

Research Paper

The Impact of ICTs on Dimensions of Urban Design, Considering ICTs as a New Urban Layer

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Abstract

This paper seeks to study the impacts of different dimensions of ICTs on urban design. Due to the inevitable digitalization of our lives which has a direct impact on urban design, it sounds that providing a redefinition of the concept of urban design is necessary. Although there are various studies about the impacts of ICTs on dimensions of cities, in this study, we consider the concept of urban design specifically. After reviewing various key aspects in urban design which were highlighted by practitioners and writers, eight dimensions were chosen to be investigated. These metrics include morphological, perceptual, social, visual, functional, temporal, environmental, and economic dimensions. We try to address digitalization in the sense that how urban design can help to bridge the science and process of urban design by investigating the impact of ICTs on a few key selected dimensions. This study aims to present a clear and compatible image of urban design in the digital era. The resulting changes from globalization are expected to update the process of urban design. The study presents a qualitative perception of the imperative-analytical technique through a content review and qualitative coding (open, axial, and selective coding) in the first part. We tried to assess the views in chronological order in an urban context to present an updated definition of urban design: urban design is a process of enhancing the qualities of urban environments which would be facilitated by using ICTs tools.

Keywords: *ICTs, Urban design definition, Urban design dimensions, Digital city.*

1. INTRODUCTION

Information and communication technologies (ICTs) affect our lives considerably. One of the obvious impacts is the difficulty of running our routine life without accessing the internet (Castells, 1996). ICTs change our understanding of many concepts which are dramatically different from their traditional ones (Yousefi & Dadashpoor, 2020). It is important to address the influences of this newly emerged factor in various applied disciplines such as urban design which is closely related to people's environment aiming to make them better places to live (Carmona, 2021). Here, we are presenting a review of key elements of the ICTs in urban design by contemporary authors.

The first concept about ICT-based cities was introduced in 1981 primarily with the notion of "electronic cottage" (Maeng & Nedović-Budić, 2008) and the last controversial subject was presented as "live city" (Resch et al., 2012). According to several studies that addressed the concept of urban design, which will be reviewed in the next part, a few defining metrics can be conceived in this discipline. These metrics include morphological, perceptual, social, visual, functional, temporal, environmental, and economic. In this study, we will try to understand the impacts of ICTs on the aforementioned metrics in urban design to particularly address the following questions.

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- What are the impacts of ICTs on the aforementioned metrics of urban design?
- What could be the redefinition of “urban design”, considering the impacts of ICTs?
- How can planners and designers take advantage of ICTs as a tool to improve the quality of people’s lives?

2. REVIEW OF THE LITERATURE

Here, there are three main aspects to be considered: urban design definitions, the impacts of recent movements and schools of thought on urban design, and the emergence of ICTs in urban design.

2.1. A Chronological Review in Definitions of Urban Design

In an attempt to introduce a redefinition of urban design, it would be sound to consider former studies chronologically to understand the trend of thought

process in this discipline. The term “urban design” often has been associated with some ambiguities, which can be partly attributed to its multi-disciplinary nature (Inam, 2002) along with newly emerging issues related to other subjects such as sustainability. A few authors meanwhile believe that urban design plays a supporting and constructive role in bridging various basic disciplines (Bentley, 1998), and regard it as an asset that remained valued to both academia and practice (Verma et al., 2011). In Table 1, a chronological survey is presented to highlight the focused aspects of urban design.

The numbers written in front of the focused aspects show the frequency of that aspect in urban design definition in the view of authors and practitioners of that period. This shows that in 1950-1975, 1975-2000, and 2000-present, the *visual*, *social*, and *environmental* aspects as selective coding were the focused points, respectively. According to axial data coding, we have eight codes in previous urban design definitions: morphological, perceptual, social, visual, functional, temporal, environmental, and economic.

Table 1. Chronological Definitions and Focused Aspects in Urban Design

Definitions of Urban Design by Authors and Practitioners (Open Coding)	Focused Aspects (Axial Coding)	Duration/ Reference
<ul style="list-style-type: none"> - Art of making relation; - making a strong image; - a part of urban planning concerning aesthetic aspects; - organizing physical elements and activities. - Organization of space, time, meaning, and communication; - urban planning under artistic principles; - the process of producing an artistic product; - considering environmental management; - economic welfare and collective life. 	<ul style="list-style-type: none"> - Visual (5), - Perceptual (2), - Functional (2), - Morphological (3). 	1950-1975/ Stein (1955), Lynch (1960), Cullen (1961), Gutheim (1962), Canter (1970)
<ul style="list-style-type: none"> - taking into consideration the fourth dimension (time); - considering fundamental connections to society and economy; - controlling and leading landscape both visually and mentally. 	<ul style="list-style-type: none"> - Social (7), - Temporal (2), - Visual (6), - Perceptual (5), - Environmental (3), - Functional (4), - Morphological (5). 	1975-2000/ Rapoport (1977), Camillo Sitte (1979), Rossi (1982), Castells (1983), Lynch (1984), Oxman (1987), Southwotrth (1989), Calthrope (1993), Madani Pour (1997)
<ul style="list-style-type: none"> - taking into consideration the fourth dimension (time); - considering fundamental connections to society and economy; - controlling and leading landscape both visually and mentally. 	<ul style="list-style-type: none"> - Temporal (2), - Economic (1), - Social (4), - Perceptual (5), - Visual (2), - Functional (4), - Environmental (6), - Morphological (4). 	2000- Present/ Jon Lang (2006), Cuttbert (2008), Carmona & Tiesedell (2010), Golkar (2011), Carmona (2014)

2.2. Impacts of Recent Movements on Urban Design

Since the advent of urban design, it has been influenced and developed by various movements such as the global village, TOD, TND, practice movement, etc. According to Table 1, for instance, in the late 20th century, ecological concerns have focused more on designing one place. In the later years, besides previous considerations, economic issues have further been addressed in contrast to the last decades. Since the global village, more attention has been given to expanding the possibility of communication within a universal scale (McLuhan, 1969). Overlooking this evolving trend, we have faced with post-industrialism (Bell, 1973), the third wave (Toffler, 1981), the compression of time and space (Harvey, 1999), the age of information and social networks (Castells, 1996), the death of distance (Cairncross, 1997), and finally, the fourth industrial revolution (Schwab, 2017). Moving forward, the continued advances in digitalization and entrance of ICTs into people’s lives appear to have a direct impact on forming future trends in urban design.

During the last century, considerable efforts have been put in planning urban environments to establish meaningful connections between such areas and technology (Philips, 1996). Evidence can be found in Howard Gardens (1898), followed by the industrial city of Tony Garnier (1899), the Frank Lloyd Wright Township (1909), and the contemporary city of Le Corbusier (1922). The effects of proposed ideas on urban planning and development varied on their extent, some exhibited nationally while others extended their impact globally. As the ongoing changes continue to appear in technology and the urban environment, understanding their relationship also requires new models. Although new concepts have emerged in the field of planning and design, often

their basis relies upon futuristic ideas which can be explained using ICTs functions.

2.3. Emergence of ICTs in Urban Design

Since the concept of the electronic cottage has been introduced (Toffler, 1981), there have been many other connected terms emerged such as a technological city (Fishman et al., 1987), the cable city (Dutton, 1989), the smart city (Batty, 1990), the invisible city (Batty, 1990), Telecommunication City (Fathy, 1991); City of Bits (Mitchell, 1995), Ideal Electronics City (Mitchell, 1995), Digital Locations (Horan, 2000), and Inclusive City (Hwang et al., 2016), most of which are chronologically presented in Table 1.

Given the rapid growth of ICTs, these collective movements tend to create a need for a new definition of the city that incorporates related notions including space, time, distance, and even territory (Firmino, 2005). These lines of efforts have provided solid evidence for the presence of an interaction between ICTs and life in cities which constitute the main elements studied through the discipline of urban design. Since 1962, there have been several developing ideas and practices about the impact of ICTs which were primarily initiated by the global village followed by theories such as the virtual city and the live city. In Figure 1, the key ideas are depicted to demonstrate the mainstream of thought that evolved during this period. As is evident, the frequency of studies has been visibly increased since 1990 compared to the similar group of studies during 1950-1990. Overall, the body of collected evidence and their evolving pattern in the past years, verify the growing connections between ICTs and life in cities that have been studied through urban design discipline.

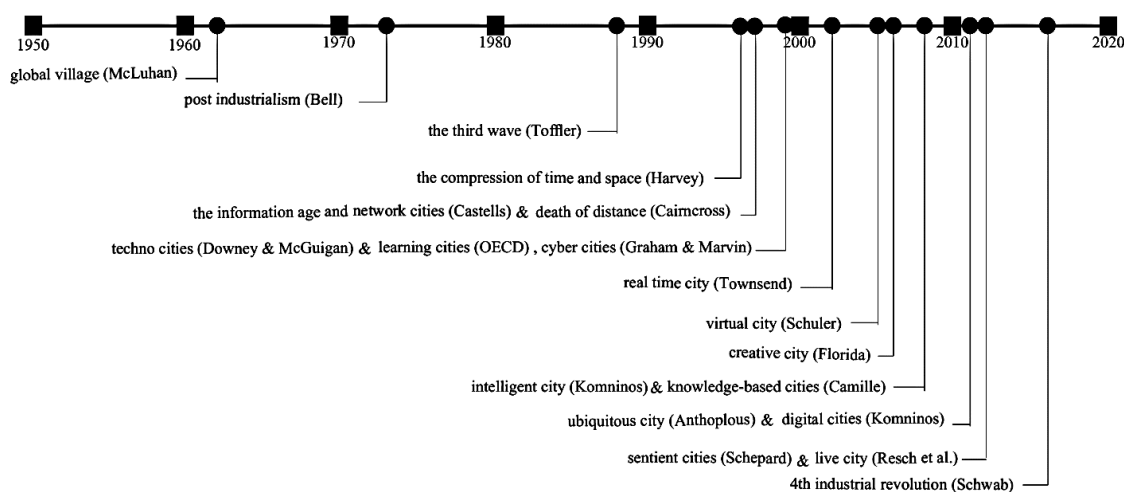


Fig 1. The Chronological Line of Thought about the Impacts of ICTs on Cities

3. MATERIAL AND METHODS

“How? How much? With what results? These questions are especially useful to analysts when they are blocked in their analyses and cannot seem to see anything but the standard ways of explaining phenomena” (Strauss & Corbin, 1998, P. 90). In a book focused on writing styles by Lamont (Lamont, 1994), the use of questions was suggested as a way of getting a writing project off the ground. She suggested that asking the right questions helps a writer overcome the initial barriers of not knowing where to start. Although Lamont was primarily talked about writing methods, the notion of “asking questions as a way to respond and make the comparison” can be extended as a technique not to generate data, rather to generate ideas or ways of looking at the data. In the introduction part of this paper, according to Strauss and Corbin, three questions were addressed. The first one seeks to find the “amount” of impacts of ICTs on metrics of urban design (how much?). The second one tries to find “the results” of this study (what results?). And the last is about “the way of applying” the outcomes for practitioners (how?). Such questions set a meaningful framework for looking at data and their subsequent analysis.

In this study, to consider a redefinition of urban design, 19 articles and books are selected to extract the focused aspects in three durations (1950-1975), (1975-2000), (2000-present). These durations are considered based on specific focused points in urban design which are visual, social, and environmental, respectively. First, by using open coding, the codes are extracted from various definitions. Then, by using axial coding, we organized the codes. Finally, we studied the impact of ICTs on selective codes.

After reviewing numerous articles and books about the impact of ICTs on various metrics of urban design using a content analysis method, a few metrics are identified and selected to be presented in the redefinition of urban design by using the same way of coding explained in the previous part. Up to ten articles, each with a focus on a particular metric of urban design, have been studied. The most recent articles (2010-2020) were selected to review the most updated changes and trends.

Since the current research has a theoretical dimension and is mainly constructed based on qualitative subjects, the imperative-analytical method can be applied to describe the main concepts of the research.

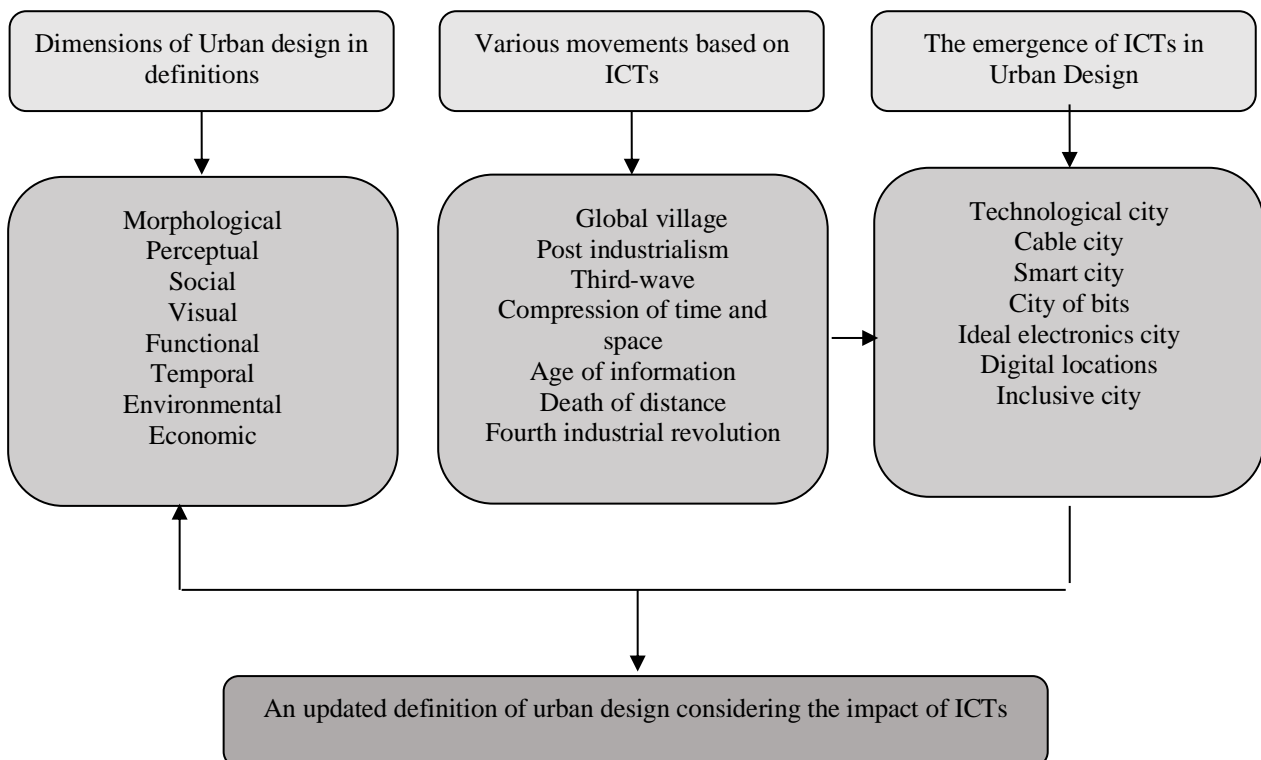


Fig 2. The Model of Research

4. RESULTS: THE IMPACT OF ICTS ON URBAN DESIGN DIMENSIONS

The urban design seeks ways to make cities more livable, so any changes in the context should be considered in its practices. As discussed earlier, ICT is an inescapable factor in our lives, hence studying its impacts on previously known dimensions of urban design helps to enhance several urban-related indices. These include goals for enhancing urbanity, facilitating urban investment and sustainability along improving the livability of cities, health, and well-being, all of which are known as emerging controversial issues in urban design (Badland et al., 2014). As an example, the attempt to attain sustainability via physical means alone is nonsensical. Instead, the city ought to be envisioned as the manifestation of many co-evolutionary processes (Daneshpour & Shakibamanesh, 2011). Here, we are addressing the impacts of ICTs on a few selected dimensions suggested by contemporary authors.

4.1. Morphological Dimension

Urban environments have always been closely associated with manufacturing technologies, transport, and communications. Throughout history, urban form has changed as a result of altering economic, cultural, legal, physical, political, social, and technological conditions. Among these, the ICT, despite its short history, acts as a new force adopted on a massive scale. Urban form is often defined as the degree of centralization/decentralization of urban structure (Alberti et al., 1999). “It has been assumed that knowledge-based developments coupled with ICT would trigger centrifugal, while the findings suggest

that ICT evoke centripetally” (Maeng & Nedovic-Budic, 2010, P. 111).

With the advent of virtual cities, urban planners focused more on the degree of centralization. A virtual city has been increasingly gaining the qualities of real cities, and as a result, more users have been attaining a realistic sense of being in urban places. After digitalization and the continued growth of virtual cities, the importance of the city centers has been further taken into account (Maeng & Nedovic-Budic, 2010). These are mainly due to the role of being places for the transition of goods and services, as well as the resulted face to face interaction.

Another factor in morphology is “distance” which is a physical element in real cities; however, it tends to lose its conventional meaning in a virtual city because of the presence of spatial data (Döllner et al., 2006). With the advancement in transportation and the possibility of data management digitally, the importance of distance tends to fade away as people can transfer large-scale data through the internet with a significant reduction in the need for physical traveling.

It seems to be proper and important to define “territory” following the digitalization (Donath, 1997), not only in physical areas but in virtual ones as well. Before emerging digitalization, a territory holds a physical definition which is essentially an area in which a specific group of people is allowed to enter. In urban spaces which are equipped with ICT tools (e.g. digital screens and media), people can interact and communicate closely, resulting in a reduction in human density within these territories. The aforementioned factors have been considered and listed in Table 2.

Table 2. Effective Factors of ICTs on Morphology

Effective Factors of ICTs on Morphology	Before Digitalization	After Digitalization
Centralization/ decentralization	<ul style="list-style-type: none"> - Better accessibility in central parts of cities - More facilities in central parts of cities 	<ul style="list-style-type: none"> - Excessive importance of the center - A good place for transition of goods and services - Best place for face to face interactions
Distance	<ul style="list-style-type: none"> - Defined as a physical element - Importance of metrical distance 	<ul style="list-style-type: none"> - Distance disregard because of transportation development - Importance of spatial data in the virtual city
Territory	<ul style="list-style-type: none"> - Physically considered 	<ul style="list-style-type: none"> - Privatization of places by using a digital tool
Urban growth	<ul style="list-style-type: none"> - Horizontal and vertical growth of cities 	<ul style="list-style-type: none"> - Horizontal growth of cities because of fading importance of distance - More compact cities because of excessive usage of virtual space

4.2. Perceptual Dimension

According to Piga and Eugenio (2015), it is necessary to investigate the complex relationship between humans and the environment to understand the perceptual dimension. Human beings need to experience a space to adjust it with their former experiences to comprehend it (Grutter, 1996). Batty (2012) and Miller and Page (2009) believe that cities welcome innovations since individuals and groups both can do various types of activities. These activities will later lead to a pattern being adopted by people to reflect different spatial, socio-economic, and environmental images as well as to develop new spatial patterns (Batty, 2012).

Given the ability of physical spaces to stimulate emotions and evoke a sense of attachment is important for gaining the sense of a place (Ujang & Shamsudin, 2012), physical exposure to a place helps to build such attachments (Taylor, 2009). Before digitalization, what has been characterized by a legible city was related to physical elements such as landmarks and districts (Lynch, 1960), while nowadays through digitalization, understanding a place is not restricted to its physical experiences only. Rather, for instance, it is possible to recognize a place by a virtual tour where new ideas and designs in various parts of the world are extensively presented, serving to stimulate public creativity and demonstrate innovative ideas for professional designers (Batty, 2012). In Table 3, an itemized comparison has been made about the impact of ICTs before and after the advent of digitalization.

4.3. Social Dimension

Wireless networks were the first piece of innovation that favored a shift of communication into the public realm. By transforming the internet into a mobile service, public space can now support a wider range of activities (Humphreys, 2010). According to Table 4, before digitalization, three types of activities were recognized namely as necessary, social, and selective (Gehl, 2007); while through digitalization,

there seem to be no limitations for establishing a social activity “for being in a place” since it can readily take place through social networks.

Upon the emergence of the internet, some cafes, restaurants, and bars added web access as an option to their services (Lee, 1999), which turned out to be a very attractive feature. Many home workers and freelancers are willing to spend more time in such semi-public spaces to simultaneously do their jobs and enjoy open space (Stadler, 2013). On a larger scale, such internet-embedded places have also encouraged people to interact beyond their local territories and, to some extent, overcome the feeling of isolation from the world.

Another important social aspect of the internet is providing people with the chance to get access to services and places (Sørensen & Torfing, 2018). With the advent of ICTs, most people are expected to have an equal chance to have access to these services through the internet (Battarra et al., 2018), although there are some groups of people such as the elderly who hardly or limitedly can use those services. It should be noted that providing essential infrastructures for ICTs should be accompanied by enhancing citizens’ digital literacy (Zarrabi et al., 2015) to make a proper platform to use its efficiency for all social groups.

One of the main concerns about having vibrant, inclusive urban spaces is the issue of security particularly in specific hours late at night or very early in the morning. Following digitalization and through social networks; however, this concern fades away as most people can freely communicate with each other almost any time. That being said, there are still some privacy challenges with some applications that, for instance, allow others to find friends or other individuals. These facts underscore while the accessibility of information about others sounds to be a useful feature, some people are yet highly concerned or unwilling to put their privacy at risk (Becker & Geer, 1957). To consider this issue, such applications provide an option for users to be turned off in cases of not being willing to be observed by others.

Table 3. Effective Factors of ICTs on Perception

Effective Factors of ICTs on Perception	Before Digitalization	After Digitalization
Patterns of activity	- It is the result of repetitive actions	- The patterns form based on people’s needs and requirements
Creativity	- Restricted to just tangible things in physical space	- Inspired by ideas all over the world
Urban environment	- Based on visual perception - Being in the environment	- Virtual tours throughout every place you wish.
Cognitive map	- It is the result of experiencing and being in a place physically	- Shaping cognitive maps through virtual tours - The possibility of using other’s experiences

4.4. Visual Dimension

According to Lynch (1960), a legible city has a coherent pattern with some elements such as landmarks and nodes to be addressed. These visual elements help people to establish their cognitive map which describes the clarity of a city (Herzog & Leverich, 2003; Kelly & Kelly, 2003; Koseoglu & Onder, 2011; Lynch, 1960). A cognitive map can be conceived as a mental representation that serves the individual to acquire, code, store, recall, and decode information about the relative locations, and hence attributes the phenomena to everyday life or a metaphorical spatial environment (Tolman, 1948). After digitalization, people are often able to build up a cognitive map through virtual tours even for places they have never been exposed to. Henceforth, the legibility of a city in the digital era is recognized by the specific values we assign to an environment, or the way we navigate through and experience it (Wessel et al., 2018).

As it is outlined in Table 5, the aesthetic feature is another key factor influencing the visual dimension

even after digitalization, which underscores aesthetics and has always been an indispensable component in human lives (Danto, 1981). People often seek a favorable and beautiful settlement to live in even when minimal ideas such as “less is more” were introduced. For example, designed facades and colorful cityscapes along with green spaces still encourage people to visit and walk around old cities. These elements also play a role in promoting continuity of street network and urban fabrics as a whole, which in turn facilitate public movements and flow. Via digitalization, such factors have been often ignored through developing modern cities. Currently, modern cities are made up of separate cells which create discontinuity in the overall city texture and routes (Batty et al., 2006).

Implementing digital tools in urban spaces helps planners and designers to enhance the qualities of these places. Such tools can offer various opportunities in visualization and simulation of old buildings, and in effect, can closely interact with the sense of attachment features to a place (Abdel-Aziz et al., 2016).

Table 4. Effective Factors of ICTs on Social Metric

Effective Factors of ICTs on the Social Dimension	Before Digitalization	After Digitalization
Cultural dimension	- Limited to local to national cultures.	- Getting familiar with other cultures around the world
Interaction between people	- Physical and bilateral communication	- Video conference and more than two people interaction
Interaction between people and technology	- Reduction of physical interaction	- Using technology as a tool for improvement
Sociability	- Physical interaction	- Global interaction - Sharing ideas globally
The durability of being people in the place	- Limited duration especially for women - Limited hours of available services	- Longer duration because of better surveillance and public transportation
Information and communication	- Exchange data through interaction and publishing - Requirement of at least two people for social activity	- Limitless accessibility to data in any size everywhere
Activities	- Including necessary, social, and selective activities	- Not limited to physically being in a place - The possibility of doing various activities virtually

Table 5. Effective Factors of ICTs on Visual Metric

Effective Factors of ICTs on Visual Metric	Before Digitalization	After Digitalization
Aesthetics	- Physical setting and elements like ornaments	- Simulation through urban spaces or enhancement of digital tools
Continuity	- Encouragement for walking in cities - Harmonized facades - The specific spectrum of colors	- discontinuity in city texture and routes
Legibility	- Defined by physical elements - Finding the way through symbols and paths	- Defining by the amount of understanding and transparency of data

4.5. Functional Dimension

With the emergence of the internet and social networks, the issue of not using urban spaces has been raising a matter of concern (Hagan, 2000); in particular, when cyberspace was considered as a substitute for using urban spaces. Meanwhile, the emergence of portable communication technologies has led to the possibility of always being connected to digital spaces, which translate “carrying” the internet wherever the user goes. Through this transformative period, a new term namely “hybrid spaces” is formed. Such spaces merge the physical and the digital medium into an integrated social environment, mainly driven by the mobility of users connected via the mobile technology devices (De Souza e Silva, 2006); which in turn may alter people’s behavior in such newly emerged spaces.

Since online services are on-demand everywhere for the majority of people, compact forms of cities and high-density areas are noticeably impacted in various respects. Examples include saving energy especially in the commuting sector, preserving land, concentrating and collecting economic activities, and creating a necessary threshold for mass transit alternatives (Orum & Jenks, 2019). These features together facilitated the formation of compact Transit-Oriented Development (TOD) (Shum & Watanabe, 2017), through which people can easily get access to their required services.

There have been also some improvements in services that used to be dependent on weather conditions which thus no longer suffer from harsh climates. Upon usage of digitalization and

cyberspaces; however, it is possible to do numerous kinds of online activities such as paying bills, online banking, participating in work meetings, or playing games in virtual space, regardless of weather conditions (Aljawabra & Nikolopoulou, 2010). In Table 6, effective factors of ICTs on functional dimensions are addressed.

4.6. Time Dimension

Within the last three decades of the 20th century, it appears that a conceptual shift in the meaning of transportation networks has been occurred along with those concepts regarding space, place, and time. City, urban space, and citizens experience the simultaneity of non-simultaneous things in social, economic, cultural, and political scopes (Habibi, 2015).

According to the Table 7, before digitalization most events took place somewhat linearly or sequentially. The linear behavior is originated from the nature of social practice and human activities, showing the monotony of actions, movements, and imposed structures (Lefebvre, 2004). Nowadays for instance, meanwhile, people can perform their tasks on the web and simultaneously communicate with friends and do exercise! One of the subsequent effects of such multi-task activities can be the duality perception of time. People can send online messages and the receiver can respond whenever at their convenience with almost no time limitation. On the contrary, before digitalization, people had to constantly be aware of global time zones for making phone calls or leaving messages.

Table 6. Effective Factors of ICTs on Function

Effective Factors of ICTs on Function	Before Digitalization	After Digitalization
Plausibility	- The kind and amount of activities is related to the time and weather	- By using ICTs, various activities can be done at any time in any place
Variety	- Limited to welcome activities in a specific place and culture	- Unlimited activities in virtual spaces unless somebody reports them to be restricted
Density and urban space form	- Urban sprawl - Lower density	- Compact cities - Variety of plausible activities in a small place

Table 7. Effective Factors of ICTs on Time

Effective Factors of ICTs on the Temporal Dimension	Before Digitalization	After Digitalization
The rhythm of time use	- Defined and contracted perception of time - The concept of linear time	- A duality in the perception of time - The possibility of being in different places simultaneously
Facts about time use	- The limited-time of using urban spaces	- A long time of using real spaces - Unlimited time of using virtual spaces
Urban time policies	- Considering a limited time of usage by the law - A low sense of convenience because of security	- No policies about the time of usage from virtual space

4.7. Environmental Dimension

ICT can have both negative and positive impacts on the environment. There are some advantages in using ICTs which indirectly led to decreasing environmental pollutions as a result of, for instance, decreased volume of traveling and increased paperless business transactions and one-click shopping. This trend not only accelerates the business process but also helps people to find, compare, and buy/sell desired products and services readily and quickly (Plepys, 2002). On the other hand, there are other aspects of ICT which adversely affect the environment. ICT products and disposals can bring negative environmental impacts, by increasing CO₂ emissions from electricity production of power plant units (Higón et al., 2017). As it is becoming more convenient for people to do their jobs online, this may induce further horizontal expansion of suburbs, which subsequently requires driving far distances and consuming more fossil fuels (Plepys, 2002).

Following industrialization, the notion of efficiency has become one of the top goals to achieve in most societies; which potentially leads to more pressure on the working environment. According to Table 8, due to the generation of several environmental issues caused by industrialization,

sustainable development was proposed as a resolution model to improve environmental qualities and values (Nasrollahi et al., 2020). By doing such, ICTs can intervene and be used as a technical platform for the enhancement of environmental qualities.

4.8. Economic Dimension

Economic growth is a quantitative indicator for the scale of goods production and service supplement. ICT enables goods and services to be produced more efficiently (Higón et al., 2017). Contemporary discourses on development consistently recognize ICT as a requirement for sustaining economic growth and improvement of social conditions (Avgerou, 2003). ICT is perceived as an instrument for economic and social gains within a market. One of the main contributors of economic growth is attributed to the innovative applications in the manufacturing and service sectors (Plepys, 2002). This enables manufacturers to develop more sophisticated products with the use of ICT tools.

According to Table 9, the emergence of ICTs led to more convenient trading, thus more people were encouraged to trade online and expand their network by educating and getting engaged with related forums such as a stock exchange.

Table 8. Effective Factors of ICTs on the Environment

Effective Factors of ICTs on the Environment	Before Digitalization	After Digitalization
Environmental pollutions	- Natural purification of the environment	- Less traffic - More pollution because of excessive usage of electricity
Urban sprawl	- Less density - Discreet buildings	- Death of distance caused by online jobs - More driving to downtown

Table 9. Effective Factors of ICTs on the Economic Dimension

Effective Factors of ICTs on the Economic Dimension	Before Digitalization	After Digitalization
Economic growth	- Restricted to work time - Slower progress	- ICTs as a requirement for economic growth - More efficient product
Facilitating trades	- Physical treatments - Face to face trading - Cash payment	- 24-hour online trading - Online transfer of money

5. DISCUSSION

Through time, various issues have influenced urban design as an interdisciplinary field such as sustainability, smart growth, ICTs, and so on. In this study, our focus has been on the impacts of ICTs on urban design. ICTs have changed our lives dramatically. Understanding the causes and effects of such changes can make it possible to excel the advantages and mitigate the upcoming disadvantages. After reviewing the literature on different dimensions of urban design given to practitioners, eight key metrics are identified and addressed, including morphological, perceptual, social, visual, functional, temporal, environmental, and economic.

A few of these notions about the impacts of ICTs were introduced before digitalization which turned out to be not exactly true in reality, such as declination of the importance of center (Dadashpoor & Yousefi, 2018). It has been believed that cities will become more centrifugal rather than centripetal (Maeng & Nedovic-Budic, 2010) based upon the theory of death of distance (Cairncross, 1997). On the contrary; however, after digitalization, we are facing the high importance of the center as a proper place for interactions.

Another notion about morphological dimension is that cities would grow less, because of an increasing number of compact cities (Orum & Jenks, 2019). However, since nowadays people can work online, distance is no longer a matter of significance. People can live in rural places and perform their job/tasks over the internet, meaning more urban sprawl may happen (Maeng & Nedovic-Budic, 2010). Since the numbers of people who live in suburbs are often less than people in urban areas, the services are centralized in the latter which leads to a commutation from suburbs to urban areas. To examine the expenses imposed on cities through this phenomenon, urban planners and designers can use some applications to estimate and compare the results. To do this estimation, the number of travels and their duration should be studied in a period to examine the environmental and economic expenses of living in suburbs in comparison to living in urban areas.

Here, we try to answer the questions of the first part more specifically.

➤ *What are the impacts of ICTs on dimensions of urban design?*

The advent of ICT has greatly influenced urban design dimensions in various forms, with a combination of both positive and negative outcomes.

It is important to identify those effects and incorporate them in the process of urban planning and design. Facilitating transportation and creating places with higher security, for example, are among the positive impacts of ICTs. While driving far distances results in time/energy waste and thus air pollution is considered a negative impact that should be taken into account.

➤ *What is the redefinition of “Urban Design” by considering the impacts of ICTs?*

Urban design is a process in which various factors are influential. Currently, we focused on technology and information, presumably one of the most important factors. It is argued that ICTs can potentially enhance the products of urban design using several tools. These can improve urban design performance and enhance the quality of urban spaces as it proceeds towards a final goal. Therefore, urban design can be viewed as a large-scale process in which digitalization facilitates each of its constituent sub-process.

Urban design is a process of enhancing the qualities of urban environments which would be facilitated by using ICTs tools.

➤ *How can planners and designers use ICTs as a tool for improving the quality of people’s lives?*

Currently, digital tools have been installed in numerous urban spaces. On one hand, urban planners and designers can observe the ways of using such spaces by users. Also, they can compare the duration of being in urban spaces in equipped areas to their previous rate of usage. In this way, they can design urban spaces better and improve their qualities. On the other hand, digital tools such as interactive public displays allow users to express their ideas to inform designers about positive and negative points. This would make a closer interaction between designers and users which leads to a higher rate of urban participation to improve the quality of people’s lives.

6. CONCLUSION

The speed of urban growth in recent decades has faced cities with many challenges. As cities develop more, they experience more rapid changes. The amount of change became uncontrollable especially after the advent of ICTs. The impact of ICTs should be considered in all aspects of people’s lives. The disciplines related to the quality of people’s lives are more focused on such changes because the newly emerged facilities can change the way of providing services. It is undeniable that everything can be done

easier and faster by using the advantages of ICTs. These advantages can be used in all disciplines including urban design. The experts in this field can use such advantages to enhance the quality of urban spaces. This study is a starting point for further investigations in this field. Previous research and studies focused on ICTs as a tool to enhance urban qualities. Here, we tried to introduce ICTs as a new urban layer that affects all urban dimensions. We seek to continue our studies in this field in a context to test our findings.

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