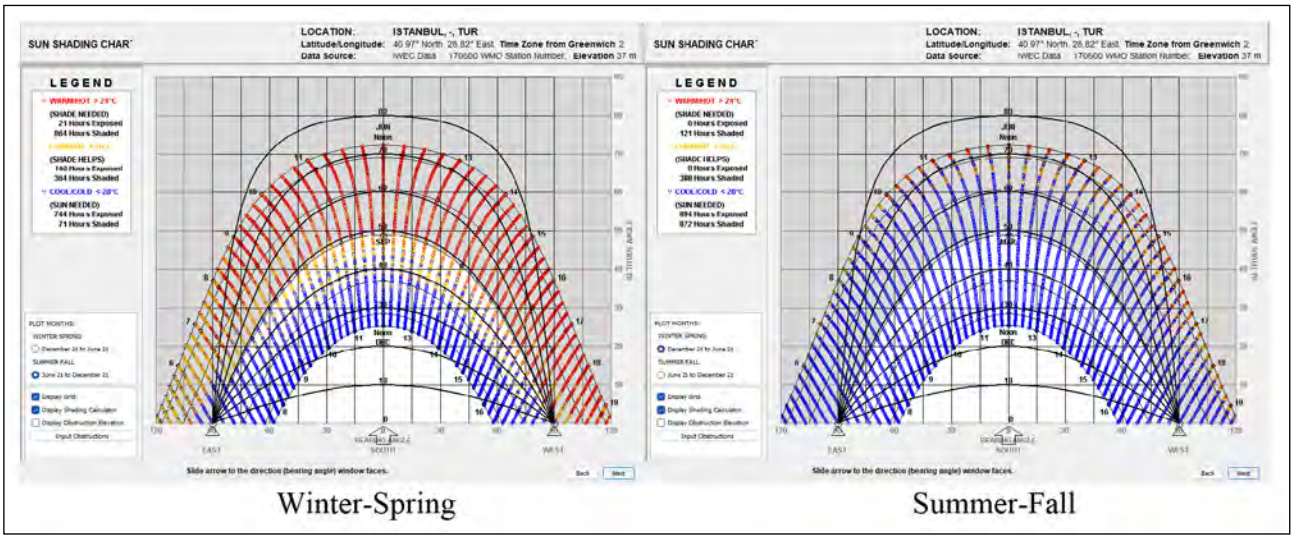

Figure 6. An example of solar control analysis with Sun Shading Chart: The situation of sunlight exposure on the southern facade as a result of the addition of horizontal fins with 37.5 cm ranges.

- *The maximum horizontal/vertical fin range* is the range that provides minimum shading and maximum solar gain depending on sunlight exposure conditions of the building facade and solar control performances of fin types.

Process of Conducting Calculations

Calculations related to visual and thermal comfort criteria were performed by following the steps given below, respectively. It was based on dividing the fin ranges by the ceiling height and the width of the facade as integers.

1. The fin ranges were first determined for the G1 glazing, which has the highest light transmittance and solar heat gain coefficient.
2. Fin ranges that provided the minimum level of daylight criteria for horizontal and vertical fins were identified. Since horizontal fins did not restrict the horizontal viewing angle, this criterion was considered only for vertical fins. Since the minimum level of sunlight exposure criterion could not be achieved in the northeast and northwest directions, it was taken into account that the minimum level of the other three daylight criteria should be achieved in these directions.
3. The appropriateness of the fin ranges, determined in accordance with daylight criteria, in terms of solar control was investigated. In this context, it was ensured that the solar gain rates of minimum horizontal and vertical fin ranges were as parallel to each other as possible based on the directions. For

the minimum fin ranges, the solar gain was targeted to be 25% in the northeast and northwest directions and 50% in the other directions. In the determination of the minimum horizontal fin range, ensuring ≥300 lx daylight in the east, west, northeast, and northwest directions where the facade has less sunlight exposure and providing solar control (solar gain and shading) in the south, southeast, and southwest were effective. In the solar control studies, the appropriateness of fin ranges was checked by taking advantage of the sun's horizontal and vertical orbits that change by the seasons. The largest altitude angle of the sun for the horizontal fin in the southern direction and the direction of the sunlight at sunset for the vertical fin in the western direction are shown as examples in Figure 7. The fin ranges determined in the second step had to be revised according to the solar control studies. Which level the revised fin ranges provide for each of the daylight criteria was recalculated.

4. A decrease in the number of fins, that is, an increase in the fin range, increases the need for mechanical cooling in hot weather conditions, and therefore energy consumption. For this reason, it was aimed to provide minimum shading and maximum solar gain in determining the maximum horizontal and vertical fin ranges. For this purpose, shading and solar gain rates were investigated by systematically changing the fin numbers. For the maximum fin ranges, the fact that solar gain rates showed similarity by the directions was taken into account. It was calculated which level the determined fin ranges provide for each of the daylight criteria. It was checked whether the minimum level of protection from glare was achieved or not. It was planned to revise the fin ranges to achieve the minimum level for this criterion in the case that the minimum degree could not be achieved. However, there was no need to revise the fin range in terms of glare in spaces that received light from a single facade.
5. By referencing the minimum and maximum fin ranges determined for G1 glazing without solar control features, the minimum and maximum fin ranges were calculated for the other three glazing types. The

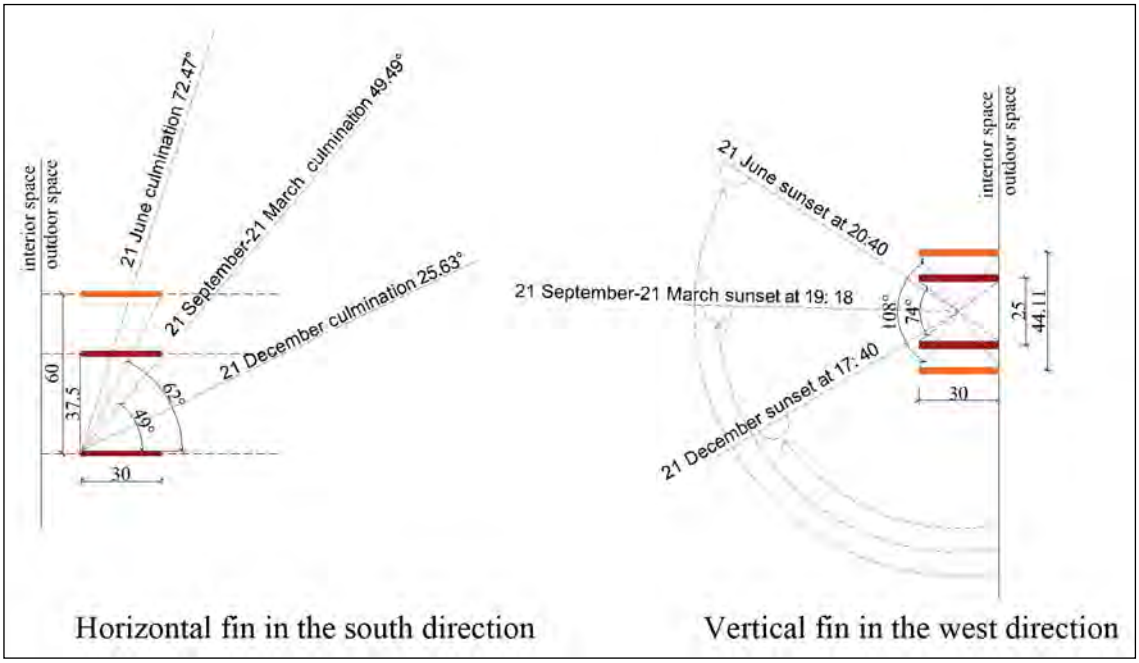

Figure 7. The minimum and maximum fin ranges determined for the horizontal fin in the south direction and vertical fin in the west direction.

Table 3. Determination of fin ranges for glazing type G2: South direction

Glazing type	Horizontal range (cm)		Vertical range (cm)	
	Minimum	Maximum	Minimum	Maximum
G1	37.5 (h/8)	60 (h/5)	37.5 (a/40)	50 (a/30)
G2	37.5×1.25=46.88	60×1.25=75	37.50×1.25=46.88	50×1.25=62.5
	300/46.88=6.4≅6	300/75=4	1500/46.88=32	1500/62.5=24
	300/6=50; h/6	300/4=75; h/4	1500/32=46.88; a/32	1500/24=62.5; a/24

Table 4. Shading and solar utilisation rates of the minimum and maximum fin ranges for G1 glazing

	Annual shade need and sun need (hour)		Minimum and maximum ranges of horizontal fin						Minimum and maximum ranges of vertical fin					
			Min	Annual Shading and Solar Gain (%)		Max	Annual Shading and Solar Gain (%)		Min	Annual Shading and Solar Gain (%)		Max	Annual Shading and Solar Gain (%)	
Direction	Shade need	Sun need	h/n	S	SG	h/n	S	SG	a/n	S	SG	a/n	S	SG
South	828	2247	h/8	97	73	h/5	76	85	a/46	62	52	a/30	51	71
East	334	1278	h/6	47	80	h/4	30	94	a/62	37	53	a/36	20	71
West	572	1092	h/6	30	79	h/4	18	93	a/60	25	50	a/34	12	69
Southeast	552	1962	h/8	76	70	h/5	47	84	a/66	53	50	a/30	22	71
Southwest	778	1788	h/8	56	68	h/5	34	86	a/70	62	50	a/34	25	69
Northeast	228	800	h/5	64	74	h/4	38	80	a/46	85	27	a/24	46	51
Northwest	454	624	h/5	40	73	h/4	24	78	a/40	55	25	a/20	27	50

S: Shading, SG: Solar gain, h/n: Room height/number of fins, a/n: Facade width/number of fins.

minimum and maximum fin ranges for G2, G3 and G4 glazing types were determined by increasing the fin range of G1 in a way that they would be inversely proportional to the shading coefficient of G1 glazing. For this, the number of fins, in which the ceiling height can be divided as an integer, was also taken into account, as was considered with the G1 glazing. That is, in the case when the fin number turns out to be a decimal number, it is rounded to the nearest integer. For example, the ratio of the shading coefficient between G1 and G1 glazing is 1.25 (0.64/0.51). The horizontal and vertical fin ranges determined for the G2 glazing in the southern direction are presented in Table 3 as an example. In the table, the expressions in parentheses indicate the number of fins. For example, (h/8) means that there are 8 horizontal fins in a room with a ceiling height (h) of 300 cm, and (a/40) means that there are 40 vertical fins in a room with a width (a) of 1500 cm. By the described calculation, it was checked whether the ranges determined for all windows meet the minimum degree for daylight illuminance and the other daylight criteria. It was verified that the optimum ranges defined for glazing G1, G2, G3, and G4 met the minimum (or medium/high) value of all daylight criteria.

6. The comfortable time percentages related to thermal comfort were calculated for the minimum and maximum fin ranges determined for all glazing types.

CALCULATION RESULTS

The shading and solar gain ratios for the minimum and maximum horizontal/vertical fin numbers and ranges determined in relation to the seven directions faced by the long wall of the office room are given in Table 4. The table shows the hours when there is a need for the annual shading and solar gain for G1 glazing, as well as the annual shading and solar gain ratios (%) calculated depending on these hours. For example, as shown in Figure 5, the annual need for shading in the southern direction is 828 hours, and the need for solar gain is 2247 hours. When the fins with a range of 37.5 cm are designated to the south, the need for shading decreases to 21 hours, and the need for solar gain decreases to 1638 hours (Figure 6). In this case, the shading and the solar gain rates become 97% (807/828=0.97) and 73% (1638/2247), respectively. The parallelism in solar gain rates between directions is clearly visible, except for the use of vertical fins in the northeast and northwest directions. This is due to the fact that in the simulations of the two directions mentioned, solar gain is allowed by 25%, different from the other directions (50%).

The number of horizontal (H) and vertical (V) fins, the thermal and visual comfort criteria of the minimum and maximum ranges between the fins, and the changes depending on the glazing type (G1, G2, G3, G4) and directions are presented in Figure 8. In the table, thermal comfort statistics are considered under the headings Hot (Ht), Neutral (Nt), and Cold (Cd). The levels that the criteria of the view out (VO), exposure to sunlight (ES), daylight provision (DP), and protection from glare (PG) provide in terms of visual comfort are expressed in colours (red: minimum, yellow: medium, green: high). The criterion for which even the minimum degree could not be achieved is indicated in grey. For each case considered, the table shows the ratio of the ceiling height to the number of horizontal fins (h/n), the ratio of the facade width to the number of vertical fins (a/n), and the ratio of the distance between the fins to the size of the fin (b/c).

Direction	Fin type	Glass type	Visual-thermal comfort criteria values for min. fin									Visual-thermal comfort criteria values for max. fin								
			Minimum range of fin		Comfort statistics			Visual comfort criteria				Maximum range of fin		Comfort statistics			Visual comfort criteria			
			h/n a/n	b/c	Ht	Nt	Cd	VO	ES	DP	PG	h/n a/n	b/c	Ht	Nt	Cd	VO	ES	DP	PG
S	H	G1	h/8	1.25	52	45	3					h/5	2.00	59	39	2				
		G2	h/6	1.66	47	48	5					h/4	2.50	54	43	3				
		G3	h/5	2.00	43	51	6					h/3	3.33	49	47	4				
		G4	h/5	2.00	40	53	7					h/3	3.33	47	48	5				
	V	G1	a/46	1.09	57	40	3					a/30	1.66	63	35	2				
		G2	a/36	1.38	51	45	4					a/24	2.08	56	41	3				
		G3	a/30	1.66	46	49	5					a/20	2.50	51	45	4				
		G4	a/26	1.92	45	49	6					a/18	2.50	49	47	4				
W	H	G1	h/6	1.66	53	43	4					h/4	2.50	56	41	3				
		G2	h/5	2.00	48	46	6					h/3	3.33	49	45	6				
		G3	h/4	2.50	40	52	8					h/3	3.33	42	50	8				
		G4	No fin		46	47	7					No fin		46	47	7				
	V	G1	a/60	0.83	50	50	8					a/34	1.47	50	45	5				
		G2	a/48	1.04	52	52	11					a/28	1.78	44	49	7				
		G3	a/40	1.25	53	53	13					a/22	2.27	40	51	9				
		G4	a/34	1.47	53	53	13					a/20	2.50	38	52	10				
E	H	G1	h/6	1.66	49	47	4					h/4	2.5	53	44	3				
		G2	h/5	2.00	40	53	7					h/3	3.33	45	49	6				
		G3	h/4	2.50	36	55	9					h/3	3.33	38	54	8				
		G4	No fin		42	51	7					No fin		42	51	7				
	V	G1	a/62	0.8	38	53	9					a/36	1.39	46	48	6				
		G2	a/50	1.00	33	56	11					a/28	1.79	40	52	8				
		G3	a/40	1.25	31	56	13					a/24	2.08	36	54	10				
		G4	a/36	1.39	30	57	13					a/20	2.50	35	55	10				
SW	H	G1	h/8	1.25	51	45	4					h/5	2.00	61	36	3				
		G2	h/6	1.66	47	47	6					h/4	2.50	54	42	4				
		G3	h/5	2.00	43	50	7					h/3	3.33	50	45	5				
		G4	h/5	2.00	40	53	7					h/3	3.33	47	47	6				
	V	G1	a/70	0.71	48	46	6					a/34	1.47	61	36	3				
		G2	a/56	0.89	43	50	7					a/28	1.78	55	41	4				
		G3	a/46	1.08	39	53	8					a/22	2.72	50	45	5				
		G4	a/40	1.24	39	53	8					a/20	2.50	48	46	6				
SE	H	G1	h/8	1.25	50	46	4					h/5	2.00	59	39	2				
		G2	h/6	1.66	45	49	6					h/4	2.50	52	44	4				
		G3	h/5	2.00	41	52	7					h/3	3.33	47	48	5				
		G4	h/5	2.00	38	54	8					h/3	3.33	45	49	6				
	V	G1	a/66	0.73	49	46	5					a/30	1.66	61	37	2				
		G2	a/52	0.96	43	50	7					a/24	2.08	54	42	4				
		G3	a/44	1.13	39	53	8					a/20	2.50	48	47	5				
		G4	a/38	1.32	38	54	8					a/18	2.78	47	48	5				
NW	H	G1	h/5	2.00	42	52	6					h/4	2.50	44	50	6				
		G2	h/4	2.50	35	56	9					h/3	3.33	37	55	8				
		G3	h/3	3.33	31	57	12					h/2	5.00	33	56	11				
		G4	No fin		34	55	11					No fin		34	55	11				
	V	G1	a/40	1.25	36	56	8					a/20	2.50	44	51	5				
		G2	a/32	1.56	31	59	10					a/16	3.57	36	56	8				
		G3	a/26	1.92	27	60	13					a/14	3.57	31	57	12				
		G4	a/24	2.08	26	60	14					a/12	4.16	30	58	12				
NE	H	G1	h/5	2.00	40	53	7					h/4	2.50	42	53	5				
		G2	h/4	2.50	33	57	10					h/3	3.33	35	56	9				
		G3	h/3	3.33	29	59	12					h/2	5.00	31	58	11				
		G4	No fin		32	57	11					No fin		32	57	11				
	V	G1	a/46	1.08	34	58	8					a/24	2.08	40	54	6				
		G2	a/36	1.38	28	60	12					a/20	2.50	33	57	10				
		G3	a/30	1.66	24	61	15					a/16	3.12	29	59	12				
		G4	a/26	1.92	24	60	16					a/14	3.57	28	59	13				

H: horizontal, V: vertical, Ht: hot, Nt: neutral, Cd: cold, VO: view out, ES: exposure to sunlight, DP: daylight provision, PG: protection from glare, h/n: room height/number of fins, a/n: facade width/number of fins, b/c: distance between fins/fin size.
Level of visual comfort criteria: Minimum Medium High Unavailable

Figure 8. Change of the comfort criteria of horizontal and vertical fin ranges depending on glazing types and directions.

ASSESSMENT OF THE RESULTS

The study results summarised in Figure 8 can be assessed as follows:

- The sunlight exposure of the building facade is the main determinant of the fin ranges. In directions with high sunlight exposure rates (south, southwest, and southeast), the horizontal and vertical fin ranges (b) are narrower compared to the directions with lower sunlight exposure rates (west, east, northwest, and northeast).
- When the minimum and maximum horizontal/vertical fin ranges determined for all directions were examined, it was found that the vertical fin ranges were generally narrower.
- Due to the low transmittance of G4 glazing in the west, east, northwest, and northeast directions, the minimum degree of daylight illuminance is provided only in the non-fin state. Accordingly, for the case where the G4 glazing type was applied without a fin, other daylight criteria and comfortable time percentages were calculated.
- Vertical fins provide more positive results in terms of ensuring the illuminance, while horizontal fins provide more positive results in terms of protection from glare.
- Vertical fins prevent solar gain more compared to horizontal fins. In parallel, the criterion of exposure to sunlight related to visual comfort provided higher degrees in horizontal fins.
- As the shading coefficient of glazing types decreases (i.e., the shading property increases),
    - o the neutral time percentages become higher despite the fact that distance between the fins increases,
    - o the difference between the neutral time percentages of the minimum and maximum fin ranges decreases.
- Horizontal fins in the southern direction are more successful than vertical fins in terms of shading and solar gain. In parallel, their neutral time percentages are also higher than that of vertical fins. Horizontal fins also gave more positive results than vertical fins in terms of protection from glare, exposure to sunlight, and view out.
- The solar control performances in the east and west directions are lower compared to the other directions. In these directions, as the shading coefficient of glazing types decreases, the difference between the neutral time percentages of horizontal and vertical fins also decreases. The vertical fins in the east and west direction have quite narrow ranges. In these directions, the glare protection performances of vertical fins are higher than horizontal fins.
- The solar control performance in the southwest and southeast directions is lower compared to the south direction. The thermal comfort and visual comfort performances of the horizontal/vertical fins in these directions are parallel.
- Since the neutral time percentages are higher for vertical fins in the northwest and northeast directions, it can be said that they give a more positive result in terms of shading than horizontal fins. However, in these directions, even the minimum level of exposure to sunlight, cannot be ensured. In parallel with this, vertical fins also greatly prevent solar gain.
- While the directions that provide the highest neutral comfortable time percentage are northwest and northeast, the directions that provide the highest warm time percentage are south, southeast, and southwest.
- Since the horizontal viewing angle is not restricted in horizontal fins, a high degree is provided in all fin ranges.
- Higher degrees of the exposure to sunlight criterion are provided in the south, southwest, and southeast directions. In addition, in these directions, horizontal fins are more advantageous in terms of exposure to sunlight.
- The medium level of daylight illuminance was provided at the minimum and maximum vertical fin range, which was determined for the glazings G1 in the southern direction. In addition, the medium level of daylight illuminance was provided at the maximum vertical fin range, which was determined for the glazings G2 in the southern direction. In all other directions and fin ranges, the minimum degree was able to be achieved in the illuminance.
- In the north-western and north-eastern directions, high degrees were provided in terms of protection from glare in all ranges designated for horizontal/vertical fins.

DISCUSSION

This study proposes a method for limiting horizontal and vertical fin ranges based on the current visual and thermal comfort standards. Appropriate fin ranges were determined by using climate-based data and analysing visual and thermal comfort criteria. The study was conducted in a module office room, which was assumed to locate in an office building. It is obvious that in rooms with different sizes and different transparency ratios considered in the study, the results may differ. Though with the method proposed in this study, thermal and visual comfort conditions can be determined for each office room, or the office room that can provide targeted comfort conditions can be designed. The study determined the minimum and maximum fin ranges

for spaces in different directions. The optimum range can be considered to be close to the middle of the minimum and maximum fin ranges.

Fin types and exposure to sunlight according to the directions significantly affect the performance of thermal and visual comfort criteria. For example, vertical fins affect the illuminance less compared to horizontal fins. This finding is in parallel with other studies (Lee et al., 2017). In addition, the shading performances of fin types show differences depending on the exposure to sunlight which is in accordance with the literature (Kirimtat et al., 2016; Yusoff et al., 2022). The finding that the horizontal fins in the southern direction are the most efficient fins in terms of shading and sun gaining confirms the relevant literature (Olgyay & Olgyay, 1957; Mangkuto et al., 2021). In this direction, the glazing type with high shading properties and the horizontal fin provided a high neutral time percentage and low cold time percentage. Horizontal fins in the southern direction are also positive in terms of visual comfort. Due to the movement of the sun, the potential of the southern building facade to be exposed to sunlight and provide the required illuminance is higher than in other directions. Furthermore, the finding that horizontal fins significantly prevent glare in this direction confirms the study by De Luca (De Luca et al., 2022). Therefore, in terms of thermal and visual comfort, the optimal direction is south and the type of fin is horizontal. The finding that vertical fins outperform horizontal fins in the east and west directions parallels O'Brien's work (O'Brian et al., 2013). The performance of solar control in the east and west directions is lower compared to other directions. In some studies, unlike horizontal and vertical fins, diagonal (i.e. angled) and adaptive shading elements have performed better in these two directions (Freewan, 2014; Mangkuto et al., 2021). Unlike the literature, in this current study, the neutral time percentages in horizontal and vertical fins approached each other much, especially with the increase in the shading properties of glasses in the eastern and western directions. This research showed that vertical fins also give positive results in northwest and northeast directions, consistent with Lee's study (Lee et al., 2017). In this present study, the neutral time percentage of vertical fins in these directions was higher compared to horizontal fins. Horizontal and vertical fins in the south-western and south-eastern directions gave close results to each other. Therefore, it can be said that horizontal+vertical fins show high performance in this direction (Kim et al., 2015).

The daylight and solar energy transmittance of glazing types directly affect thermal and visual comfort. Glazing types of lower shading coefficient (G3 and G4) showed more positive results in terms of thermal comfort which is in accordance with the literature (Ascione et al., 2020). The same glass types were also more effective in protecting from glare. However, G1 and G2 glasses gave more positive results in terms of daylight illuminance which confirms the literature (Rasmussen & Pedersen, 2019).

In modern building design, horizontal and vertical fins contribute to facade aesthetics as well as solar control. In terms of facade integrity, fins with the same range are usually designed in all directions. In this study, it was tried to seek an answer to the question *"Is there an optimal fin range for rooms facing different directions"*. For this reason, the common fin ranges for the rooms facing the cardinal and ordinal (*intercardinal*) directions were determined. For example, for the G1 glazing, the horizontal fin ranges common in the cardinal directions (*south, west, and east*) were 50 cm (h/5) and 60 cm (h/6). The common vertical fin range for G1 glazing was between 37.5 cm (a/40) and 41.66 cm (a/36) in these directions. On the other hand, in the ordinal directions (*southwest, southeast, northwest, and northeast*), the common horizontal fin range for G1 glazing was 60 cm (h/5). In these directions, the common vertical fin ranges for the same glazing (G1) were between 37.5 cm (a/40) and 44.12 cm (a/34). However, the ranges that were common to the cardinal/ordinal directions did not offer the optimal solution for all directions. Indeed, the horizontal fin range of 60 cm, which was common for ordinal directions, was the minimum range determined for the northwest and northeast directions. Similarly, the horizontal fin range of 60 cm was the maximum range determined for the southeast and southwest directions. The thermal and visual comfort effects of the common (60 cm) horizontal fin range in 4 different directions were also different. Therefore, considering the sunlight exposure relative to the directions is important in terms of holistic facade design and energy consumption. Beyond the horizontal/vertical fin, kinetic facade, biomimicry, and parametric facade designs suitable for the sunlight exposure of spaces are also being made today (Mahmoud & Elghazi, 2016).

CONCLUSION

Large glass surfaces are often used in modern office structures. The increase in the transparency ratio in the building envelope leads to the glare problem and causes excessive heat gain or heat loss depending on the season. This phenomenon makes it mandatory to carry out solar control with shading elements. The size, shape, number, and location of these elements also affect the architectural shaping of the building. In this context, as well as providing a comfortable physical environment for office workers, it is also important that the building acquire the character of a contemporary work of art. The formation of the physical environment depends on the control of elements such as heat, light, and sound. In this study, by taking into account only heat and light among these elements, a method was developed that can be used in the design of horizontal/vertical shading elements that provide thermal

and visual comfort conditions. It should also be noted that for a complete indoor environment, the requirements for auditory comfort should also be taken into account.

The method proposed in the study is aimed at limiting horizontal or vertical fin ranges. The minimum and maximum fin ranges that could meet the minimum conditions of all visual and thermal comfort criteria were determined on a sample of a module office room. The effects of minimum and maximum fin ranges on comfort criteria were revealed, and thereby, designers were allowed to choose depending on their priorities. The results of this study in which the change of fin ranges by directions was also examined can also be used to make basic design decisions. The calculation of the initial construction and maintenance costs of the fins was excluded from the scope of this study. In future studies, by analysing the initial construction and maintenance costs of horizontal and vertical fins, their appropriateness depending on the directions can also be investigated from an economic point of view. In addition, the study can be improved by investigating the effect of shading and solar gain rates of fins on total energy consumption.

- *This article is based on the ongoing PhD Dissertation entitled as Optimization of horizontal and vertical fins on building facades in terms of visual and thermal comfort by Gülçin Süt under the supervision of Prof. Dr. Leyla Dokuzer Öztürk at Yıldız Technical University, Department of Architecture.*

ETHICS: There are no ethical issues with the publication of this manuscript.

PEER-REVIEW: Externally peer-reviewed.

CONFLICT OF INTEREST: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

FINANCIAL DISCLOSURE: The authors declared that this study has received no financial support.

REFERENCES

Ascione, F., Bianco, N., Iovane, T., Mauro, G. M., Napolitano, D. F., Ruggiano, A., and Viscido, L. (2020). A real industrial building: Modeling, calibration and Pareto optimization of energy retrofit. Journal of Building Engineering 29:101186. https://doi.org/10.1016/j.jobe.2020.101186.

ASHRAE, ANSI/ASHRAE Standard 55-2016. Thermal environmental conditions for human occupancy. Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 2017.

CIBSE GA. Environmental design. London: The Chartered Institution of Building Services Engineers; 2006.

Climate Consultant 6 (2019). Energy Design Tools. Retrieved August, 2019.

Darula, S. and Malikova, M. (2017). Sunlight Exposure: Minimum Solar Altitude, Proceedings of the 22nd International Conference SVETLO.

De Dear, R. and Brager, G. S. (1998). Developing an adaptive model of thermal comfort and preference. https://www.buildingenergysoftwaretools.com/software/climate-consultant.

De Luca, F., Sepúlveda, A., and Varjas, T. (2022). Multi-performance optimization of static shading devices for glare, daylight, view and energy consideration. Building and Environment 217:109110.

DeKay, M. and Brown, G. Z. (2013). Sun, wind, and light: architectural design strategies. John Wiley & Sons.

European Committee for Standardization. (2005). Ergonomics of the thermal environment Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria (CEN Standard No: EN ISO 7730:2005).

European Committee for Standardization. (2007). Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics (CEN Standard No. EN 15251:2007).

European Committee for Standardization. (2018). Daylight in buildings (CEN Standard No. EN 17037:2018).

European Committee for Standardization. (2022). Daylight in buildings (CEN Standard No. TS EN 17037:2022).

Fanger, P. O. (1970). Thermal comfort. Analysis and applications in environmental engineering. Thermal comfort. Analysis and Applications in Environmental Engineering.

Freewan, A. A. (2014). Impact of external shading devices on thermal and daylighting performance of offices in hot climate regions. Solar Energy 102:14–30. https://doi.org/10.1016/j.solener.2014.01.009.

Illuminating Engineering Society. (2013). Recommended practice for daylighting buildings (IES Standard No. RP-5-13).

Khoroshiltseva, M., Slanzi, D., and Poli, I. (2016). A Pareto-based multi-objective optimization algorithm to design energy-efficient shading devices. Applied Energy 184:1400–1410.

Kim, M., Leigh, S. B., Kim, T., and Cho, S. (2015). A study on external shading devices for reducing cooling loads and improving daylighting in office buildings. Journal of Asian Architecture and Building Engineering 14(3):687–694.

Kirimtat, A., Koyunbaba, B. K., Chatzikonstantinou, I., and Sariyildiz, S. (2016). Review of simulation modelling for shading devices in buildings. Renewable and Sustainable Energy Reviews 53:23–49. https://

doi.org/10.1016/j.rser.2015.08.020.

Kuhn, T. E. (2017). State of the art of advanced solar control devices for buildings. Solar Energy 154:112–133.

Lee, K. S., Han, K. J., and Lee, J. W. (2017). The impact of shading type and azimuth orientation on the daylighting in a classroom–focusing on effectiveness of façade shading, comparing the results of DA and UDI. Energies 10(5):635. https://doi.org/10.3390/en10050635.

Mahmoud, A. H. A. and Elghazi, Y. (2016). Parametric-based designs for kinetic facades to optimize daylight performance: Comparing rotation and translation kinetic motion for hexagonal facade patterns. Solar Energy 126:111–127. https://doi.org/10.1016/j.solener.2015.12.039.

Mangkuto, R. A., Koerniawan, M. D., Apriliyanthi, S. R., Lubis, I. H., Hensen, J. L., and Paramita, B. (2021). Design optimisation of fixed and adaptive shading devices on four façade orientations of a high-rise office building in the tropics. Buildings 12(1):25. https://doi.org/10.3390/buildings12010025.

Manzan, M. (2014). Genetic optimization of external fixed shading devices. Energy and Buildings 72:431–440. https://doi.org/10.1016/j.enbuild.2014.01.007.

Manzan, M. and Padovan, R. (2015). Multi-criteria energy and daylighting optimization for an office with fixed and moveable shading devices. Advances in Building Energy Research 9(2):238–252. https://doi.org/10.1080/17512549.2015.1014839.

Matzarakis, A., Mayer, H., and Iziomon, M. G. (1999). Applications of a universal thermal index: Physiological equivalent temperature. International Journal of Biometeorology 43(2):76–84. https://doi.org/10.1007/s004840050119.

Mazria E. (1979). The Passive Solar Energy Book. Rodale Press, Emmaus, PA.

Neufert, E. and Neufert, P. (2012). Architects' data. John Wiley & Sons.

Nicol, F. (2004). Adaptive thermal comfort standards in the hot–humid tropics. Energy and Buildings 36(7):628–637. https://doi.org/10.1016/j.enbuild.2004.01.016.

Nicol, F., Humphreys, M., and Roaf, S. (2012). Adaptive thermal comfort: Principles and practice. Routledge.

Noorzai, E., Bakmohammadi, P., and Garmaroudi, M. A. (2022). Optimizing daylight, energy and occupant comfort performance of classrooms with photovoltaic integrated vertical shading devices. Architectural Engineering and Design Management 1:1–25.

NSI/ASHRAE Standard 55-2005, "Thermal Environmental Conditions for Human Occupancy", American National Standards Institute, 2005.

O'Brien, W., Kapsis, K., and Athienitis, A. K. (2013). Manually-operated window shade patterns in office buildings: A critical review. Building and Environment 60:319–338.

Olgyay, A. and Olgyay, V. (1957). Solar control and shading devices. Princeton University Press, New Jersey.

Panero, J. and Zelnik, M. (1979). Human Dimension & Interior Space. A Source Book of Design Reference Standards, Watson-Guptill Publications, New York.

Parkinson, T., De Dear, R., and Brager, G. (2020). Nudging the adaptive thermal comfort model. Energy and Buildings 206:109559.

Paule, B., Boutillier, J., Pantet, S., Sutter, Y., and Sa, E. (2018). A lighting simulation tool for the new European daylighting standard. Proceedings of BSO, 2018, 4th.

Rasmussen, H. F. and Pedersen, T. S. (2019). An industry perspective on building simulations with solar shading. In E3S Web of Conferences. EDP Sciences 111:03048.

Rijal, H. B., Humphreys, M. A., and Nicol, J. F. (2017). Towards an adaptive model for thermal comfort in Japanese offices. Building Research & Information 45(7):717–729. https://doi.org/10.1080/09613218.2017.1288450.

Schouws, T. (2022). Measuring Daylight: The New European Standard and the effect on Green Building Certificates [Unpublished master thesis]. Delft University of Technology.

Settino, J., Carpino, C., Perrella, S., and Arcuri, N. (2020). Multi-objective analysis of a fixed solar shading system in different climatic areas. Energies 13(12):3249.

Wu, Z., Li, N., Wargocki, P., Peng, J., Li, J., and Cui, H. (2019). Field study on thermal comfort and energy saving potential in 11 split air-conditioned office buildings in Changsha, China. Energy 182:471–482.

Yılmaz, F. Ş. (2019). Binalarda gunışığı performans olcutlerine guncel bir bakış: EN 17037 standardı ve uygulaması.10. Ulusal Aydınlatma Sempozyumu, İzmir, Turkiye.

Yusoff, W. F. M., Shaharil, M. I., Mohamed, M. F., Rasani, M. R. M., Sapian, A. R., and Dahlan, N. D. (2022). Review of openings with shading devices at naturally ventilated buildings. Architectural Engineering and Design Management 1:1–17. https://doi.org/10.1080/17452007.2022.2095553.

Zitzler, E. (1999). Evolutionary algorithms for multiobjective optimization: Methods and applications (Vol. 63). Ithaca: Shaker.

Megaron, Vol. 17, No. 4, pp. 658–672, December 2022

Megaron
https://megaron.yildiz.edu.tr - https://megaronjournal.com
DOI: https://doi.org/10.14744/MEGARON.2022.47827

Article

Assessment of urban surface performance of open spaces with multi-criteria decision-making method

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ARTICLE INFO

Article history
Received: 02 April 2022
Revised: 20 December 2022
Accepted: 21 December 2022

Key words:
Analytic network process (ANP); multi-criteria decision-making (MCDM); urban open spaces; urban surface index; urban surfaces

ABSTRACT

The research presents a multi-criteria decision-making method that focuses on evaluating spatial performance by considering all areas without roads or structural elements as "urban surfaces". In this context, the Seyyid Ömer neighbourhood in Istanbul's Fatih district, as the study area, was discussed in detail in terms of physical, ecological, and social criteria and their sub-criteria. While the physical criteria include the size of each area and enclosure; the ecological criteria were studied with permeability rates and the normalised difference vegetation index (NDVI) value, which measures unit area through the amount of chlorophyll. In addition, the type of property and land use in the urban context, which are the main factors for citizens' interaction with open spaces, were included as sub-criteria under the main social criterion. The relationships between the identified criteria and the open space typologies in the neighbourhood were converted into an index using the analytical network process (ANP) to measure the urban surface performance. The developed index indicated that some urban voids stand out even more than the important ones and have greater potential than urban parks such as Çukur Bostan in terms of social and vegetation qualities. As a result of the research, a map of the importance level was created to illustrate the potential areas for improving the urban ecological performance. Then, various pocket parks such as Şelaleli Park and Skate Park and urban voids regarding their physical, ecological and social values were extracted as potential urban open spaces. With this structure, the research proposes a multi-criteria index that can be used to evaluate the potential of urban surfaces by putting them on a multi-dimensional and computable scale.

Cite this article as: Serdar Yakut ES, Cenani S, Çağdaş G. Assessment of urban surface performance of open spaces with multi-criteria decision-making method. Megaron 2022;17(4):658–672.

INTRODUCTION

Cities are holistic structures of hybrid ecosystems that change and transform with human and environmental interaction. Although a limited part of the world consists of built surfaces, a significant proportion of the human population is concentrated in these areas (Alberti et al., 2003). The cumulative effect of human action and the built

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Published by Yıldız Technical University Press, İstanbul, Turkey
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environment in the near future is predicted to increase the number of people living in metropolitan areas and account for 70% of the world's population (Lin & Grimm, 2015). This situation also corresponds to the land use and environmental problems that increase and intensify over time with the centralisation of population, production and movement. Therefore, cities leave a huge ecological footprint on the world (Alberti et al., 2003, p.1170). The increasing horizontal and vertical urban growth causes the open and green areas to decrease both in quality and quantity. The atmospheric temperature has increased by about 1°C since the Industrial Revolution, which is an important aspect in the destruction of natural areas and the formation of the greenhouse effect. The prediction is that should this trend continue in this way, the temperature difference will reach 1.5°C in 2040 (IPCC, 2018, 2021, p.1). However, today, increasing environmental awareness in the context of climate change, with the effect of fundamental environmental problems such as urban heat islands and drought, compels cities to focus on both problems and potentials. Therefore, research on the ecological qualities of urban surfaces and the importance of their use in urban life is gaining more importance (Kazmierczak & James, 2007; La Rosa, 2014; Niemelä, 2014; Dyson et al., 2019). In addition to ecological features such as the distribution and quality of green areas are the main factors that directly shape and determine the quality of life and stage of the world population (Reid et al., 2005, pp. 71–84).

In the current literature, importance is placed on studies focusing on various specialised subjects such as the ecological qualities of green spaces in the urban fabric through vegetation (Firozjaei et al., 2020), examining their potential according to property typologies (Dyson et al., 2019), and focusing on the urban accessibility relationship of open spaces (Liang et al., 2021). However, it can be said that there are still gaps in examining the interactions of people with urban open spaces and in revealing the property, usage typologies, and green space qualities provided by these surfaces from a holistic perspective. Therefore, the theoretical infrastructure of urban ecology can be applied in order to deepen the potential of urban surfaces to create physical space in terms of providing social benefits. Although urban open spaces have become the focus of ecology-based design approaches, it should not be ignored that urban ecology, an approach that integrates natural science and social sciences, and a frontier profession that has not yet been widely evaluated. In particular, the attitude of ecological studies that ignored built environments until the second half of the twentieth century played a significant role in the emergence of this situation (Grimm et al., 2008). Today, while considerable progress has been made on urban ecology (Mcdonnel, 2011, p.756), research on the use and environmental qualities of urban landscapes is still not at the same level as research on natural landscapes. At this point, many research topics have been suggested, aiming to link the theory and practice of urban ecology with its socio-demographic, ecological, and technological dimensions, and focusing on the benefits they provide to the citizens of the city (James et al., 2009; Niemelä, 2014; Verma et al., 2020).

The conceptual framework offered by urban ecology is based on socio-ecological systems which are put at the centre of ecosystem services. This framework is based on the integration of the social structure in which humans exist into the ecological structure (Niemelä et al., 2011, p. 1–4). As the keystone of urban ecological systems, urban areas come to the fore as urban spaces which have vegetation cover but no structure (Dunnet, et all., 2007, p. 8), that citizens benefit from directly or indirectly (Baycan-Levent et al., 2002), and that provides an environment for different activities and experiences depending on the spatial pattern of the urban fabric (Van Herzele and Wiedemann, 2003, p. 110). These spaces also typically include valuable landscape remains with respect to biodiversity carrying the traces of cultural life (Barthel et al., 2007) in terms of being a cumulative result of users, objects, or actions in and around them (Madanipour, 1996). In this situation, landscape elements form "Novel Ecosystems" (Hobbs et al., 2006, p. 2) reflecting both the social and ecological qualities of the city.

Another feature that has a key place in the formation of this originality and in the basis of urban life is that these spaces are physical stages that allow for the accidental intersections of social life. The systematic structure of these areas, which define the interaction area of the society and reveal the character of the settlement they built, is shaped by urban fiction (Erdönmez & Akı, 2005). It would be appropriate to focus on the smallest hierarchical unit, the urban space, where the ecological effects and social equivalents of this spatial limitation can be observed. The subject of examining the relations it establishes with its environmental context in terms of the fact that the neighbourhood scale hosts many different open space constructions and usage (Rouse & Bunster-Ossa, 2013) has been considered as a limiting factor within the scope of the research.

The objective of this study is to determine the performance of urban areas by examining their spatial qualities along with social and ecological dimensions. For this purpose, a selected urban district, suitable as a benchmark for the evaluation of socio-ecological characteristics, was analysed using weighted multi-criteria based on city plans. In this regard, the multi-criteria decision-making (MCDM) method (Triantaphyllou, 2000) was selected for its convenience in analysing the complex relationships of the open space typologies. To this end, the importance levels of the criteria were determined using the analytical network process (ANP), which stands out as a superior method for creating a cyclic and interactive network relationship among

the criteria (Saaty, 2002). Spatial analysis and performance maps were then generated for the neighbourhood pattern based on the study area. As a result, an index for assessing the performance of the urban surface was developed.

METHOD

Various methods have been utilised in the literature in order to understand the complex structures of cities and ecological processes. The leading of these methods is numerical grading, in which indexes and indicators are used as comparison tools. While indicators represent the attributes and functions of a system (Gallopin, 2005), indexes represent more complex values consisting of weighted sub-elements of many different indexes or indicators (Wu & Wu, 2012). Therefore, indexes are important tools for analysing the multi-factor relational structures of dynamic urban systems and making self-evaluations about their current status (Huang et al., 2015). Although indexes have an important place in measuring sustainability, the accuracy of the results they provide cannot always be guaranteed. The value of an index rather than its conformity to reality can be measured by its explanatory-interpretive representation capacity and functionality (Machado, 2004, p. 100). The most common indicators used to measure the ecological qualities of urban open spaces are the size of green areas per capita, the ratio of green areas, and the extent of green areas. If taken on a larger scale, the next most common indicators are conceptual evaluation schemes from upper scales to lower scales approaches (Raymond et al., 2017) to evaluating ecosystem services with sustainable urban ecology (Olalla-Tárraga, 2006; Larondelle & Haase, 2013), and closer to residential areas, suitability analyses and evaluation indexes. These indexes include landscape metrics such as landscape structure indicators (Cook, 2002), landscape network connectivity indexes (Saura et al., 2011), open area indexes, habitable area indexes (Bölen et al., 2011) or vegetation surface width, distribution density (Liu et al., 2016), and weighted fractal indexes (Zhao et al., 2014). In addition to these, it is seen that indicators such as public space quality indexes (Siregar, 2014), visibility analyses, visual impact assessments (Saeidi et al., 2018), and urban landscape quality indexes (Gavrilidis et al., 2016) are used in examining the relations between public uses and their physical components. However, it can be said that these approaches focus on a singular main criterion and its sub-criteria clusters. From this point of view, the research aimed at a holistic analysis of the focus of three main, based on the fact that cities are unique ecosystems shaped by human influence. To highlight the problems and potentials of the physical, ecological, and social characteristics, the methodology of this study was built as a holistic evaluation

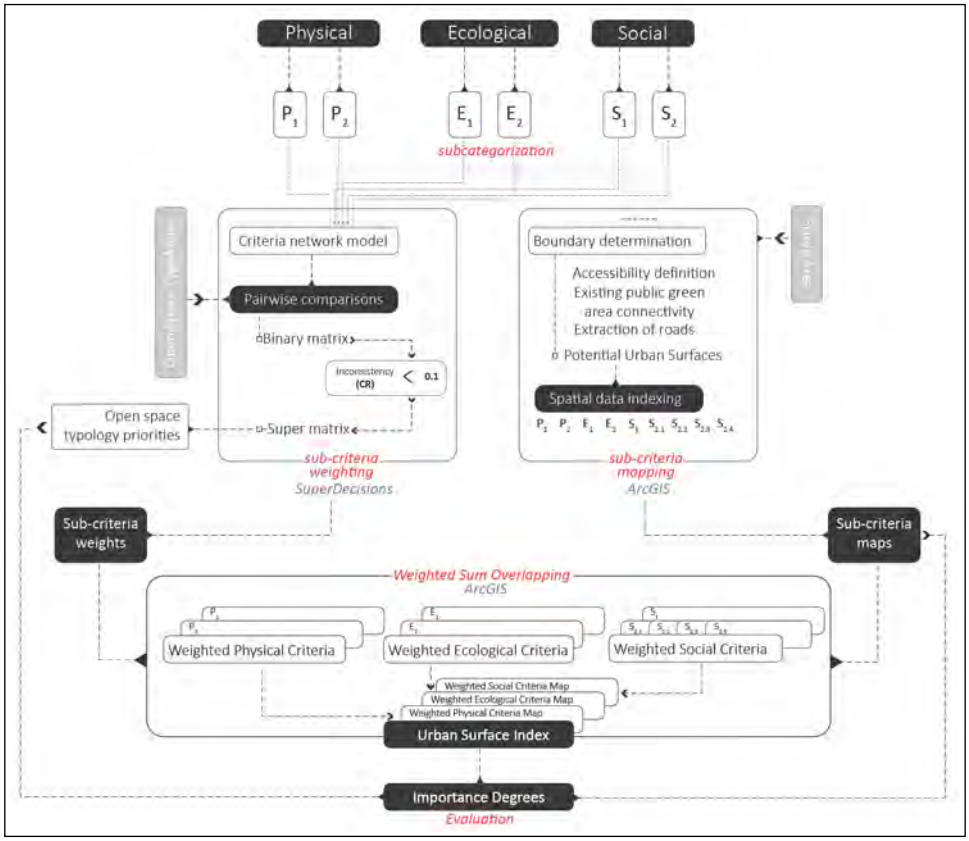

Figure 1. Methodology flow.

through sub-categorisation, sub-criteria mapping and weighting, overlapping of the maps' weighted sum, and evaluation (Figure 1). While the first step emerged from the literature review, the weighting of the selected sub-criteria was elaborated using the analytical network process (ANP) method in SuperDecisions Software (Saaty, 2002). With the aim of analysing the characteristics of the routers of each spatial unit under the mechanism of multi-criteria decision-making (MCDM), all criteria related to the urban open space typologies were weighted with binary and multiple comparisons to obtain the important values and criteria weights. Subsequently, the urban surface index was obtained by mapping each sub-criterion and combining it with each weight in ArcGIS (Esri, 2020). As a result, the urban surface performances of all open areas in the study area were measured and compared with the current situation.

Criteria and Weighting

Research on open space is diverse, as it is a component of visual perception (Cullen, 2012), the image of the city (Lynch, 1960), a social interaction environment, and the infrastructure system in relation to the impact of green space (Benedict & McMahon, 2012). The spatial functionality of the areas within the structured texture varies according to the characteristics, settlements, and typologies of environmental uses (Walzer, 1986, p. 470). Therefore, this functionality is directly related to the size and accessibility of urban surfaces. Also, vegetation quality and density are diminished in commercial functions such as squares with high levels of spatial movement and access, they improve as one descends toward the city park and private spaces. In order to evaluate urban surfaces quantitatively, unit areas were divided into two sub-criteria under the physical, ecological, and social main criteria, and their sub-criteria evaluations were shown in Table 1. The physical criteria were unfolded into the land size and enclosure values. Land dimensions reflect the value of all unit areas (A*i*) in m^2 in the neighbourhood, excluding roads, pavements, and structural elements. The enclosure value is the ratio of the accessible boundary length (Px*i*) to the entire boundary length (P*i*) of the area, where all open areas are not blocked by any structural element.

Ecological criteria expanded into permeability and vegetation quality based on orthographic photo information. Permeability of the surface is defined as the ratio of each unit area (A*i*) to its impermeable surfaces (Ax*i*). Vegetation quality was obtained with the normalised difference vegetation index (NDVI) which is calculated through orthographic photographs throughout the neighbourhood. NDVI is a numerical notation that measures the quality of green areas with the amount of chlorophyll and is a method used by many natural resource researchers for many years (Takács et al., 2014). Its value is measured by the difference and amount of radiation intensity reflected by plants between the near-infrared (NIR) and visible red (VIR) regions (Carlson & Ripley, 1997). Even though the index does not distinguish the typology of vegetation, such as trees, shrubs, or land cover, the value of the spectrum expresses the knowledge of the relative comparison between them. The index outputs values in the range of −1.0 to +1.0. Values between −1.0 and 0.0 indicate that there is no vegetation, while values between 0.0 and +0.5 indicate that there is very little vegetation like groundcovers, shrubs or small trees; and above +0.5 means rich vegetation like broad canopy tree-dominated areas (Bakay, 2012, p. 11).

The social criteria were defined as publicness types of zoning status and land-use characteristics. The parks, playgrounds, and neighbourhood gardens were considered as public spaces; parking lots were considered semi-public areas. Also, urban voids between building blocks were included in the study as private open spaces. Land-use types were examined as the accessibility of all residential,

Table 1. Criterion list with sub-criteria and their evaluation units

Main-criteria	Sub-criteria	Evaluation
Physical	Land size	A*i*
	Enclosure	PX*i*/P*i*
Ecological	Permeability	AX*i*/A*i*
	Vegetation index (NDVI)	(NIR – VIR) / (NIR + VIR)
Social	Property types	Public, semi-public, private
	Land use types	Residential, commercial, religious, education

Table 2. COpen space typologies

Open Space Typologies			
Urban squares	Pocket parks	Playgrounds	Neighbourhood parks
Market squares	Courtyards	Shortcuts	
Urban parks	Urban voids	Private gardens	Traffic islands

commercial, religious, and educational buildings within the boundaries of the neighbourhood within the 500 m walkable zone and were mapped for each. Within the scope of this research, the characteristics of the open space typologies at the neighbourhood scale in the context of the urban environment were taken into consideration in terms of evaluating the social relations of the citizens with their surroundings. These typologies are listed in Table 2. After establishing the criteria and open space typologies, the weighting stage was initiated. At this stage, the objective was to evaluate the open space typologies that could be included in the neighbourhood scale using the established criteria and to make numerical comparisons between them. Thus, the importance levels of the selected criteria were determined, as well as the importance levels of the open area typologies. The ecological, social, and physical characteristics of open spaces were developed using the multi-criteria decision-making (MCDM) model during this process. MCDM follows a flow in which multiple active criteria are considered and the most appropriate option is determined as a result (Yıldız, 2014).

Analytic Network Process

The analytical network process (ANP) stands out in an associative with analytic hierarchy process (AHP) which is one of the most commonly used mathematical methods and the most robust decision measurement theory in solving complex problems involving more than one variable (Kou & Ergu, 2016). The focus of both methods includes breaking down a complex problem into sub-problems and combining the solutions corresponding to each of them with expert opinions (Saaty, 2002). In this way, it serves as a tool that assists the designer make decisions by determining the relative importance of the given criteria in order to select the most appropriate outcome from the listed pool of alternatives. Through its hierarchical structure, the criteria integrated into the system are evaluated independently. At this point, the ANP method becomes prominent as a superior method because it establishes a cyclical and interactive network relationship between the criteria and the alternatives. Thanks to this reciprocal system, a holistic priority matrix is created by using the pairwise comparisons of each node for the goal with Saaty's importance scale of 1–9 (Table 3).

Therefore, within the holistic approach of this study, ANP was used as the main decision-making system, due to its compatibility with the analysis of not only quantitative but also implicit factors. From this point of view, the criteria identified from the literature were evaluated using the SuperDecisions Software (Saaty, 2002). SuperDecisions is a free educational software developed by Saaty and his team. Thanks to its strong link to theory, and suitability, it is widely used by decision-makers and academics (Mu & Pereyra-Rojas, 2016; Ruano, 2018; Mirzaei & Nowzari, 2021). The software works with a cyclical, systematic model to achieve the goal. Each criterion should be compared for all alternatives in terms of their priorities by specialists. In order to obtain the priority values of the criteria based on the selected open space typologies at the neighbourhood scale, each criterion was evaluated in pairs in a comparison model (Figure 2). This model consisted of three modules: the objective for determining priority values, the alternatives for the typologies, and the sub-criteria that included all the main physical, ecological, and social criteria. In this cyclical model, the pairwise comparisons of each sub-criterion were scored between 1 and 9 in relation to the alternatives (Figure 3). This resulted in the priority list (Table 4) for each sub-criterion and the values for the main criteria based on this list in a range between 0.0 and 1.0.

As a result, all priority distributions of open space typologies were obtained for each sub-criterion for relative criteria. Not only the ranking of priorities but also the weighting of sub-criteria for each alternative was elaborated. In this sense, urban parks, neighbourhood parks, private gardens, and courtyards are the most important open space types; social and ecological main criteria are more important rather than physical ones. As a total result of comparisons, all sub-criteria with respective weights were illustrated in Figure 4.

Table 3. Saaty's importance scale of 1–9 (Saaty, 2002)

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favour one activity over another
5	Strong importance	Experience and judgment strongly favour one activity over another
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	For compromise between the above values	Sometimes one needs to interpolate a compromise judgment numerically because there is no good word to describe it

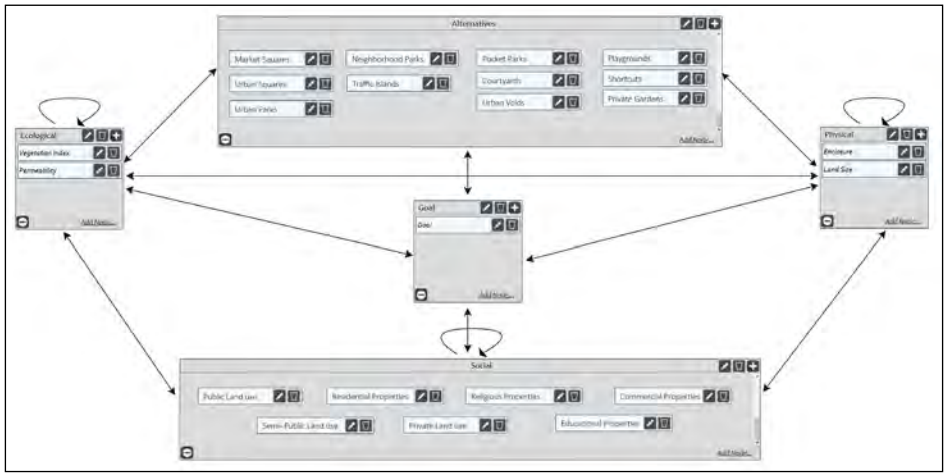

Figure 2. ANP network of relationships from SuperDecisions Software (Creative Decisions Foundation, 2021).

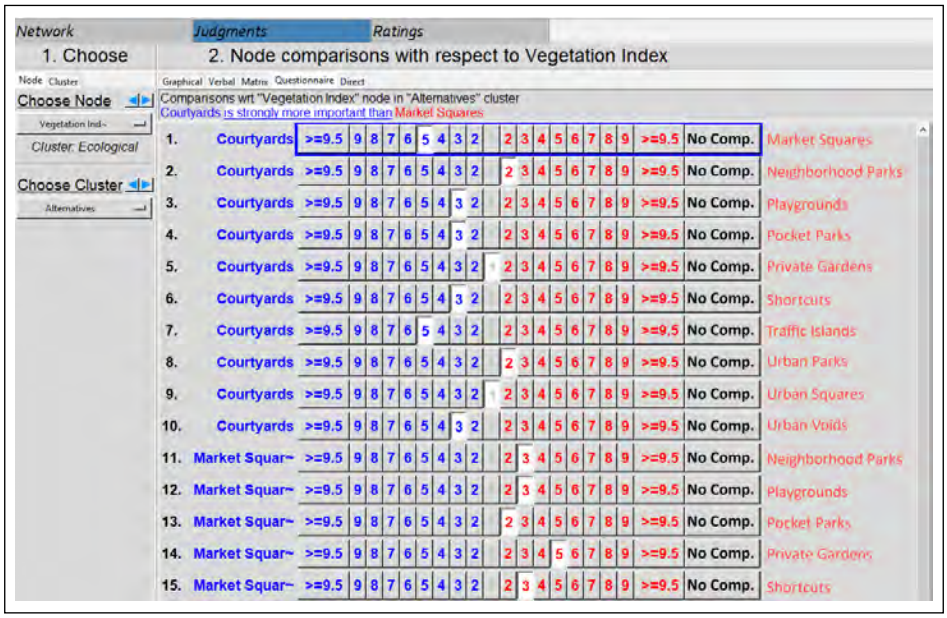

Figure 3. Pairwise comparison questionnaire for vegetation index from SuperDecisions program (Creative Decisions Foundation, 2021). Each criterion was compared for all alternatives as binary evaluation.

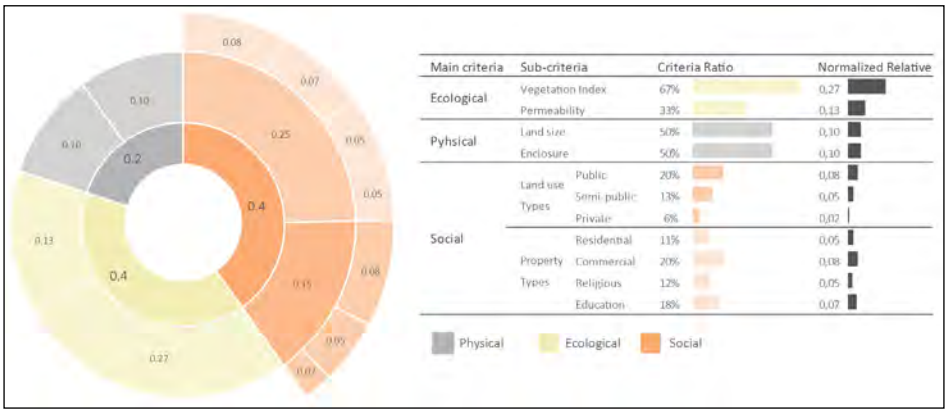

Figure 4. Sub-criteria weights and ratios for each criteria group.

Table 4. Priority table for each open space typology based on related sub-criteria weights

Priority	Open Space Typologies	Criteria Weight Distribution											Priority Values (Normalized by Cluster)
		Ecological		Physical		Social							
						Property Types			Land use Types				
		Vegetation Index	Permeability	Enclosure	Land size	Public	Semi-public	Private	Religious	Education	Residence	Commercial	
1	Urban parks	0.5	0.5	0.333	0.667	0.18	0.136	0.108	0.094	0.151	0.196	0.135	0.15456
2	Neigh-bourhood parks	0.667	0.333	0.667	0.333	0.177	0.134	0.107	0.124	0.184	0.13	0.144	0.13141
3	Private gardens	0.667	0.333	0.333	0.667	0.11	0.138	0.184	0.135	0.135	0.199	0.099	0.11488
4	Court-yards	0.5	0.5	0.25	0.75	0.185	0.138	0.11	0.154	0.113	0.188	0.113	0.10161
5	Play-grounds	0.667	0.333	0.25	0.75	0.169	0.139	0.114	0.098	0.213	0.149	0.119	0.08673
6	Urban squares	0.8	0.2	0.667	0.333	0.214	0.136	0.095	0.156	0.119	0.092	0.189	0.08131
7	Pocket parks	0.75	0.25	0.75	0.25	0.179	0.135	0.108	0.114	0.089	0.157	0.219	0.08078
8	Market squares	0.667	0.333	0.667	0.333	0.178	0.134	0.107	0.139	0.114	0.092	0.235	0.07229
9	Shortcuts	0.667	0.333	0.80	0.20	0.136	0.165	0.112	0.142	0.132	0.089	0.223	0.06869
10	Urban voids	0.667	0.333	0.667	0.333	0.178	0.134	0.107	0.086	0.171	0.126	0.199	0.05809
11	Traffic islands	0.5	0.5	0.333	0.667	0.169	0.135	0.124	0.148	0.097	0.118	0.21	0.04964

As shown in Figure 4, while the social and ecological criteria were equally rated at 0.4, the physical criteria achieved a value of 0.2. Accordingly, the ecological criterion of the vegetation index gained importance in its own group with a value of 0.67, surpassing the surface permeability (0.33). While this value represented the highest percentage of the total criteria pool at 0.27%, it was followed by surface permeability with a value of 0.13. Within the physical criteria, both land size (0.5) and enclosure (0.5) had equal weight as a 0.1 normalised relative value. Social criteria were divided into several sub-headings; property types (0.15) have 3, and land use types (0.25) have 4 sub-headings. While commercial had the highest value (0.2) among property typologies, public spaces (0.2) ranked first among land use typologies.

STUDY AREA

After weighing the criteria, the study area was selected considering the neighbourhood layout. The main selection parameters were specified as long-standing neighbourhoods, which have traditionally built textures to test existing ecological and social values regarding vitality and open space interactions. For this purpose, Seyyid Ömer neighbourhood, one of the oldest neighbourhoods of Istanbul, located in the historical peninsula of Fatih district, was selected as the study area. It is located within the coordinates 41°01'21, N°28'56 and is surrounded by the Byzantine walls, the Golden Horn and the Marmara coast.

Aside from its dissolved neighbourhood texture, an area that draws attention is Fındıkzade Çukur Bostan which gained the function of a garden by having vegetables and fruits planted by its fertile lands after the dysfunctionality of the open-air cisterns from the Byzantine period (istanbul.net.tr, n.d.). It can be argued that this type of function has an increasing effect on the vicinity, and creates a common memory of open space usage. Due to its fragmented but adequately preserved open space system and cultural background, the area promises a valuable neighbourhood pattern in the heart of the Historical Peninsula (Figure 5). The current map of the neighbourhood's orthophotos,

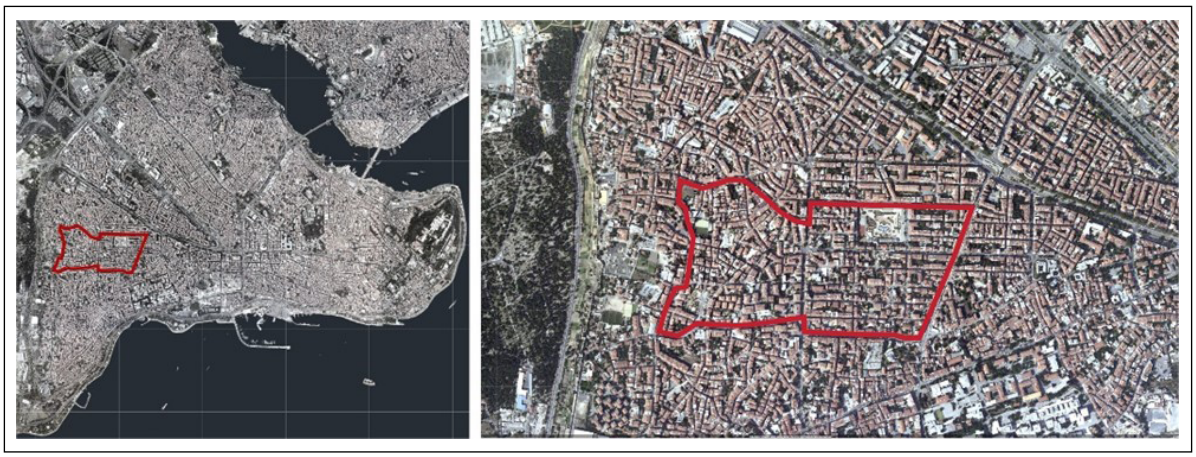

Figure 5. The location of Seyyid Ömer Neighbourhood in the Historical Peninsula and Istanbul Fatih District (Fatih Municipality, n.d.).

which are accessible online, and the 2012 development plan (Fatih Municipality) was used as the main data sources.

URBAN SURFACE INDEX EVALUATION

Based on the weights of the criteria and sub-criteria evaluations from ANP method, importance values were integrated into the index formula for urban surface performance measurement. The primary objective was to develop a measurement mechanism that enabled the identification of problems and potentials within the built texture by treating open spaces as holistic surfaces. From this point of view, the urban surface index was calculated by the weighted sums of the spatial values of the areas within the built texture per unit surface (Equation 1). Accordingly, when UX*i* is the urban surface index, α corresponds to the relative importance weight of the j criterion, and β*ij* corresponds to the scaled spatial value of all surfaces. When the number of all urban surfaces is expressed with n, the sum of the values of each area gives the UX*i*. In this direction, the outputs of the multiple decision-making model were combined with their spatial values using the ArcGIS program and the urban surface index values of alternative open spaces were revealed.

$$UXi = \sum_{j=1}^{n} \alpha j * \beta ij \quad (1)$$

Evaluation of the urban surface index was conducted on the study area in four main steps: First, the boundary of the computable index area was extracted. Then, all sub-criteria maps were created and rescaled in ArcGIS, after that overlapped by their weights to create each main criteria map. Last but not least, all main criteria maps, ecological, physical, and physical criteria, were overlapped with weights to obtain the final urban surface index value (Figure 6). First, the spatial boundary of the open areas to be included in the calculation within the study area was determined. Considering accessibility and connectivity, a 150m convergence limit to existing public green spaces and main access lines was defined, based on the location of public green spaces within a maximum of 5 minutes walking distance from public buildings and commercial areas (Bayer & Bell, 1998). Issues such as the spatial bond of urban green surfaces with users and how environmental

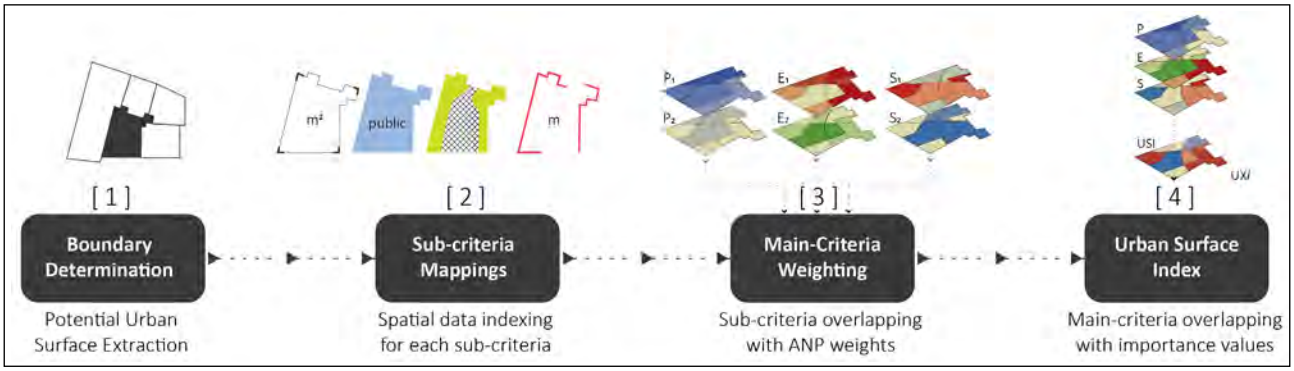

Figure 6. The flow diagram of computation of urban surface index.

functions support them diversify and strengthen the public use of that urban surface (Haq, 2015). In addition to these, the calculation area was determined by leaving roads and sidewalks outside the space boundary. All sub-criteria maps were generated based on this boundary determination. Since there are different sub-criteria and parameters, all maps were reclassified to bring all maps into the same unit based on Saaty's importance table (Saaty, 2002). With this classification, the aim was to combine the criteria consisting of different units (m^2, m, quality, etc.) into one raster data unit. Three distinct data sets were visualised while creating the criteria maps (Figure 7).

Quantitative values such as area dimensions, enclosure values, and surface permeability were converted into raster data by scaling from 1 to 9 by using the "reclassify" method. In addition, the values obtained from the analysis of raster data, such as vegetation quality, were also scaled on a scale of 1–9 with the same method. According to this value range, the analysis result with the lowest score is represented by 1, while the analysis result with the highest score is shown with 9. Since each of the produced maps displays different outputs, this unit of measure is shown in separate legends for the colours used in each map. The weights obtained from the decision support model were

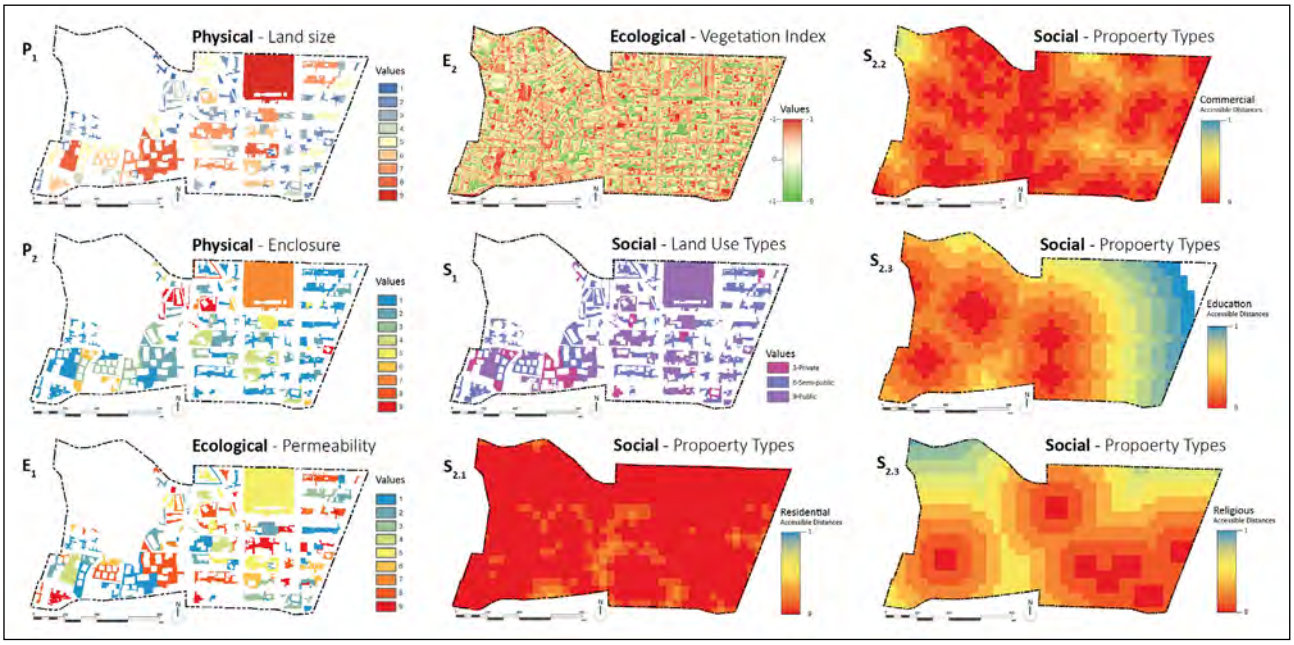

Figure 7. Sub-criteria maps for all main criteria groups.

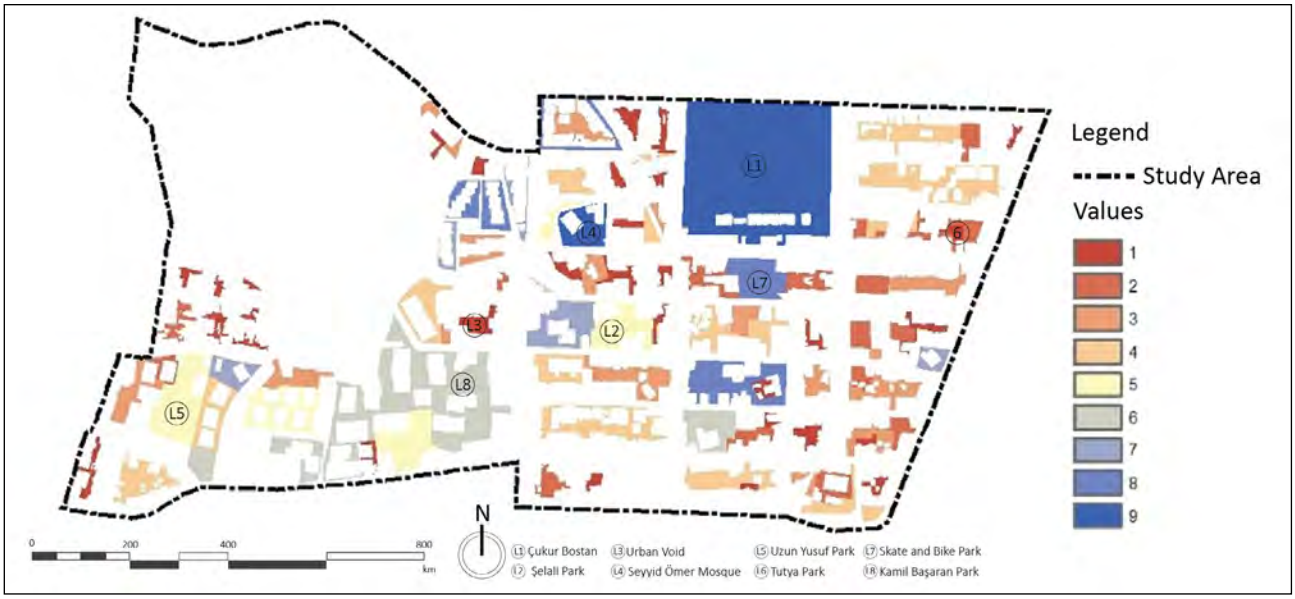

Figure 8. Weighted physical criteria map.

used in order to quantify the social characteristics of the areas and to compare them with other criteria. In the context of urban open spaces, the importance weights for public, semi-public, and private space types were 0.2, 0.13, and 0.06, respectively. The values were then converted to a scale of 1–9 for the land use type raster map, with public use assigned a value of 9, semi-public space 6, and private space 3. Also, property types were integrated into the mapping of impact areas within the research's accessible distances. After the sub-criteria maps were obtained, the "weighted sum" method was used in the ArcGIS program, which gave a superimposed result by evaluating the spatial attributes according to their importance. This method is used to calculate multiple functions in a multi-criteria decision-making process (Yang, 2014). By overlapping the spatial values of all criteria with weights, this method generates new spatial quantitative results.

The function of the urban surface index was calculated within the scope of the research by combining the sub-criteria from top to bottom. In order to obtain a weighted physical criteria map, land size, and enclosure maps were combined with their relative importance values according to the main criteria follows as evenly (Figure 8). By this method, the surface permeability and NDVI maps were combined with 0.33 and 0.67 weights for the ecological criteria map (Figure 9). And the land-use and property type

Figure 9. Weighted ecological criteria map.

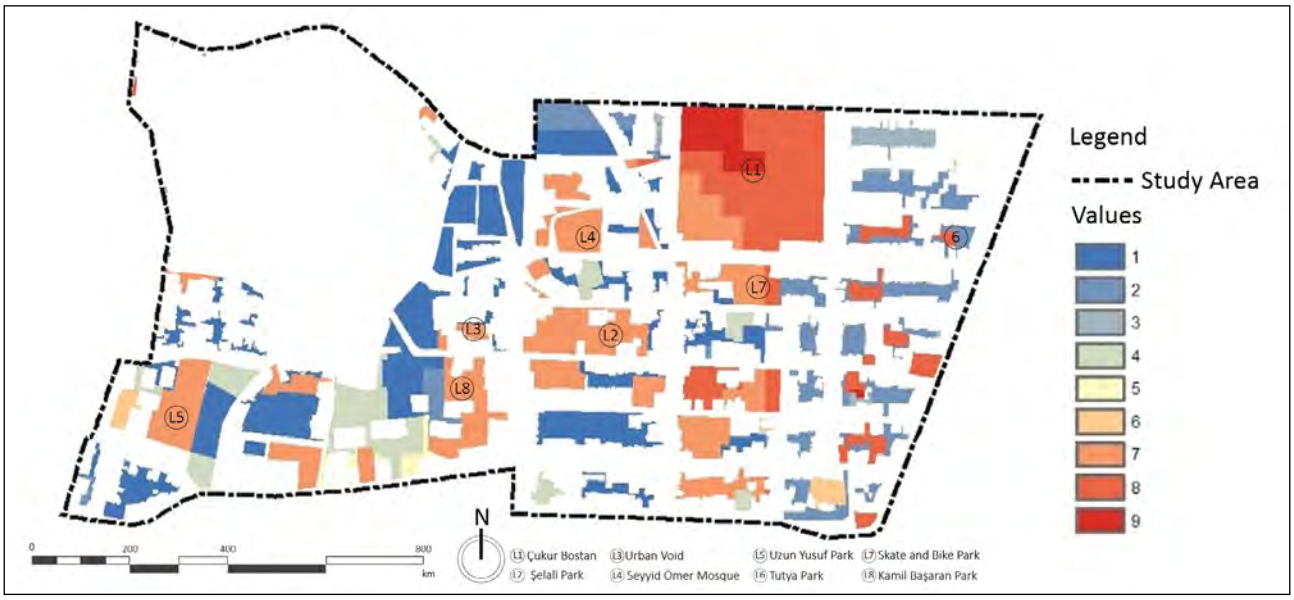

Figure 10. Weighted social criteria map.

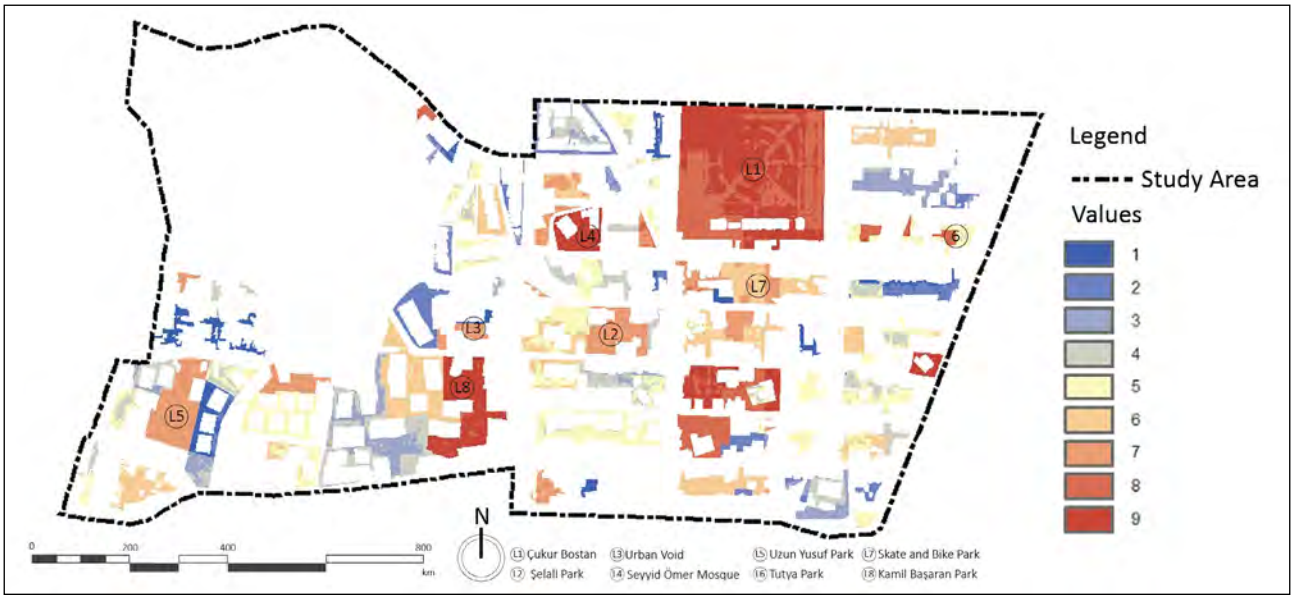

Figure 11. Urban surface index.

mappings were superimposed according to the 0.61 and 0.39 values for the social criteria map (Figure 10). Then, the maps indicating the weights between each of the three main criteria, the social and the ecological values share both 0.4 and physical 0.2, were once again calculated with the "weighted sum" method. At the end of this process, the urban surface index values of the study area were obtained (Figure 11).

RESULTS

The map of weighted physical criteria (Figure 8) shows that Çukur Bostan (L1) receives the highest rating. Other highly rated areas are some urban voids between blocks of buildings, the Skate and Bike Park (L7) and the Seyyid Ömer Mosque (L4). It can be inferred that these areas were rated based on their enclosure values rather than land size. The other moderately evaluated areas are mostly small pocket parks such as Uzun Yusuf Park (L5) and Şelaleli Park (L2) in terms of their land sizes. In the elaboration of the map with the weighted ecological criteria (Figure 9), the highest rated areas are mainly non-functional urban voids (L3) and some neighbourhood parks such as Tutya Park (L6) and Kamil Başaran Park (L8) with their surroundings. On the other hand, Çukur Bostan (L1) and Şelaleli Park (L2) were rated moderately despite their physical importance. These contradictions become clear by comparing the maps with the main criteria. However, the weighted social map (Figure 10) shows some parallel results for both main criteria. While Çukur Bostan (L1) receives the highest value similar to other criteria groups, some areas that receive a high value from physical or ecological criteria stand out, such as Skate and Bike Park (L7) and Kamil Başaran Park (L8). Also, some areas such as Uzun Yusuf Park (L5) and Şelaleli Park (L2) distinguished despite their low physical and ecological values.

When all maps are evaluated together, building blocks with different zoning types and wide openings stand out in terms of supporting urban ecological values. In fact, it is seen that the ecological criteria of Çukur Bostan (L1) district park, which has the largest surface area in the neighbourhood, is lower than the values of the private or public areas between some building blocks. However, open spaces in the immediate vicinity of the main streets, where commercial use is concentrated, have the potential to establish a spatial relationship to form a network system. When compared with the current zoning status, it can be said that increasing the ecological values of urban surfaces such as schoolyards or parking lots, which have semi-public use characteristics, has an important potential to increase the quality of life. It can be deduced that the open areas in the neighbourhood are predominantly used areas with different zoning typologies under 4 Ha. The areas that stand out with the greatest potential are Çukur Bostan (L1), which is currently used as a public space, and the surrounding educational and religious buildings. In addition to these, it is seen that large building blocks containing some residential buildings have physical potential. On the other hand, the physical qualities of the blocks, which were completely surrounded by structures, received a low response.

As can be seen, Çukur Bostan (L1), whose green features draw the most attention in terms of structural texture, has an average score in terms of ecological criteria, while it increases the urban surface index with its social and physical values. On the other hand, Tutya Park (L6) and Kamil Başaran Park (L8) also receive a high overall index score despite their lower scores on some criteria. Therefore,

Figure 12. Importance degrees of the surfaces.

inferences can be made about expanding the size or usage patterns of existing surfaces or improving their potential within their existing borders. At this point, it would be useful to evaluate the alternative open space typologies obtained during the determination of the criterion weights together with the index results. This would be important in terms of developing the existing areas and revealing the potential surfaces that can be brought to the city. As mentioned above, the limit of open areas, which have the highest weights in terms of ecological, social, and physical criteria, can be considered to be 6 points. Thus, the ecological, social, and physical characteristics of surfaces are classified into three categories according to the benefits they provide to cities (Figure 12). A degree of "Very Important" describes the surfaces on the 8–9 scale, "Important" represents the 6–8 scale, and "Least Important" is the 1–6 scale. The purpose of a triple classification is to establish a framework for designing strategies. By defining the action range on a 6–9 scale, it is possible to develop strategies for improvement and/or renewal in these areas, as well as strategies for transformation and/or re-functioning.

DISCUSSION AND CONCLUSIONS

The study of urban ecology has resulted in the development of a paradigm that places a calculable premium on the sustainability of cities (Wu, 2014). Computable criteria can be viewed as indicators and indexes used in quantitative evaluations in the literature. In this respect, it can be said that this research will contribute to the reflection of the theoretical studies and modelling approaches, especially at the landscape scale, into practice, based on the context of urban ecology, which still has gaps in the literature. With this structure, the "Urban surface index", developed within the scope of this research, provides outputs that can direct planning and design by placing the qualities of open spaces on a calculable scale. By considering cities with a complex and multi-dimensional systems approach, this index can examine the ecological, social, and physical indicators of open space in a multi-dimensional way. Nevertheless, most of the literature examines the indicators in a homogeneous and uni-dimensional way. As such, the majority of this research assesses cities as a whole using large-scale remote sensing methods (Patel & Mukherjee, 2015; Mourya et al., 2021). Some urban ecology studies focus on more specific areas; however, their objectives are usually about on one or a few indicators such as biodiversity (Deslauriers et al., 2018), climate comfort (Gómez et al., 2018) or rarely on socio-ecological interactions like population density and vegetation cover (Grove et al., 2014). As can be seen, research that focuses on indices or indexes based on urban ecology usually overlooks the interdependent and complex relationships through uniform indicators.

In this study, the Seyyid Ömer neighbourhood in Istanbul's Fatih district was analysed in terms of physical, ecological, and social criteria and their sub-criteria. By applying a multi-criteria decision-making method, ANP was used to determine an index for elaborating urban open space performances. The index indicated that some urban voids stand out even more than the important ones and have greater potential than urban parks in terms of social and vegetation qualities. As a result of the research, a map of the importance level (Figure 12) was created to illustrate the potential areas for improving the urban ecological performance. In summary, neighbourhood and urban parks such as Çukur Bostan (L1), Kamil Başaran Park (L8)

and pocket parks like Tutya Park (L6) with some urban voids nearby the religious buildings gained the highest importance. On the other hand, various functional open spaces with some neighbourhood parks such as Şelaleli Park (L2), Skate and Bike Park (L7) and Uzun Yusuf Park (L5) show potential through the urban surface index. Using this index, these areas were identified as open spaces that need improvement and can contribute to the urban ecological value of the neighbourhood. In this respect, research represents a point that combines theory and practice. Research shows detailed comparisons based on neighbourhood scale by considering the existing qualities of urban open spaces under sub-categories. In addition, it also reveals under which main criteria the existing urban surfaces should be improved. The research is unique in that it focuses on both the scale of a neighbourhood and a multi-dimensional analysis perspective of urban structure. Given the emphasis of contemporary urban ecology theory on socio-ecological relationships, the research has great potential to provide a guide for the redesign of urban open spaces in densely built cities, particularly in Istanbul.

In the present study, the primary criteria relationships were highlighted by limiting the criteria (e.g., land size, enclosure) for the characteristics of urban surfaces. For this reason, it can be said that the measurement units are few in number. For future studies, the sub-criteria for site-specific assessments such as air, water, or sound pollution can be. In particular, in an approach that aims to study the city in different dimensions, the relationship of social life to space should be addressed through field observations. Considering these conclusions, it can be said that the index revealed by this particular research will provide important data for the analysis of the factors that determine the performance of the urban surface and spatial design.

ETHICS: There are no ethical issues with the publication of this manuscript.

PEER-REVIEW: Externally peer-reviewed.

CONFLICT OF INTEREST: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

FINANCIAL DISCLOSURE: The authors declared that this study has received no financial support.

REFERENCES

Alberti, M., Marzluff, J. M., Shulenberger, E., Bradley, G., Ryan, C., and Zumbrunnen, C. (2003). Integrating humans into ecology: Opportunities and challenges for studying urban ecosystems. BioScience 53(12):1169–1179.

Bakay, E. (2012). The role of housing estates' green surfaces in forming the city climate of Budapest. Applied Ecology and Environmental Research 10(1):1–16.

Barthel, S., Andersson, E., and Ahrné, K. (2007). Measuring social–ecological dynamics behind the generation of ecosystem services. Ecological Applications 17(5):1267–1278.

Baycan-Levent, T., Van Leeuwen, E., Rodenburg, C., and Nijkamp, P. (2002). Development and management of green spaces in European cities: A comparative analysis. Research Memorandum 25.

Bayer, R. and Bell, D. A. (1998). The Essential Communitarian Reader (A. Etzioni, Ed.). Rowman & Littlefield.

Benedict, M. A. and McMahon, E. T. (2012). Why Green Infrastructure ? In Green infrastructure: linking landscapes and communities. Island press. pp. 1–23.

Bölen, F., Dülger Türkoğlu, H., and Yirmibeşoğlu, F. (2011). İstanbul'da yapılaşma yoğunluğu-yaşanabilir alan ilişkisi. İTÜDERGİSİ/a 8(1).

Carlson, T. N. and Ripley, D. A. (1997). On the relation between NDVI, fractional vegetation cover, and leaf area index. Remote Sensing of Environment 62(3):241–252.

Cook, E. A. (2002). Landscape structure indices for assessing urban ecological networks. Landscape and Urban Planning 58(2–4):269–280.

Creative Decisions Foundation. (2021). SuperDecisions Software. Retrieved 26 October 2021 from http://www.superdecisions.com/downloads/.

Cullen, G. (2012). Concise townscape. Routledge.

Deslauriers, M. R., Asgary, A., Nazarnia, N., and Jaeger, J. A. (2018). Implementing the connectivity of natural areas in cities as an indicator in the City Biodiversity Index (CBI). Ecological Indicators 94:99–113.

Dunnet, N., Swanwick, C., and Wooley, H. (2007). Improving urban parks, play areas and open spaces. Department of Landscape, University of Sheffield. In.

Dyson, K., Ziter, C., Fuentes, T. L., and Patterson, M. (2019). Conducting urban ecology research on private property: Advice for new urban ecologists. Journal of Urban Ecology 5(1):001.

Erdönmez, M. E. and Akı, A. (2005). Açık kamusal kent mekanlarının toplum ilişkilerindeki etkileri. Megaron 1(1):67.

Esri. (2020). Install ArcGIS Pro(version 2.8). https://pro.arcgis.com/en/pro-app/latest/get-started/install-and-sign-in-to-arcgis-pro.htm.

Fatih Municipality. (n.d). Fatih Belediyesi Coğrafi Bilgi Sistemi. Retrieved 14.09.2021 from https://kentrehberi.fatih.bel.tr/webgis/.

Firozjaei, M. K., Fathololoumi, S., Weng, Q., Kiavarz, M., and Alavipanah, S. K. (2020). Remotely sensed urban surface ecological index (RSUSEI): An analytical framework for assessing the surface ecological status in urban environments. Remote Sensing 12(12):2029.

Gallopin, G. C. (2005). Indicators and their use: information for decision-making. Sustainability: Critical Concepts in the Social Sciences 3:257–273.

Gavrilidis, A. A., Ciocănea, C. M., Niţă, M. R., Onose, D. A., and Năstase, I. I. (2016). Urban landscape quality index–planning tool for evaluating urban landscapes and improving the quality of life. Procedia Environmental Sciences 32:155–167.

Gómez, F., Valcuende, M., Matzarakis, A., and Cárcel, J. (2018). Design of natural elements in open spaces of cities with a Mediterranean climate, conditions for comfort and urban ecology. Environmental Science and Pollution Research 25(26):26643–26652.

Grimm, N. B., Faeth, S. H., Golubiewski, N. E., Redman, C. L., Wu, J., Bai, X., and Briggs, J. M. (2008). Global change and the ecology of cities. Science 319(5864):756–760.

Grove, J. M., Locke, D. H., and O'Neil-Dunne, J. P. (2014). An ecology of prestige in New York City: Examining the relationships among population density, socio-economic status, group identity, and residential canopy cover. Environmental Management 54(3):402–419.

Haq, S. (2015). Urban green spaces and an integrative approach to sustainable environment. In Urban Ecology: Strategies for Green Infrastructure and Land Use. Etingoff, K., Ed. Apple Academic Press. pp. 147–166.

Hobbs, R. J., Arico, S., Aronson, J., Baron, J. S., Bridgewater, P., Cramer, V. A., Epstein, P. R., Ewel, J. J., Klink, C. A., and Lugo, A. E. (2006). Novel ecosystems: Theoretical and management aspects of the new ecological world order. Global Ecology and Biogeography 15(1):1–7.

Huang, L., Wu, J., and Yan, L. (2015). Defining and measuring urban sustainability: A review of indicators. Landscape Ecology 30(7):1175–1193.

IPCC (2021). Climate change widespread, rapid, and intensifying, United Nations (UN). 6:0–6.

IPCC (2018). Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, … T. Waterfield (Der.). In Press.

istanbul.net.tr. (n.d.). FATİH İstanbul Rehberi. Retrieved 26.10.2021 from https://www.istanbul.net.tr/istanbul-rehberi/dosyalar/bolumler/fatih/7/77.

James, P., Tzoulas, K., Adams, M. D., Barber, A., Box, J., Breuste, J., Elmqvist, T., Frith, M., Gordon, C., and Greening, K. (2009). Towards an integrated understanding of green space in the European built environment. Urban Forestry & Urban Greening 8(2):65–75.

Kazmierczak, A. and James, P. (2007). The role of urban green spaces in improving social inclusion.

Kou, G. and Ergu, D. (2016). AHP/ANP theory and its application in technological and economic development: The 90th anniversary of Thomas L. Saaty. Taylor & Francis. 22:649–650.

La Rosa, D. (2014). Accessibility to greenspaces: GIS based indicators for sustainable planning in a dense urban context. Ecological Indicators 42:122–134.

Larondelle, N. and Haase, D. (2013). Urban ecosystem services assessment along a rural–urban gradient: A cross-analysis of European cities. Ecological Indicators 29:179–190.

Liang, X., Tian, H., Li, X., Huang, J.-L., Clarke, K. C., Yao, Y., Guan, Q., and Hu, G. (2021). Modeling the dynamics and walking accessibility of urban open spaces under various policy scenarios. Landscape and Urban Planning 207:103993.

Lin, T. and Grimm, N. B. (2015). Comparative study of urban ecology development in the US and China: Opportunity and Challenge. Urban Ecosystems 18(2):599–611.

Liu, Y., Meng, Q., Zhang, J., Zhang, L., Jancso, T., and Vatseva, R. (2016). An effective building neighborhood green index model for measuring urban green space. International Journal of Digital Earth 9(4):387–409.

Lynch, K. (1960). The image of the city (Vol. 11). MIT press.

Machado, A. (2004). An index of naturalness. Journal for Nature Conservation 12(2):95–110.

Madanipour, A. (1996). Design of Urban Space: An Inquiry into a Socio-Spatial Process. University of Newcastle.

Mcdonnel, M. (2011). The history of urban ecology: An ecologist perspective. Urban ecology: Patterns, Processes and Applications 5–13.

Mirzaei, N. and Nowzari, R. (2021). Applying a combination of AHP, ANP, and PROMETHEE methods to find the optimal location for solar power plant. Avrupa Bilim ve Teknoloji Dergisi 32:1076–1085.

Mourya, M., Kumari, B., Tayyab, M., Paarcha, A., and Rahman, A. (2021). Indices based assessment of built-up density and urban expansion of fast growing Surat city using multi-temporal Landsat data sets. GeoJournal 86(4):1607–1623.

Mu, E. and Pereyra-Rojas, M. (2016). Practical decision making: An introduction to the analytic hierarchy process (AHP) using super decisions V2. Springer.

Niemelä, J. (2014). Ecology of urban green spaces: The way forward in answering major research questions. Landscape and Urban Planning 125:298–303.

Niemelä, J., Breuste, J., Elmqvist, T., Guntenspergen, G.,

James, P., and McIntyre, N. E. (2011). Introduction. In Urban ecology: patterns, processes, and applications. OUP Oxford. pp. 1–4.

Olalla-Tárraga, M. Á. (2006). A conceptual framework to assess sustainability in urban ecological systems. International Journal of Sustainable Development and World Ecology 13(1):1–15.

Patel, N. and Mukherjee, R. (2015). Extraction of impervious features from spectral indices using artificial neural network. Arabian Journal of Geosciences 8(6):3729–3741.

Raymond, C. M., Frantzeskaki, N., Kabisch, N., Berry, P., Breil, M., Nita, M. R., Geneletti, D., and Calfapietra, C. (2017). A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas. Environmental Science & Policy 77:15–24.

Reid, W. V., Mooney, H. A., Cropper, A., Capistrano, D., Carpenter, S. R., Chopra, K., Dasgupta, P., Dietz, T., Duraiappah, A. K., and Hassan, R. (2005). Key Questions in the Millennium Ecosystem Assessment. In Ecosystems and human well-being-Synthesis: A report of the Millennium Ecosystem Assessment. Island Press. pp. 71–84.

Ruano, M. (2018). Decision Making within the Tourism Industry with AHP: Determining key influential factors affecting foreign visitors' decision to revisit Belize. National Taipei University of Technology, Taiwan. Central America.

Rouse, D. C. and Bunster-Ossa, I. F. (2013). Green Infrastructure in Practice. In Green infrastructure: a landscape approach. American Planning Association. pp. 17–46.

Saaty, R. (2002). Decision making in complex environments: The analytic network process (ANP) for dependence and feedback; A Manual for the ANP Software SuperDecisions. Creative decisions foundation, Pittsburgh, PA.

Saeidi, S., Mirkarimi, S. H., Mohammadzadeh, M., Salmanmahiny, A., and Arrowsmith, C. (2018). Assessing the visual impacts of new urban features: Coupling visibility analysis with 3D city modelling. Geocarto International 1–17.

Saura, S., Estreguil, C., Mouton, C., and Rodríguez-Freire, M. J. E. I. (2011). Network analysis to assess landscape connectivity trends. Application to European Forests (1990–2000) 11(2):407–416.

Siregar, J. P. (2014). Assessment of public space quality using good public space index (Case Study of Merjosari Sub District, Municipality of Malang, Indonesia). Procedia-Social and Behavioral Sciences 135:10–17.

Takács, D., Varró, D., and Karlócainé Bakay, E. (2014). Comparison of different space indexing methods for ecological evaluation of urban openspaces. Applied Ecology and Environmental Research 12(4):1027–1048.

Triantaphyllou, E. (2000). Multi-criteria decision making methods. In Multi-criteria decision making methods: A comparative study. Springer. pp. 5–21.

Van Herzele, A. and Wiedemann, T. (2003). A monitoring tool for the provision of accessible and attractive urban green spaces. Landscape and Urban Planning 63(2):109–126.

Verma, P., Singh, P., Singh, R., and Raghubanshi, A. (2020). Urban ecology: emerging patterns and social-ecological systems. Elsevier.

Walzer, M. (1986). Public space-pleasures and costs of urbanity. Dissent 33(4):470–475.

Wu, J. (2014). Urban ecology and sustainability: The state-of-the-science and future directions. Landscape and Urban Planning 125:209–221.

Wu, J. and Wu, T. (2012). Sustainability indicators and indices: An overview. Handbook of Sustainability Management. 65–86.

Yang, X.-S. (2014). Weighted Sum Method. In Nature-inspired optimization algorithms. Elsevier. pp. 201–204.

Yıldız, A. (2014). En İyi Üniversite Seçiminde Analitik Ağ Prosesinin Kullanımı. İleri Teknoloji Bilimleri Dergisi 3(2):108–119.

Zhao, X., Deng, L., Wang, H., Hua, L., and Chen, F. (2014). Landscape classifications for landscape metrics-based assessment of urban heat Island: A comparative study. IOP Conference Series: Earth and Environmental Science 17(1):012155.

Megaron, Cilt. 17, Sayı. 4, ss. 673–683, Aralık 2022

Megaron
https://megaron.yildiz.edu.tr - https://megaronjournal.com
DOI: https://doi.org/10.14744/MEGARON.2022.80037

Makale [Article in Turkish]

Erzurum tarihi kent dokusu mekân dizimi ve erişilebilirlik analizi

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MAKALE BİLGİSİ

Makale Hakkında
Geliş: 22 Kasım 2021
Revizyon: 24 Ekim 2022
Kabul: 25 Ekim 2022

Anahtar sözcükler:
Mekân dizin analizi; okunabilirlik; tarihi kentler

ARTICLE INFO

Article history
Received: 22 November 2021
Revised: 24 October 2022
Accepted: 25 October 2022

Key words:
Space syntax analysis; legibility; historical city

Space and accessibility analysis of Erzurum historical urban zone

EXTENDED ABSTRACT

Erzurum's historical urban texture has lost its layered structure over time, and its integrated structure with the city has deteriorated.
The present study aims to determine the physical characteristics of Erzurum's historical city centre and their influence on pedestrian movements in order to quantify spatial legibility.
The present study employs the Space Syntax technique. Developed by Hiller & Hanson (1984), this method serves as an approach for analysing the complex structure of cities, and it has been applied in a variety of disciplines.
All types of maps and aerial photographs, related publications, theses, the conservation plan dated 6.8.1986, and the open-source software DepthmapX were used as primary materials in the present study. Field observations, expert evaluations, and field and numerical data were used as secondary materials.
The present study focuses on Erzurum's historical city centre, which is protected as a first and third-degree archaeological site. The study area was divided into four regions for examination. Region I involves the Erzurum Castle and its surroundings; Region II involves the Twin Minaret Madrasa and its surroundings; Region III involves the Yakutiye Municipality building and its surroundings; Region IV involves the Yakutiye Madrasa and its surroundings.
The Photoshop program was used to visualise the suggestions presented at the conclusion stage. The present study can be categorised as applied research because of this characteristic.
Over time, historical cities evolve and develop a layered structure. The relevance of historical textures is recognised in planned cities, and the historical texture is conserved. The city of Erzurum, which was selected as the study area, is one of the cities where the historical urban environment and street texture could not be preserved. The historical city centre, which is a first- and third-degree protected area connected to the city's busiest street, has become isolated over time, the area has become run-down with the gradual withdrawal of the historical city's inhabitants, and the lack of responsibility and abandonment has resulted in security issues. The relationship between spatial accessibility and this scenario was investigated in the present study. The findings of the analysis and methodology are represented graphically. An axial map of the study area was first constructed, followed by a spatial legibility graph. According to the graphic results, the accessibility value in Regions I and IV are better as a result of the arrangements made in the form of city squares, whereas the accessibility value in Regions II and III is rather low. In order for the space to achieve a permeable structure, access points are defined and depicted on maps.

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Published by Yıldız Technical University Press, İstanbul, Turkey
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In the conclusion section of the present study, the beneficial aspects of the relationship between accessibility and landscaping as found in the field studies were analysed, and field suggestions were included. The historical street texture of Erzurum has almost completely vanished in the area, according to investigations. In terms of legibility, it has been decided that the urban landscape studies conducted in Regions I and IV are more applicable. The historical urban texture of Regions II and III has been assessed to be complex, lacking a substantial level of comfort, and also insufficient in terms of security due to the isolation brought on by this turmoil, resulting in poor walkability.
The importance of accessibility in historical urban textures, as well as its implications for spatial use, have been evaluated in the present study. The use of digital software is critical in the planning of historical urban textures, which are becoming more relevant around the world and in our country. The present study, which was conducted in Erzurum's historical city centre, is unique in regional terms. In terms of urban memory, historical urban textures are extremely important. The approaches that represent the spirit of the space, integrate with the traditional texture and respect the urban stratification, as well as the aesthetic value they offer to the city, emerge as the unifying element of city squares. The feasibility of recent urban transformation works in and around Erzurum Castle within the context of the layered structure was assessed in the present study. This distinguishes the study in regional terms.
Point proposals that have been expanded in terms of the coherence of the study area, which has a significant resource value in terms of preserving the remaining pieces of history, make the study distinctive in another respect.

ÖZ

Zaman içerisinde değişerek günümüze gelen tarihi kentlerin sahip olduğu sosyal, mimari ve ticari doku kentsel mirasın en önemli bileşenleridir. Günümüzde hızla değişen kentlerin çoğu, tarihi kimliğini koruyamamış ve tarihi doku önemini yitirmiştir. Kentsel mirasın sürdürülebilirliğinin sağlanması kültür aktarımı açısından da oldukça önemlidir ve korunması zorunludur. Bu amaçla pek çok planlama kararlarının alındığını ancak bu kararların her zaman yeterli olmadığı ve bilimsel temellere dayanmadığı görülmektedir. Çok katmanlı yapıya ve oldukça zengin kültürel birikime sahip olan Erzurum Tarihi kent çekirdeğinin ne yazık ki son 10 yıl içinde hızlı yok olması oldukça üzücüdür. Çözüm olarak kent merkezinde bulunan ancak kentten soyutlanarak kent yaşamından uzaklaşmış olan bölgelerin kent yaşamına yeniden katılması ve kent ile bütünlüğünün sağlanması önerilmektedir. Bu araştırma Erzurum kenti tarihi dokusunu oluşturan iç kale ve çevresini içine alan 1. derece ve 3. derece kentsel sit alanı ve çevresini kapsamaktadır. Çalışmanın ana amacı, Erzurum tarihi kent çekirdeğinin fiziksel özellikleri ve bu özelliklerin yaya hareketlerine olan etkisinin belirlenerek mekân okunabilirliğinin ölçülmesidir. Bu amaçla 2019 yılında uygulanmaya başlanan, ilk etabı bitmiş olan koruma amaçlı imar planı kararları incelenerek tarihi kent çekirdeğinin kent ile bütünleşme yolları araştırılmıştır. Tarihi kent çekirdeği mekân dizim analizi yöntemi ile alan erişilebilirliği, alan bütünleşmesi ve sokak okunabilirliği analiz edilmiştir. Analiz sonucunda, Erzurum tarihi kent çekirdeğinin erişilebilirlik ve bütünleşme açısından iyiye yakın olduğu, ancak tarihi sokak dokusunun özgünlüğünü yitirmiş olduğu görülmüştür. Analiz sonuçları değerlendirilerek Erzurum tarihi kent çekirdeğinin kent ile yeniden bütünleşmesi, erişilebilirliğinin ve mekânsal okunabilirliğinin artması için bazı kriterler ortaya konulmuştur.

Atıf için yazım şekli: Turgut H. Space and accessibility analysis of Erzurum historical urban zone. Megaron 2022;17(4):673–683. [Article in Turkish]

GİRİŞ

Kentlerde tarihi dokunun korunması ve kültürel mirasın sürdürülebilirliği konuları 2863 sayılı Kültür ve Tabiat Varlıklarını Koruma Kanunu kapsamındadır. Çok katmanlı kent merkezlerinde kültürel mirasın yönetimi konularında kanunun 6. maddesinde yer alan kentsel arkeolojik sit kavramına uygun ciddi çalışmaların günümüze kadar yeterince yapılmadığı vurgulanmalıdır. Ayrıca tarihi kent merkezlerinin bütünlüğünün korunamadığı alanlarda 3. Derece Arkeolojik Sit Alanı ilanlarının çözüm olmadığı da görülmektedir (Belge, 2004). Tarihi ortak mirasların korunması çalışmaları kanunlara dayandığı kadar bilimsel temellere de dayanmalıdır. Dünya kentlerinin başarılı örnekleri incelendiğinde, başarılarının çok yönlü araştırma çalışmalarının sonucu olduğu ortaya çıkmaktadır. Tarihi çevrelerin, yaşayan mekânlar olarak planlanmasının da koruma çalışmalarında başarı oranını artırdığı pek çok örnekte görülmektedir. Örnek bir çalışma ile 2006-2007 yılları arasında Erzurum tarihi kent dokusunun %12 oranında tahrip olduğu, tahribatın daha çok terk edilmiş binalarda gözlemlendiği ortaya konulmuştur (Atabeyoğlu ve ark., 2011). Korumanın en önemli katkısı, tarihi çevreyi sürdürülebilirliği için uygun kararlar ve uygulamalar ile yeniden yaşanabilir hale getirebilmektir (Arabacıoğlu ve Aydemir 2007; Mehanna ve Mehanna, 2019). Artan nüfusun getirdiği sorunlar tarihi kent dokusunda etkisini daha da artırmaktadır. Kentsel planlamalar ile tarihi dokunun üzerindeki baskılar azaltılabilir. Günümüzde pek çok bilgisayar programının planlama çalışmalarında kullanılması ile analitik yaklaşımlar yapılabilmektedir. Bu tür analitik yaklaşımlar tarihi kent dokularının sürdürülebilirliği açısından önemlidir.

Kentsel dönüşüm çalışmalarında; tarihi kent dokusunun azami ölçülerde korunabilmesi esas olmalıdır. Harap durumdaki bazı binaların yıkılarak kaldırılması geleneksel sokak dokusunun kaybolmasına yol açmaktadır. Yıkılması

zorunlu olan binalar tarihi dokuya uygun olarak yeniden inşa edilmeli ve yeniden inşa sürecinde de tarihi kent dokusunun fiziksel, sosyal ve kültürel özelliklerinin korunması amaçlanmalıdır. Böylelikle kentsel dönüşüm çalışmaları tarihi dokunun modern kentle birlikte ve modern kent içinde sürdürülebilmesi için önemli bir fırsat haline gelecektir. Unutmamalıyız ki sokak ağlarının mekânsal doku ve mekân dizimi ile ilişkisi şehir formunu, dolayısıyla da kentsel sürdürülebilirliği etkileyen önemli parametrelerdendir (Omer ve Kaplan, 2017; Alalouch ve ark., 2019). Tarihi kentlerin katmanlı yapısı mekân diziminin şekillenmesinde etkili olmaktadır (Bibri ve Krogstie, 2017). 1970'li yılların sonunda geliştirilen mekân dizimi *(Space Syntax)* (Hillier ve Hanson, 1984), farklı alanlarda uygulanan ve geliştirilen tekniklerle de pek çok çalışmaya konu olmuştur (Coop ve Thomas, 2007; Malek, 2015; Fladd, 2017; Lebendiger ve Lerman 2019; Baumanova, 2020). Mekân dizimi *(Space Syntax)* alan morfolojisi ile ilişkili olduğu kadar insan ve çevre etkileşimini de ortaya koymaya çalışan bir yöntem olarak karşımıza çıkmaktadır (Battistin, 2019). Mekân dizimi *(Space Syntax)* analizinde kent sokak ağlarını incelerken; eksenel analiz, segment analiz, okunabilirlik, erişilebilirlik ve görünürlük analizleri kullanılmaktadır (Dalton ve Dalton, 2001; Dağ, 2005; Gündoğdu, 2014; Malek, 2015). Mekân dizimi analizi çalışmalarında iki boyutlu haritalarla DepthmapX ve son zamanlarda QuantumGIS eklentisi olarak kullanılabilen Space Syntax Toolkit programları kullanılmaktadır (Öztürk, 2018). Mekân dizimi *(Space Syntax)* tekniği ile sokak ağlarının mekânsal yapısı arasındaki ilişki, grafikler ile ortaya konulmaktadır. Böylece parçadan bütüne doğru kentsel sistemin ilişki durumu değerlendirilmekte ve gelecek planlamalar için ipuçları vermektedir (Hillier, 1999; Önder ve Gigi 2010; Valipour, ve ark., 2019; Lebendiger ve Lerman, 2019). Mekân analiz kavramları; konfigürasyon yani yapılandırılmış mekân kavramı, doğal hareketlilik kavramı, enforme edilmiş grid kavramı, grafik kavramı ve analizi, derinlik kavramı, entegrasyon yani bütünleşme kavramı olarak sıralanabilir (Narvaez ve ark., 2012).

MATERYAL VE YÖNTEM

Materyal

Arkeolojik bulgularla varlığının yontma taş devrine kadar dayandığı tespit edilen Erzurum kenti bugünkü yerine bir kale şehir olarak beşinci yüzyılda ve Doğu Romalılar tarafından taşınmıştır. Kentte 1080 yılında başlayan Türk hâkimiyeti (Solmaz, 1999) kısa süreli bazı kesintilere uğramış olmakla birlikte asırlar boyu devam etmiş ve Mustafa Kemal Paşa önderliğindeki milli mücadele ile kesinlik kazanmıştır. Coğrafi konumundan kaynaklanan stratejik değeri ve ipek yolu dahil ticaret yolları üzerinde bulunmasından kaynaklanan ticaret merkezi olma özelliği kenti askeri ve ticari yönden her dönem önemli kılmıştır. Kentin ekonomik ve stratejik önemi kentin çok katmanlı kültürel yapıya sahip olmasını sağlamıştır (Solmaz, 1999; Sutay, 2020).

Tarih kaynaklarında; geçmişte kentin üç kat surlar ile çevrili olduğu ifade edilmektedir (Solmaz, 1999). Bugün kent tarihi dokusu; iç kale ve çevresinin bulunduğu 1. derece ve 3. derece kentsel sit alanı; Erzurum Kültür Tabiat Varlıkları Koruma Kurulu'nun 17.12.1993 gün ve 601 sayılı kararı ile korunmaya alınmıştır. Kültür Varlıklarını Koruma Bölge Kurulu'nun 25.09.2013 tarih ve 892 sayılı kararı ile Erzurum Kalesi, 1. Derecede Arkeolojik Sit, Kale Çevresi 3. Derecede Arkeoloji Sit, İç kale surlarının içinde kalan bölümler kentsel sit alanı ve bu alan dışında kalan ve tarihi dokuyu yansıtan yakın bölümler ise etkileme geçiş alanı olarak ilan edilmiştir. Erzurum Büyükşehir Belediyesi tarafından tarihi dokunun korunması ve gelecek nesillere sağlıklı bir şekilde aktarılması amacıyla 15 Ocak 2016 tarihinde Koruma Amaçlı İmar Planı yapılmıştır. Bu imar planı doğrultusunda şehrin Kültür Varlıklarını Koruma Bölge Kurulu tarafından belirlenen sit sınırları ve etkileme geçiş alanı sınırları içinde kalan bölümleri için yeniden yapılaşma şartları oluşturulmuştur (Altundağ, 2019). Yeniden yapılanmanın etkilediği; 1. derece ve 3. derece arkeolojik sit alanını kapsayan; Erzurum Kalesi ve çevresi, Çifte Minareli Medrese, Ulu Camii, Şair Nefi Ortaokulu, Taş Ambarlar ve çevresi, Yakutiye İlçe Belediye Binası ve çevresi, Yakutiye Medresesi, Lalapaşa Camii ve çevresi çalışma alanı kapsamında değerlendirilecektir (Şekil 1).

Çalışma alanı için oluşturulan hipotez; kentten ayrışmış alanların kent ile bütünleşmesinin tarihi mekânlarda ziyaretçi sayısının ve alan kullanım potansiyelinin artacağı ve sonuç olarak da kullanılmamaktan kaynaklanan köhneleşme ve yok olmanın geciktirilerek, sürdürülebilir alan kullanımına katkı sağlayacağı düşüncesi üzerine kurulmuştur. Atabeyoğlu ve ark. (2011), tarafından yapılan çalışmada vurgulandığı gibi, tarihi kent dokuları ıssızlaştıkça, güvenlik sorunları artmakta, kullanılmayan tarihi dokuların gerek bilinçsizlik gerekse iklimsel etkenler ile tahribine ve tarihi dokunun giderek yok olmasına yol açmaktadır.

Yöntem

Çalışma alanının mevcut durumdaki fiziksel özelliklerini ve bu özelliklerin yaya hareketlerine olan etkisini belirlemek için mekân dizimi *(Space Syntax)* yöntemi kullanılmıştır. Hillier ve Hanson tarafından geliştirilen ve kentlerin karmaşık yapısını analiz etmek için kullanılan yöntem (Hillier ve ark., 1987, 1993; Hillier, 1996) halen peyzaj mimarlığı, mimarlık, şehir planlama ve coğrafya gibi farklı bilim dallarında kullanılmaktadır (Öztürk, 2018).

Çalışmanın yürütülmesinde; ilgili yayınlardan, tezlerden, 6.8.1986 tarihli koruma amaçlı imar planından faydalanılmış ve açık kaynak yazılımı olan DepthMapX yazılımından istifade ile her türlü haritalar ve hava fotoğrafları kullanılmıştır. Alan değerleri A. Turner ve UCL (London's Global

Şekil 1. Çalışma alanı konumu, bölgeleri ve bölgelere ait genel görünümleri.

University) tarafından geliştirilen DepthmapX 0.8 yazılımı ile hesaplanmıştır (Pinelo ve Turner, 2010).

Çalışmanın ilk aşamasında alanın daha iyi tanımlanabilmesi için zihinsel haritalar oluşturulmuştur. Tolman tarafından 1948 yılında kullanılan zihinsel harita terimi Lynch'in 1960 yılında yaptığı çalışma ile tanımlanmıştır. Lynch'e göre kentsel doku insan zihninde oluşturduğu imaj ile algılanır. Çalışma alanında zihinsel haritaların oluşturulması gözlemlere dayanmaktadır. Avcıoğlu ve Akın (2017) çalışmasında mekânsal bilginin öznenin bilişsel süreci ile ilişkisini vurgulamaktadır. Önce duyumsal olarak algılanan mekân, kişinin mekânda geçirdiği zaman içinde zihinsel olarak da algılanır. Çalışma alanının zihinsel haritası, çalışma alanında yapılan gözlemlerden sonra yerleşim düzenleri, sokak dokuları, mekânların biçimsel özellikleri, boşluklar, alan kullanım yoğunlukları, yaya hareketliliği, altyapı, yönlendirme tabelaları ve imaj noktaları incelenerek oluşturulmuştur.

Çalışmanın ikinci aşamasında; alana ait imar planı ve hava fotoğrafları kullanılarak çalışma alanının AutoCad çizimi yapılmış, çizilen altlık DepthMapX 0.8 programına aktarılarak çalışma alanının bağlantılılık (connectivity), bütünleşme (integration) ve okunabilirlik (intelligibility) durumları incelenmiştir.

Öncelikle bu tür haritaları otomatik olarak oluşturan DepthMapX 0.8 programı ile çalışma alanının aksiyel haritaları oluşturulmuştur. Eksenel haritalar olarak da ifade edilen aksiyel haritalar karşılıklı kesişen en az sayıdaki en uzun aksların çizilmesi ile oluşturulur ve mekân çizgiler ile ifade edilir (Yıldırım ve Çağdaş, 2018; Şıkoğlu ve Arslan 2015).

Sonraki aşamada; çalışma alanı bütününde yaya hareketlerinin analiz edilebilmesi için oluşturulan eksenel haritalar üzerinden bütünleşme değerleri belirlenmeye çalışılmıştır. Bütünleşme erişilebilirlik ölçüsü olarak ifade edilmektedir (Gündoğdu ve Dinçer, 2020). İnsanların yoğun olarak kullandığı ve karşılaşma ihtimallerinin olduğu mekânlar bütünleşik (integrated) mekânlardır. İçinden çok geçilen mekânlar bütünleşik; içinden az geçilen mekânlar ise yalıtılmış veya ayrışmış (segregated) mekânlar olarak tanımlanır.

Mekânlar global bütünleşik [Radius n (Rn)] mekânlar ve lokal bütünleşik [Radius 3 (R3 veya farklı rakamlar kullanılabilir)] mekânlar olacak şekilde de sınıflandırılır. Alanı sürekli kullananlar ile içinden geçenlerin dikkate alındığı durumda global bütünleşik; yalnızca mekânı devamlı kullananların dikkate alındığı durumda lokal bütünleşik değerinden bahsedilir. Diğer ifade ile Radius n kente makro ölçekten bakarak merkeziyeti belirlerken, Radius 3 kenti bölgesel ölçekte tanımlar (Şıkoğlu ve Arslan, 2015). Dört bölgeye ayrılarak incelenen çalışma alanında kent ile bütünleşen ve kentten soyutlanmış alanlar tespit edilmiştir.

Mekân dizimi yöntemi ile yapılan bir diğer analiz, alan okunabilirliğidir. Alan okunabilirliğini Lynch; bir mekânın kolayca fark edilmesi, anlaşılabilirliği olarak tanımlamaktadır (Erem ve Erkman, 2003; Gigi, 2009). Lynch'e göre; imaj noktaları, kentsel bölgeler, sınırlar ve düğüm noktaları kentin okunabilirliği açısından önemlidir (Lynch, 2010). Lynch çalışmalarında yaya sirkülasyonunda süreklilik, başlangıç ve bitiş noktalarının olması, görülebilirliğin yüksek olması gibi kriterlerin yürüme yolunun kalitesini etkilediğini ifade etmektedir (Mehanna ve Mehanna, 2019). Kent mekânları arasında oluşturulan akslarda görsel bütünlüğün sağlanması önemlidir (Turgut, 2011). Hayta (2011) yaptığı çalışmada, global bütünleşme (Rn) ve lokal bütünleşme (R3) değerlerinin X ve Y grafiğine aktarılması ile mekân okunabilirliğinin belirlenebileceğini ifade etmiştir. Türk ve Oral (2022), Agael ve Özer (2017), Nag ve ark. (2019) yaptıkları çalışmalarda okunabilirlik değerinin bütünleşme ve bağlantılılık arasındaki korelasyon ile belirleneceğini ifade etmişlerdir. Bu çalışmada okunabilirlik, global bütünleşme ve bağlantılılık haritalarının grafiğe aktarılması ile elde edilmiştir.

Çalışma alanı için elde edilen analiz sonuçları ve zihinsel haritalardan elde edilen veriler ışığında sokak dokuları, mekânlar arasındaki geçişler, fiziksel çevrenin durumu için yorumlar yapılmış ve önerilerde bulunulmuştur. Bu öneriler photoshop programı yardımı ile grafikler halinde görselleştirilmiştir.

BULGULAR

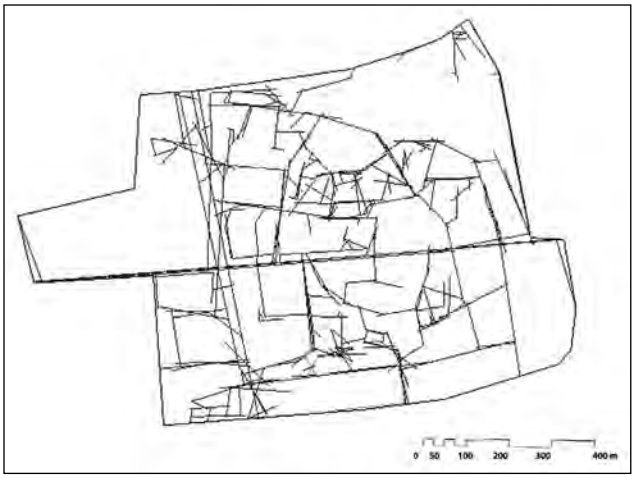
Çalışma alanı 1. derecede sit alanı ve 3. derecede sit alanını içine alan iki ana yol aksının kesiştiği dörtlü sistem içerisinde yer almaktadır.

Birinci bölgede; Erzurum Kalesi, tarihi Hanım Hamamı, Cimcime Hatun Türbesi, Caferiye Camisi ve geleneksel konut mimari örnekleri yer almaktadır. Gecekonduların ve yıkılmış tahrip olmuş tarihi konutların yoğun olduğu bölgede, 2019 yılında restorasyon ve temizleme çalışmaları başlatılmıştır. Bu çalışmalar sonucu kale çevresi açılmış ve rekreasyon faaliyetlerine elverişli yeşil alan haline gelmiştir. Alan içinde oturma yerleri, çocuk oyun alanı, gezinti yolları, su yüzeyi vb. etkinlik alanları yer almaktadır. İkinci bölge; Çifte Minareli Medrese, Ulu Camii, tarihi Şair Nefi Ortaokulu, geleneksel konut örnekleri, Taş Ambarlar, tarihi niteliği olan Bölge İdari Mahkemesi'ne kadar olan kısmı kapsamaktadır. Üçüncü bölgede; tarihi Yakutiye Belediye Binası, tarihi niteliği olan Güneş Eğitim Kurumu, 4. bölgede; Yakutiye Medresesi Müzesi, Tarihi Murat Paşa Camisi bulunmaktadır. Kentin önemli imaj noktalarının yer aldığı harita Şekil 2'de verilmiştir.

Öncelikle çalışma alanına ait aksiyel haritalar oluşturulmuştur (Şekil 3). DepthMapX 0.8.0 programı kullanılarak oluşturulan aksiyel haritalar 3205 akstan oluşmaktadır. Aksiyel analizin ana hedefi yaya hareketini tahmin etmektir. Hareket doğrusaldır. Her bir hattın çevresindeki hatlara nasıl bağlandığına bağlı olarak bir bağlantı grafiği oluşturur. Analizin sonucunda, her bir indeksin kırmızıdan (yani maksimum değer) maviye (yani minimum değer) bir renkle temsil edildiği renk spektrumu haritası oluşturulur. Haritada çok kullanılan akslar kırmızı, az kullanılan akslar mavi renkte gösterilmektedir (Jiang 2009; Montello, 1991; Klarqvist, 1993; Penn, 2003; Gündoğdu, 2014; Şıkoğlu ve Aslan, 2015; Günaydın ve Yücekaya, 2020).

Çalışma alanına ait analizler sonucunda, bütünleşme, global bağlantılılık, yerel bağlantılılık, okunabilirlik ve sinerji değerlerine ait minimum değer, maksimum değer ve ortala-

Şekil 2. Çalışma alanı imaj noktaları.



Şekil 3. Çalışma alanına ait eksenel harita.

Tablo 1. Çalışma alanı analiz sonuçları

	Minimum değer	Maksimum değer	Ortalama değer
Global bütünleşme (integration Rn)	0,94	1,22	2,33
Yerel bütünleşme (Iintegration R3)	0,544	0,632	0,850
Yerel bütünleşme (integration R5)	1	1,45	2,51
Bağlantılılık (connectivity)	1	30	4,93
Bağlantı sayısı			3205
Okunabilirlik (entegrasyon/ bağlantılılık)			0,633
Sinerji (yerel bütünleşme/global bütünleşme)			0,731

Şekil 4. a) Global bütünleşme, b) Lokal bütünleşme R3, c) Lokal bütünleşme R5.

ma değerler ile bağlantı sayıları en uzun ve en kısa bağlantı verileri Tablo 1'de verilmiştir.

Çalışma alanı toplamında belirlenen 3205 aks analizleri için Rn (global bütünleşme) ve R3, R5 (yerel bütünleşme) haritaları oluşturulmuştur.

Bütünleşme erişilebilirlik ile ilişkilidir, birimi adımdır. Global bütünleşme; düğüm noktalarına göre hesaplanmaktadır. Bir aksa olan erişimdeki n derinlik değeri olarak ifade edilmektedir. Yerel bütünleşme değerleri ise R3, R5 vb. ile ifade edilir (Şıkoğlu ve Arslan, 2015). Çalışma alanında Rn bütünleşme değeri ortalaması 2,33 olarak hesaplanmıştır. Yerel bütünleşme değeri için R3 ve R5 değerleri hesaplanmıştır. R3 ortalama değeri 0,850, R5 ise 2,51'dir (Tablo 1, Şekil 4).

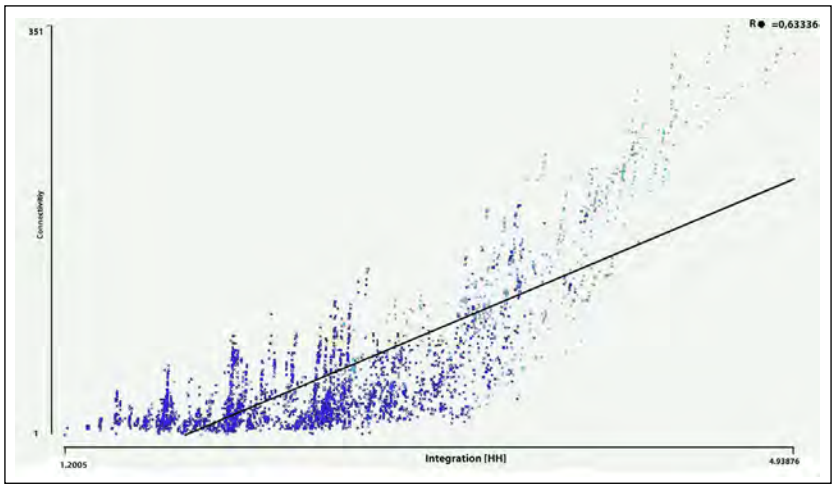
En yüksek bütünleşme değeri 1. bölgede olurken, en düşük bütünleşme değeri 2. bölgede görülmektedir.

Alan gözlemleri ile de çıkan sonuçlar desteklenmektedir. Birinci bölgenin geniş rekreasyon alanına sahip olması ve ticaret noktalarına yakın olması yoğun kullanıma olanak vermektedir. Ancak ana caddeye yakın kısımların arkasında kalan yeniden onarılarak ortaya çıkarılan geleneksel konut dokularının ve çevresinin daha az kullanıldığı gözlemlenmiştir. Alan gözlemleri sonucu 2. bölgenin kullanımında görece bir heterojenlik olduğu, iç kesimlerinin daha az kullanıldığı, dışa yakın kısımlarda hareketliliğin biraz daha arttığı saptanmıştır. Özellikle geleneksel konutların kafe ve restoran olarak kullanıldığı yerler dışında hareketliliğin az olduğu gözlemlenmiştir.

Bağlantılılık (connectivity) analizleri aksların birbiri ile olan bağlantılarını verir. Bağlantılılık değeri yüksek olan alanlar kolay ulaşılabilen alanlarıdır. Çalışma alanı 302 bağlantıdan oluşmaktadır (Şekil 5).

Haritada yüksek bağlantılar kırmızı, düşük bağlantılar mavi ile gösterilmiştir. Yüksek bağlantılılığa sahip olan hatların daha uzun hatlar olduğu gözlemlenmektedir. Bölgeler açısından değerlendirme yapıldığında 1. bölgenin diğer alan-

Şekil 5. Çalışma alanı bağlantılılık haritası.



Şekil 6. Çalışma alanı okunabilirlik grafiği.

lara göre bağlantısının daha yüksek olduğu 2. bölgenin iç kesimlerinin bağlantılılık değerinin daha zayıf olduğu görülmektedir. Bağlantılılık için elde edilen maksimum değer 30, ortalama değer ise 4,93 olarak belirlenmiştir.

Çalışma alanında yapılan bir diğer analiz okunabilirlik (intelligibility) analizidir. Kişinin mekânın bütününü algılaması, hareketin yönü ve bütünleşme değerine bağlıdır. Bütünleşme ve bağlantılılık değeri arasındaki ilişki ile okunabilirlik değeri belirlenir (Şekil 6).

X ve Y değerleri 45 dereceye ne kadar yakın ise mekânın okunabilirliği o kadar yüksektir. Çalışma alanı için yapılan değerlendirmede alan okunabilirliğinin iyiye yakın olduğu görülmektedir (R=0,633).

Kale ve çevresini içine alan 1. bölgenin bütünleşme oranı diğer bölgelere göre yüksektir. Ancak 2. ve 3. bölgelerin bütünleşme oranı düşüktür ve bu durum okunabilirlik değerini de etkilemektedir. Bir mekân bütünleşmişse yayalar tarafından yoğun olarak kullanılmaktadır ve okunabilirliği yüksektir (Semerci, 2015). İkinci ve 3. bölgelerde bağlantılılığın ve okunabilirliğin zayıf olması bu bölgelerin kent ile ayrıştığını göstermektedir.

Dördüncü bölge; Yakutiye Medresesi ve Lala Paşa Camisini de içine alan kent meydanı niteliğinde olan bölgedir. Analiz ve gözlem sonuçlarına göre alan okunabilirliğinin ve bütünlüğünün 2. ve 3. bölgelerden daha iyi olduğu, yaya akışının bu bölgelere göre daha yoğun olduğu görülmektedir.

Yaya hareketliliği; çevre kalitesini ve güvenliğini artırmanın yanı sıra sosyalleşmeyi, erişilebilirliği ve aktivite çeşitliliğini artırarak kent yaşamına katkı sağlar. Çalışma alanında yaya akışının sağlanarak tarihi dokunun canlandırılması ve yeniden kentin önemli bir parçası olabilmesi için, zihinsel haritalardan ve analiz sonuçlarından elde edilen verilere göre aşağıda yer alan öneriler yapılmıştır.

1. Geleneksel caddelerin yenilenerek, A noktalarında bağlantıların güçlendirilmesi gerekir. Bunun için aks genişlikleri ve açılar düzenlenmeli, yaya akışı yönlendirilmeli ve hareket kolaylaştırılmalıdır.

a) Kale ve çevresi DepthMapX analizlerinde kent ile en iyi bütünleşmeyi sağlamış bölge olarak karşımıza çıksa da bu bölge için gerekli iyileştirilmeler yapılmalıdır. Bu amaçla Şekil 7 (a)'da 1. bölge için öneriler verilmiştir. Öneriler kentle ve diğer bölgelerle olan bütünleşmeyi sağlamayı amaçlamaktadır.

Özellikle bölgeler arasında önemli bağlantı olan A noktası bağlantıları net izlenebilir bir rota oluşturulması ve alan bütünleşmesi açısından önemlidir.

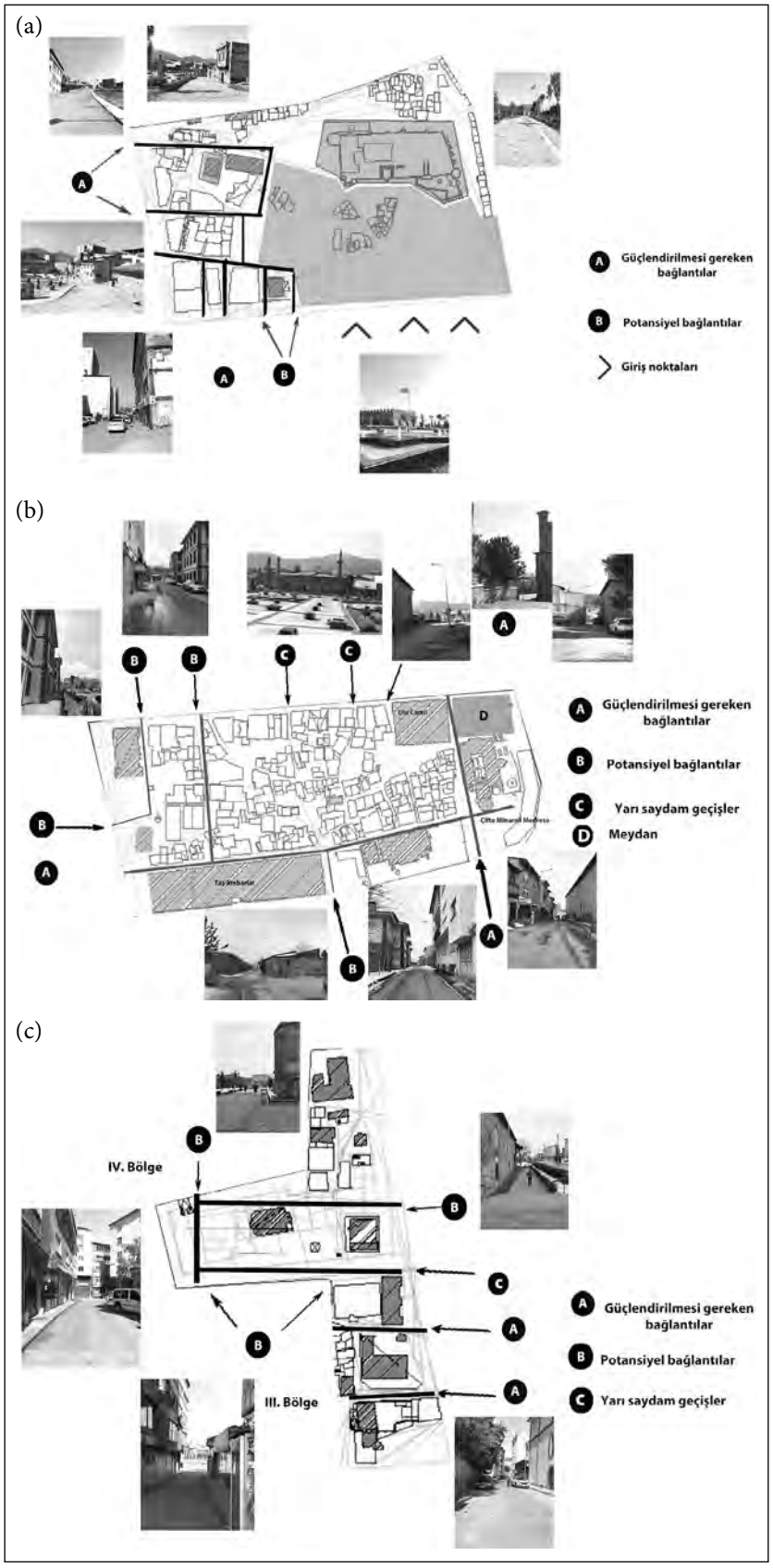
İkinci bölge; bütünleşme analizinde en zayıf bağlantıların olduğu bölge olarak belirlenmiştir. Geleneksel konut dokularının yer aldığı ana cadde üzerinde ticaret merkezlerinin bulunduğu iç bölgede ise karmaşık sokak dokusunun olduğu görülmektedir. Geleneksel konutların pek çoğu yok olmuş, kalanlar ise terk edilmiştir. Şekil 7 (b)'de 2. bölgenin kent ile bütünleşmesi için yapılan öneriler görülmektedir.

A noktaları izleme koridorları oluşturulmasında önemlidir. Aksların iyileştirilmesi ile okunabilirlik artırılmalıdır. Bölgenin en önemli sorunlarından birisi karmaşadır. Potansiyel bağlantılar ve yarı saydam geçişler ile etkileşim ve alan bütünlüğü sağlanacaktır.

Üçüncü bölge tarihi niteliğini oldukça kaybetmiştir. Bütünleşmenin sağlanabilmesi için ana aksa olan bağlantının güçlendirilmesi gerekmektedir. Dördüncü bölge ise önemli imaj noktalarını içine alan peyzaj çalışmaları ile kent meydanı niteliğini taşımaktadır. Bütünleşme analizinde alan okunabilirliğinin iyi düzeyde olduğu görülmüştür. Şekil 7 (c)'de 3. ve 4. bölgeler için yapılan öneriler görülmektedir.

Dördüncü bölge kent meydanı niteliğindedir. B noktasındaki kot farkının çözülmesi bağlantılılığı güçlendirecektir.

1. Bölgeler arasında ilişkilerin güçlendirilmesi için peyzaj tasarım çalışmaları yapılmalıdır. Özellikle Çifte Minare-



Şekil 7. (a) Çalışma alanı 1. bölge alan önerileri. (b) Çalışma alanı 2. bölge alan önerileri. (c) Çalışma alanı 3. ve 4. bölgeler için yapılan alan önerileri.

li Medrese ve Ulu Camii birleştirilerek tek bir meydan tasarımı ile alan bütünleştirilmelidir.

2. Yol bağlantıları basit ve temiz olmalı ve yan bağlantılar daha az kavisli ve açılı olmalıdır. Turner (2001)'in yaptığı çalışmada, yayaların hiç dönüş yapmamayı veya dik açıları tercih ettikleri ifade edilmektedir. Kavisler ve dönüşler arttıkça karmaşıklık artar. İkinci bölgede karmaşıklığın giderilmesi için çıkmaz yolların ve bağlantıların iyileştirilmesi gerekmektedir
3. Tarihi çekirdek dokuda ziyaretçi sayısının artması kent sirkülasyonunun eşit dağılımının sağlanabilmesi için tescilli mimari örneklerinden oluşan imaj noktalarının birbirleri ile ilişkilendirilerek kesintisiz bir güzergâh oluşturulması gerekmektedir. Güzergâh üzerinde bulunan terk edilmiş tarihi niteliği olan yapıların onarılarak yeniden işlevlendirilmesi kültürel mirasın sürdürülebilirliği açısından önemlidir.
4. Kültürel peyzajın sürdürülebilirliğinin sağlanması için tarihi sokak dokularının yeniden canlandırılması, dokuya uyum sağlamayan bölgelerin kaldırılması veya dokuya uygun hale getirilmesi, kültürel dokuya uygun pansiyon, sanat evi vb. gibi işlevlerin yer alması, bu sayede mahalle halkının ekonomik kazanç sağlaması ve toplumsal hafızanın geri kazandırılması sağlanmalıdır. Sokak dokusunun geri kazandırılması kentin peyzaj değerini de artıracaktır.
5. Trafiğin olumsuz etkisinin en aza indirilmesi, erişilebilirliğin sağlanması için yapılan düzenlemelerin tüm yaş grupların göre olması ve engelsiz ulaşımı içerir nitelikte olması gerekmektedir. Çalışma alanı tarihi dokusunda görülen en büyük sorunlardan biri, yol kenarlarının araç parkı olarak kullanılmasıdır. Yaya sirkülasyonunu olumsuz etkileyen bu durumun ortadan kalkması için uygun mesafelerde araç park alanları oluşturulmalıdır.
6. Yol akslarının iyileştirilmesinde iklimsel ögeler dikkate alınarak bitkisel tasarımda, kullanılan kent donatılarında ve kaplamalı yüzeylerde gerekli önlemlerin alınması gerekmektedir. Kışın yağan karın, yazın güneşin olumsuz etkileri dikkate alınmalıdır.

SONUÇ

Erzurum tarihi kent dokusunun geçen yıllar içinde önemli oranda tahribata uğradığı ve bu tahribatta mekânların kullanılmamasının etkisinin de olduğu düşüncesinden yola çıkılarak tarihi dokunun; sürdürülebilirliğinin sağlanabilmesi için aktif kullanılan, yaşanılabilir, canlı ve hareketli ortama dönüştürülmesi gerekmektedir. Alan çalışmasından elde edilen veriler sonucu alanın kent merkezinde olmasına rağmen kentten soyutlanmış olduğu, bunun da tahrip olma ve güvenlik sorunları başta olmak üzere pek çok sorunu beraberinde getirdiği görülmüştür.

Yapılan bu çalışma ile tarihi kent dokusunun kent ile olan ilişkilerinin belirlenmesi amaçlanmıştır. Bu amaç doğrultusunda, Erzurum tarihi kent çekirdeğinin mekânsal erişilebilirliği ve okunabilirliği sayısal olarak belirlenmeye çalışılmıştır. Alan kullanımları mekânların kent ile olan ilişkisini güçlendirmektedir. Tarihi kent merkezinde hızlı yok olmanın önlenmesi için soyutlanmış tarihi dokunun kent yaşantısına dahil olması gerekmektedir. Kültürün yani ortak deneyimlerin yaşatılması, kentlerin gençleştirilmesi açısından önemlidir.

Sonuç olarak; çalışma alanının yaya sirkülasyonunun kesintiye uğramaması, alanın bütünleşmesi açısından önemlidir. Ancak kentin büyük bir bölümünü birbirine bağlayan ana caddeler, tarihi dokunun birbirleri ile bağlantısını koparmaktadır. Ayrıca trafikten kaynaklanan egzoz, gürültü vb. etkenler tarihi dokuya zarar vermektedir. Araç yaya sirkülasyonunun ayrılması, yaya kullanım alanlarının artırılması, sirkülasyon yollarında çekiciliğin artırılması, sanatsal zenginlik sağlanması, ticaret noktalarının iç kesimlere taşınması, sokak dokularının iyileştirilmesi, yeşil alanların artırılması, çalışma alanı yaya akışının dengeli dağılımını sağlayarak erişilebilirliği ve mekânın okunabilirliğini artıracaktır.

ETİK: Bu makalenin yayınlanmasıyla ilgili herhangi bir etik sorun bulunmamaktadır.

HAKEM DEĞERLENDİRMESİ: Dış bağımsız.

ÇIKAR ÇATIŞMASI: Yazarlar, bu makalenin araştırılması, yazarlığı ve/veya yayınlanması ile ilgili olarak herhangi bir potansiyel çıkar çatışması beyan etmemiştir.

FİNANSAL DESTEK: Yazarlar bu çalışma için finansal destek almadığını beyan etmiştir.

ETHICS: There are no ethical issues with the publication of this manuscript.

PEER-REVIEW: Externally peer-reviewed.

CONFLICT OF INTEREST: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

FINANCIAL DISCLOSURE: The authors declared that this study has received no financial support.

KAYNAKLAR

Agael, F., & Özer, Ö. (2017). Human Perception in The Libyan Built Environment: Al-Khums and Bani Walid Cities As Case Studies. Archnet-IJAR, 11 (2), pp. 157-174.

Alalouch, C., Al-Hajri, S., Naser, A., & Al-Hinai, A. (2019). 'The Impact of Space Syntax Spatial Attributes on Urban Land Use in Muscat: Implications for Urban Sustainability'. Sustainable Cities and Society 46:

101417. https://doi.org/https://doi.org/10.1016/j.scs.2019.01.002.

Altundağ, M. (2019). Kentsel Dönüşüm Alanlarında Tescilli Yapılar: Erzurum Modeli [https://www.skb.gov.tr/kentsel-donusum-alanlarinda-tescilli-yapilar-erzurum-modeli-s31057k/] (Erişim Tarihi: 13.05.2021).

Arabacıoğlu, P., & Aydemir, I. (2007). Tarihi çevrelerde yeniden değerlendirme kavramı. Megaron YTÜ Mimarlık Fakültesi Dergisi, 2 (4), s. 204-12. https://dx.doi.org/.

Atabeyoğlu, Ö., Turgut, H., Yeşil, P., & Yılmaz, H. (2011). Tarihi Bir Kentin değişimi: Erzurum Kenti, İTÜ-DERGİSİ/a, no. 442, s. 41-53.

Avcıoğlu, S. S., & Akın, O. (2017). The Interpretation of Spatial Variation/Differentiation of Tuzla Köyiçi District in Context of Collective Memory and Perception af Urban Space. İdealkent, 22 (8), pp. 423-450.

Baumanova, M. (2020). Sensory synaesthesia: combined analyses based on space syntax in African Urban Contexts. Afr Archaeol Rev, 37 (1), pp. 125-141.

Battistin, F. (2019). Falerii Novi: un tesoro a rischio nell'Agro Falisco. Breve viaggio nella storia delle ricerche sul sito. Biblioteca e Società, 1 (7), pp. 9-17.

Belge, B. (2004). Çok katmanlı tarihi kent merkezlerinin yönetimi: kentsel arkeoloji ve planlama, TMMOB Şehir Plancıları Odası, Planlama Dergisi, (4), s. 48-56.

Bibri, S. E., & Krogstie, J. (2017). Smart sustainable cities of the future: an extensive interdisciplinary literature review. Sustainable Cities and Society 31, pp. 183-212. https://doi.org/https://doi.org/10.1016/j.scs.2017.02.016.

Coop, S., & Thomas, H. (2007). Planning doctrine as an element in planning history: the case of cardiff. Planning Perspectives, 22 (2), pp. 167-193.

Dağ, A. (2005). Mekansal Dizim ve Görünür Alanın Mimari Mekân Algısına Etkisi, yayınlanmamış Yüksek Lisans Tezi, İstanbul Teknik Üniversitesi Fen Bilimleri Enstitüsü.

Dalton, C. R., & Dalton, N. (2001). Omnivista: an application for isovist field and path analysis. In: Proceedings of the 3rd Space Syntax Symposium, University of Michigan, (26), pp. 1-13.

Erem, Ö., & Erkman, U. (2003). Tatil köylerinin okunabilirliğinde çevre işaretlerinin rolü. Environment, 212, pp. 51-59.

Fladd, S. G. (2017). Social syntax: An approach to spatial modification through the reworking of space syntax for archaeological applications. Journal of Anthropological Archaeology, 47, pp. 127-138. https://doi.org/10.1016/j.jaa.2017.05.002

Gigi, Y. (2009). Tarihi Mekanların Mekan Dizim Yöntemiyle Okunması, Güney Haliç Bölgesi Örneği. Yayınlanmamış Yüksek Lisans Tezi, Yıldız Teknik Üniversitesi Fen Bilimleri Enstitüsü, İstanbul.

Günaydın, S. A., & Yücekaya, M. (2020). An Investigation of Sustainable Transportation Model in Campus Areas with Space Syntax Method ICONARP International Journal of Architecture and Planning, ISSN: 2147-9380: Vol. 8 No. 1

Gündoğdu, M. H. (2014). Mekan dizimi analiz yöntemi ve araştırma konuları. Art-Sanat Dergisi, 2, pp. 251-74.

Gündoğdu, H. M., & Dinçer, E. (2020). Tekirdağ kent merkezinin yürünebilirlik açısından değerlendirilmesinde bir yöntem araştırma. Journal of Planning, 30 (3), pp. 478-507. https://doi.org/10.14744/planlama.2020.50570.

Hayta, D. (2011). Ayvalık Kent Mekanının Mekan Dizim Yöntemiyle Analizi, yayınlanmamış Yüksek Lisans Tezi, Yıldız Teknik Üniversitesi Fen Bilimleri Enstitüsü.

Hillier, B., Penn, A., Hanson, J., Grajewski, T., & Xu, J. (1993). Natural movement: or configuration and attraction in urban pedestrian movement. Environ. Plann. B, 20 (1), pp. 29-66.

Hillier, B., & Hanson, J., (1984). Social Logic of Space. Cambridge University Press, London.

Hillier, B., Hanson, J., & Graham, H. (1987). Ideas arein things, Environment and Planning B: Planning and Design, 14, pp. 363-385.

Hillier, B. (1996). Space is the Machine. Cambridge: Cambridge University Press.

Hillier, B. (1999). Space as a paradigm for understandingstrongly relational systems, Proceedings of theSecond Space Syntax Symposium; Brasilia

Jiang, B., (2009). Ranking space for predicting human movement in an urban environment

International Journal of Geographical Information Science, 23 (7), pp. 823-837. 10.1080/13658810802022822

Klarqvist, B. (1993). 'A Space Syntax Glossary'. Nordisk Arkitekturforskning, pp. 11-12. https://fenix.tecnico.ulisboa.pt/downloadFile/3779573909551/glossarySS.pdf.

Lebendiger, Y., & Lerman, Y. (2019). Applying space syntax for surface rapid transit planning. Transportation Research Part A: Policy and Practice 128 (June), pp. 59-72. https://doi.org/10.1016/j.tra.2019.07.016.

Lynch, K. (2010). Kent İmgesi, 1. Baskı, İstanbul, Türkiye İş Bankası Kültür Yayınları.

Malek, S., (2015). Spatial Cognition: Application of Space Syntax On Beyazit District, İstanbul. Istanbul Technical University, Graduate School of Science Engineering and Technology. M. Sc. Thesis. 125.

Mehanna, El-Haggag, W. A., & El-Haggag Mehanna, W. A. (2019). Urban Renewal for Traditional Commercial Streets at the Historical Centers of Cities. Alexandria Engineering Journal 58 (4), pp. 1127-43. https://doi.

org/https://doi.org/10.1016/j.aej.2019.09.015.

Montello, D. R. (1991). Spatial Orientation and the Angularity of Urban Routes. Environment and Behavior, 23(1991), pp. 47-69

Nag, D., Goswamia A. K., & Sena, J. (2019). Assessing connectivity of urban pedestrian networks: A case of Varanasi, India. Conference: 49th Annual Meeting of the Urban Affairs AssociationAt: Los Angeles, California USA.

Narvaez, L., Penn, A., & Griffiths, S. (2012). Creating Urban Place: Re-thinking the value of residential and commercial use in urban street networks. Spaces and Flows: An International Journal of Urban and ExtraUrban Studies, 2 (3), s. 149-168.

Omer, I., & Kaplan, N. (2017). 'Using Space Syntax and Agent-Based Approaches for Modeling Pedestrian Volume at the Urban Scale'. Computers, Environment and Urban Systems, 64, pp. 57-67. https://doi.org/10.1016/j.compenvurbsys.2017.01.007.

Önder, D., E., Gigi, Y. (2010). Reading urban spaces by the space-syntax method: A proposal for the South Haliç Region, Cities, Volume 27, Issue 4, p 260-271, https://doi.org/10.1016/j.cities.2009.12.006.

Öztürk, Ö. (2018). Mekan Dizimi Yöntemiyle Mekansal Değişimin İncelenmesi. Yıldız Teknik Üniversitesi Davutpaşa Kampüs Örneği., yayınlanmamış Yüksek Lisans Tezi, İstanbul Teknik Üniversitesi Fen Bilimleri Enstitüsü.

Penn, A. (2003). Space syntax and spatial cognition: or why the axial line? Environ. Behav., 35 (1), pp. 30-65.

Pinelo, J., & Turner, A. (2010). Depthmap v10 (Computer Program) UCL, Introduction to Depthmap UCL Depthmap 10 Version 10.08.00r https://archtech.gr/varoudis/depthmapX/LearningMaterial/introduction_depthmap-v10-website.pdf

Semerci, F. (2015). Meydan Kullanımlarının Analizi İçin Bir Öneri. II. International Sustainable Buildings Symposium. 28-30 May. Ankara/Turkey.

Solmaz, G. (1999). Orta Çağda Erzurum Kalesi A.Ü. Türkiyat Araştırmaları Enstitüsü Dergisi, 12, s. 231-249.

Sutay, G. (2020). Anadolu'da Moğol İstılasının Başlangıcı ve Kadım Şehır Erzurum. İksad Yayınevi, s, 163. ISBN: 978-625-7954-42-6

Şıkoğlu, E., & Arslan, H. (2015). Mekân dizim (Space syntax) analizi yöntemiyle ilgili teorik bilgiler ve mekân dizim analizi yönteminin coğrafyada kullanılabilirliği. Türk Coğrafya Dergisi, 62 (11-21). DOI: 10.17211/tcd.36109

Tolman, E. C. (1948). Cognitive maps in rats and men. Psychological Review 55 (4), pp. 189-208.

Turgut, H. (2011). Erzurum Büyükşehir Belediye binası ön bahçe peyzaj tasarım çalışmasının tasarım ilkeleri bağlamında değerlendirilmesi. Artvin Çoruh Üniversitesi Orman Fakültesi Dergisi, 12 (2), s. 185-198 http://edergi.artvin.edu.tr

Türk, H., & Oral, M. (2022) Sivas Tarihi Kent Meydanı'nın mimari ve mekânsal bağlamda mekân dizimi yöntemi ile analiz edilmesi. Hars Akademi, 5 (1), s. 185-201.

Valipour, E., Mobaraki, A., Nikoofam, M., & Tayyebisoudkolaei, S. (2019). Establishment of Space syntax to read and analyze urban network; the case of study, Famagusta city of Cyprus. Journal of Contemporary Urban Affairs, 3 (1), pp. 154-160. https://doi.org/10.25034/ijcua.2018.4692

Yıldırım, E., & Çağdaş, G. (2018). Space Syntax Analysis of Traditional Arcitectural Pattern of Gaziantep in the Context of Socio-culture. Gaziantep University Journal of Social Sciences 17 (2), pp. 508-532. DOI:10.21547/jss.357431