Categorisation of digital tools for co-creation of public open spaces. Key aspects and possibilities

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Abstract - *Information and communication technologies (ICT) have the potential to contribute to the quality and attractiveness of public open spaces and to promote their inclusiveness through a co-creating approach, when ICT tools are used with consideration. There are many different digital tools available and all the time new ones are being developed. However, there is no scholarly consensus on which types of ICT tools are best to use in a specific stage of the co-creation process to effectively support the spatial planning process. This chapter explores the literature and discusses technological and spatial quality as well as user-related aspects of different types of digital tools. Our objective is to define the basis to better understand the different potential of digital tools to meet the needs of people and be useful for all the parties involved in the co-creation process with the focus on planning and development aspects of the quality of public open places. The chapter addresses the challenges faced by urban planners and designers when they wish to integrate-ICT into the process of planning and design and the complexity of the User – ICT – POS interlink. It also explains stating points for a categorization of digital tools for co-creation. Finally, it proposes a framework for classification of digital tools for co-creation. It also takes up the challenge of identifying the criteria for the assessment of existing ICT tools, their features, added values, suitability and usefulness at a particular stage of the public open space co-creation and development process, as well as paving the way for further analyses of their advantages and disadvantages in comparison to analogue tools.*

Keywords - Digital tools, co-creation, public open space, categorization of digital tools, urban planning

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INTRODUCTION

Alongside urbanisation, the development of ICT has been growing rapidly and penetrating all spheres of our lives. Cities and urban life are particularly affected by ICT growth, as modern urban lifestyles are fast paced, and so are ICT. They have made a strong impact not only on our social behaviour and experiences, but also on the ways we understand and interact with our living environment. The physical imprints of ICT can be seen everywhere. Telecommuting influences the way people and information move, using the installation of physical objects and infrastructure to enable digital functionality and digital screens to visualize it. Every day the use of personal ICT devices is changing the potentials and spirit of places as well as the needs of their users. Still, despite the fact that ICT pervade all functions in our urban environment, little attention has been paid to their current and potential role in the design and planning of our urban environment (Graham & Marvin, 2002; Houghton, 2010).

This is especially relevant for public open spaces (POS), which have been historically recognised as a testbed for new and changing needs of communities. Can, in this fast-paced present, new digital technologies act as a necessary medium to enable and support the development of speed-down places, places which are responsive and flexible, that enable new ways of interacting and connecting socially, and boast liveability? To what extent are urban designers and planners prepared for this new situation and challenges? Do they consider altered requirements of POS which technology might bring? And do they understand all the new possibilities ICT are bringing forward for co-creation processes and activities related to the planning and design of POS? Can they plan more responsive POS according to the advanced expectations and requirements of the digital age? Finally, do they perceive digital technologies as a part of the urban milieu, such as are people or buildings?

This chapter develops a contextual review of the link between different users of ICT and public spaces in the co-creation process to effectively support the spatial planning process. It focuses on the 'how' rather than on the 'who'. In this sense, identifying and discussing the characteristics of different user groups (stakeholders) involved in specific stages of co-creation process is not in the centre of examination. Instead, we focus on defining key attributes for selecting appropriate ICT tools and aim to elucidate how certain characteristics of ICT (tools) relate to its users and POS, and can, consequently, support POS and urban planning development. Hence, this chapter discusses theoretical background, focussing on current trends, as well as issues and possibilities of integrating ICT into planning. With the view to developing a framework for ICT tools classification for use in planning matters, we examine and discuss key aspects of the User – ICT - POS connection and meaning. Finally, to better understand and assess the potentials of digital tools to support co-creation activities and promote inclusiveness of public open places, we discuss the usability of categorizing digital tools.

ICT IN URBAN DEVELOPMENT

The emergence of the "Smart city"

Many cities around the world have already embraced different opportunities, offered by the rapid development of digital technologies. The concept of "Smart cities" has been widely implemented to manage urban assets and resources more efficiently. However, there have been several objections to its implementation, especially when smart city policies have not been integrated into the city's existing infrastructure. Roche et al. (2012) argue that smart cities rely too heavily on technological aspects, where mistakes are almost inevitable, but they do not take into account the human dimension: the role social capital could play in the transformation of cities, on one hand, and, on the other, of the needs and wishes of city dwellers. Indeed, developing cities that are more technically than human-oriented is questionable in achieving the long-term prosperity and liveability of the city. Furthermore, there are several other issues connected to the development of smart cities, such as the promotion of a technocratic approach to city planning and government when implementing technology becomes a goal, e.g. installing a high-tech climate management device into a building when planting a tree would solve the situation equally well (McSpadden, 2018). Further issues are, for example, hacks, which can be devastating if a city is built on a digital infrastructure, the surveillance state reliant on profiling, etc. Hence, embracing technology as a tool is fine, as long as other variables are also taken into consideration and not compromised. Roche et al. (2012) stress that this should happen from the very beginning with studying existing dynamics of urban contexts, city's spatial, social and other structures, with the aim of empowering urban communities to adequately meet the challenges which cities face. In their view, smart cities will be successful only when people integrate technologies into their daily lives; therefore, technologies should be taken as a beginning and not as the end of a process.

Technology builds mainly on data collected from citizens, which is processed and analysed to improve cities and in this way "benefit its inhabitants and business" (European Commission, n.d.). Because of this and other (advertised) goals of a smart city, the term has been used in policy pushing by many governments across the world, mainly stressing its obvious positives and not really questioned as a policy decision (McSpadden, 2018).

Due to the critiques, the concept has expanded into more people friendly areas, using digital technologies to support also innovative urban and infrastructure planning of cities and the interaction of citizens with authorities as well. It focuses more on the perception and use of urban environment, and the forming of social relationships and cultural identity. In other words, the reformed idea of a smart city is to use technology as a tool to improve the functions, services and wealth of the cities. The reviewed literature indicates that a good understanding of the link between people – technology – place is crucial to achieve the sustainable development of cities and their open spaces.

Penetration of ICT into urban life – Are ICTs a tool to impoverish or improve public spaces?

A considerable amount of literature recognizes that the emergence of ICT has had a negative impact on the use and perception of POS as well as on its quantity and quality, since ICTs have enabled a shift to virtual space for both work and recreation (Mitchell, 2005; Riether, 2011; Stadler, 2013). Meyrowitz (1986) and Stadler (2016), for example, discuss the rise of internet-based communities and the fall of location-based communities, since, in the era of the internet, it is easier to connect with people with common interests from the whole city than from the neighbourhood. Stadler (2016) also lists fun, entertainment and joy as some of the features most often lacking in POS but as being easily attainable through ICT (e.g. playing games on mobile devices), which strengthens people's dependency on ICT devices and weakens their relation to the physical part of the city. Furthermore, Riether (2011) considers that blogs and online forums have substituted discussions in physical spaces, and social networks have replaced face-to-face meeting, while Hatuka (cited in Badger, 2012) observes that wayfinding applications on mobile phones have almost completely eliminated communications between strangers in public open spaces.

On the other hand, a substantial move of digital technologies away from the desktop to mobile devices has allowed people to shift from the workplace to public open spaces. Wireless networks, in particular, have been recognised as effective tools to shift communication back to the public realm. Moreover, some scholars speculate that people are becoming tired of ICT and are trying to reconnect with reality and value immediate social interaction (Hatuka, cited in Badger, 2012; Houghton, 2014; Stadler, 2016; Ward Thompson, 2002). Public spaces are the major platform to facilitate this new stream and so they are valuable now and will be even more valuable in the future.

Taken together, it cannot be challenged that ICT are changing the historical value of POS to society (Hatuka, cited in Badger, 2012; Houghton, 2014). The above--mentioned studies provide important insights into the changing dynamics of public open spaces (POS) and point to the urge for creating better connections between digital space and physical public space in order to reactivate POS.

The CyberParks Project[1] is an instance where the topic was approached as a new phenomenon of comprehensive interactions of the nexus constituted by people, public open spaces and technology, addressing a wide range of challenges related to understanding and producing new types of outdoor use and place characteristics. It developed a new concept of urban space, a "cyberpark" where nature and ICT technologies interlink into a new type of mediated public space, offering new responsive places of hybrid experiences and new possibilities of use and interactions

[1] COST Action TU1306: CyberParks – *Fostering knowledge about the relationship between Information and Communication Technologies and Public Spaces supported by strategies to improve their use and attractiveness*. www.cyberparks-project.eu.

with space and people, supporting new forms of engagement, communication and co-creation. In the CyberParks publication 'The Making of the Mediated Public Space' (Smaniotto Costa & Ioannidis, 2017) different authors discuss the possibilities of ICT tools to evoke and effectively support human activities towards inclusiveness and co-creation of place. The main focus of the CyberParks project is on enhancing the quality of life and space, as the lure of technology should not serve to create high-tech places but rather places that are inclusive and responsive. In a cyberpark, ICTs and their devices are a driving force, media and tool, which act as mediator between users and the virtual and real worlds. And that in turn could fuel people's greater attachment to places.

The C3Places Project, building on the outcomes of the CyberParks Project, aims at developing strategies and tools to increase the quality of POS through ICT by influencing co-creation and social cohesion effects positively. Within the context of the Project, this chapter discusses an introductory attempt to create a support for different stages and aspects of the planning process by structuring and highlighting the potential of different ICT tools. This involves presenting an overview of different aspects and key attributes of the link between people, places and technology. First, however, it is crucial to understand the possibilities of using ICT tools for urban planners and designers.

INTEGRATING ICT TOOLS INTO URBAN PLANNERS AND DESIGNERS' DEVELOPMENT OF PUBLIC SPACES

To understand the broad range of possibilities that the rapid and continued develop-ment of different types of ICT tools could provide urban planners and designers with for more successful and contemporary POS development, it is important to understand to what extent these professionals are already equipped with the knowledge and skills needed to deal with this issue, and what they still lack to achieve more efficient outcomes.

The call for a shift towards considering digital technologies in urban developmental matters was made several times in the early era of ICT. In the past, different scholars recognised both the potential of ICT and the need to integrate them in spatial planning and development. Ward Thompson (2002), for example, has forecast that digital technology will not simply replace POS; on the contrary, ICT may increase and enhance the use of POS. Ward Thompson (2002) also speculated that ICT will change POS to an extend that new forms of POS will emerge; however, this has not happened (yet) to any wider extend. Similarly, Mitchell (2005) in his book "Placing words, symbols, space, and the city" turned to urban planners to respond to the disconnection between the virtual and the physical spaces. On a broader scale, Graham & Marvin (2002) discussed the development of telecommunications in cities and highlighted the urgent need to develop new conceptual and analytical frame-works which would help policy-makers and researchers to better understand the challenges of ICT penetration in public open spaces and policy responses.

Almost a decade later, a diverse literature on innovation and ICT-related issues in cities continues to stress the limited discussion and implementation of new technologies in contemporary urban planning and design while reinforcing the opportunity of ICT to reframe how cities are organized and planned (see e.g. Dodgson & Gann, 2011; Houghton, Miller, & Foth, 2014). Among relatively few studies, carried out on this topic so far, it is worth mentioning a study by Houghton, Miller & Foth (2014), which examined the role of digital technologies in urban planning from the perspective of planners and designers. They held focus groups with planners from different backgrounds and found out that there was very little engagement of planners with the affordances of ICT in their professional practice, mainly due to insufficient knowledge and skill, agency and time constraints. The participants did, however, acknowledge ICT as an opportunity to connect with users of public open spaces, share information in and about the place with the public, and to foster faster adaptation of places.

The overview of different cases and examples of ICT use in the planning process (Falco & Kleinhans, 2019; Stadler, 2013; Šuklje Erjavec & Ruchinskaya, 2019) also shows that the use of digital tools by urban designers and planners is mostly limited to of the development of web platforms offering a more or less comprehensive set of digital tools to support different participatory activities. These are mostly related to data collection (e.g. about people's preferences, needs and activities, spatial problems requiring attention, etc.), information sharing and engagement experience (e.g. playing a game to build a city), but less in joint activities which would actively involve different actors in co-creating a public open space. Indeed, not urban planners and designers but artists seem to have been breaking new ground when it comes to experimentation with new formats of POS. Riether (2011), proposing a new prototype of public space by integrating art experiment into a space, sees art as a territory to explore new questions and experiment with new ideas. The author, too, calls for the need to rethink what incorporates urban planning to make room for a digital infrastructure. It appears that the responsiveness of spatial planning to challenges and opportunities opened by ICT tools is very slow in comparison to the extremely fast technological development. One important aspect in uncovering the reasons for this situation is the very different timeframe of changes characteristic for ICT development and urban planning and design practices. Whilst ICT development is fast, urban planning and design practices are complex and bound to social, political, cultural, spatial as well as natural development processes that are, except for natural disaster effects, usually very slow. This may explain the slow response of urban design, as professional practice, to the opportunities of new technologies and the emergence of better connections between digital and physical public open spaces.

Still, ICT offer interactive and innovative tools which can better connect people and places; therefore, it is important for urban planners and designers to acknowledge, understand and direct the interaction of physical and digital layers (Houghton et al.,

2014). In order to adequately explore the wide range of possibilities which different types of ICT tools can provide urban open space planners and designers with and to use ICT tools with consideration, understanding the characteristics of ICT tools and how these pertain to planning and design approach levels, processes, steps, connections and time flow may help urban planners and designers to use them with greater ease. A structured overview of the different aspects of ICT tools, to form selection criteria of appropriate ICT tools, may help planners and designers in their decision-making. Classification possibilities are discussed in the next section.

COMPLEXITY OF THE USER-ICT-PUBLIC SPACES NEXUS

Many of the contributions for the conceptual framework of this chapter derive from the outcomes of the COST Action project CyberParks. Within the CyberParks Project different working groups explored challenges to the User-POS-ICT relationship from different angles of various disciplines. Such a transdisciplinary approach enabled acknowledging the breadth of the topic and the development of diverse interesting frameworks. The baseline is structured according to the degree of users' engagement with the ICT used. It consists of four main categories of ICT-technologies: Augmented Reality, Localization Technology, Wireless Network and Vision Technology, plus three additional dimensions of ICT that were recognized as important: Human Behaviour toward ICT, Privacy and Security Assurance, and Environmental Development. All of them are illustrated with practical examples closely related to spatial quality, user needs, spatial attributes and added value of ICT for public spaces as depicted in Fig. 1 (Ioannidis & Smaniotto Costa, 2019).

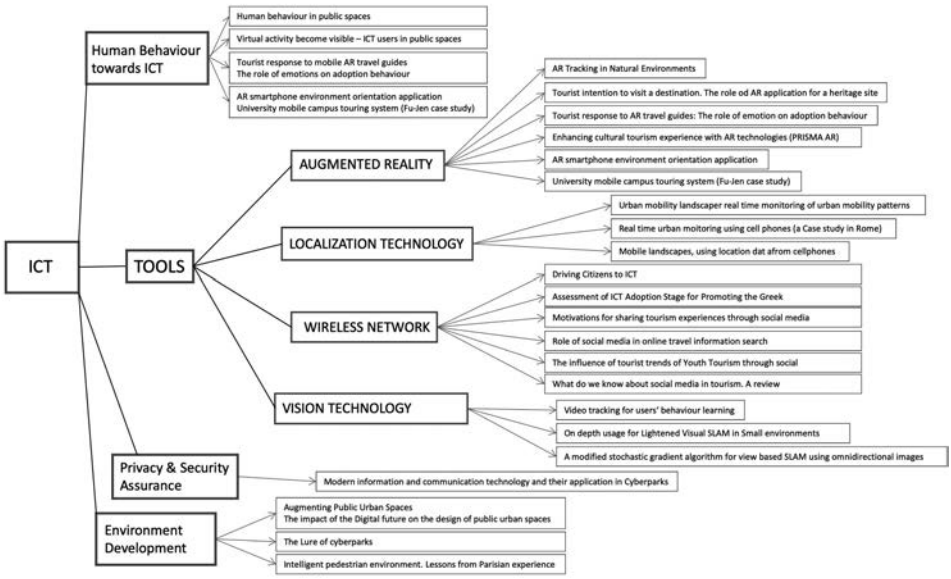

Fig. 1. Understanding the diffusion of the digital into public spaces
(Ioannidis & Smaniotto Costa, 2019: 245)

The focus of CyberParks was on researching and defining the (possible) added value of applied technology for users and uses of places, how digital tools are affecting user-behaviours and users' spatial needs and how all this impacts the development, characteristics and quality of public open spaces. Five working groups explored relevant issues (digital tools and methods, urban ethnography, conceptual reflection on ICT, place and society, cyberpark design challenges and dissemination activities), investigated the shape and scope of ICT impacts and the opportunities digital technology creates to improve the liveability and inclusiveness of place as well as new forms of involving people into the urban design and development processes. In Working Group 4: Creating Cyberpark[2] which focussed on ICT impact on urban open space design issues, participants explored the possibilities of new uses and technologically mediated activities and spatial characteristics of a new type of POS – the *"cyberpark"*. To better present the new challenges, an overview table was prepared explaining what kind of provision and spatial attributes are needed for new hybrid space activities and "cyberspace use" (Table 1).

CYBERSPACE		OPEN URBAN SPACE
Cyberspace use	**Hybrid space activities**	**Provision**
Gaming / playing	Location-based play, playable city	Play devices, urban games that use (at least partly) the real space – tasks linked to special places of elements
Meeting and communication	Meet in space, not necessarily synchronous	Post office infrastructure/benches (read only within a perimeter)
Creating, artistic expression	Virtual graffiti, online sound and music Interaction with the user Co-creation of place	ICT functions embedded in furniture, trees, lamp posts, touch screen painting displays (uploadable and local chalking), post office infrastructure as part of the Internet of Things (IoT)
Learning and information	Gaining new knowledge, raising awareness, raising responsibility Helping to recognize the place, to orient, to read its functions Learning about the environment you are in at the moment and its history	Audio-visual displays – multifunctional elements, part of paving, walls, buildings… focusing the user's attention on particular elements Artistic interventions
Legibility – orientation	Navigation of both space and information	Way-marking, physical and conceptual structuring, GPS, etc.
Exercise, health, mental restoration	Group activity, individual activity	IoT, exercise infrastructure Support with measurement opportunities, competition possibilities, (bio-) monitoring for individual to be attracted to do exercise
Buying, acquiring material goods, sharing business opportunities	Delivery points, commons	IoT supporting pop-up markets, local trade, yard sales – in space we may provide suitable locations – urban design guidelines?

Table 1: Users activities technologically mediated
(prepared by Working Group 4 - Creating Cyberpark. CyberParks Project[3])

[2] Ina Šuklje Erjavec was a vice-chair of the CyberParks Project and member of its Working Group 4 (http://cyberparks-project.eu/working-groups/4-creating-cyberpark).

[3] http://cyberparks-project.eu/working-groups/4-creating-cyberpark

Furthermore, possible benefits (added value) of the implementation of the three categories of applied technology (Position informatics, Sensory informatics, Synergetic interfaces) in public spaces for users and uses of places were listed as:

- Enhancement of publicness,
- Increase in the performance of public open spaces,
- Increase in the production and co-creation of public open spaces,
- Increase in the knowledge on users and on uses,
- Dissemination of information in/about the places,
- Use of ICT as a support and challenge for new outdoors activities.

These benefits also serve as basis for a response matrix that combines the typology of public spaces for the Pool of Examples of CyberParks, which aims to increase the understanding of the benefits of technology to enhance places in order to achieve added value (i.e. new outdoor experiences, innovative ways of using places) (Ioannidis & Smaniotto Costa, 2019). This approach was structured more in detail in a final overview table of Working Group 4 (Implication of Spatial Aspects). It presents the how and what kind of user needs can be addressed by providing and implementing ICT, what the added values are, how they relate to attributes of place and which aspects of spatial quality can be enhanced and improved upon (Table 2).

Spatial quality aspects	User needs	Attributes	Provision/ICT implementation	Added Values
(Public) Accessibility	Physical accessibility orientation, navigation, access for all (inclusiveness) Accessibility to technology – skills/use, affordability, equality (inclusiveness)	Easy to use (intuitive) devices, user-centred design (no need to be ICTliterate) Path quality (access for all) online information before visiting place - available for all needs	Wayfinding apps – clear information on physical qualities online, 'filtering' of needs based on user profile/requirements Overlaying of additional information within App for specific purposes (augmented reality); Insitu devices **LT, AR**	Enhancing access for all (facilitating it) and responding more specifically to user requirements, possibility for user feedback to enrich data
Security	Perception of safety in the space, not to be controlled or observed; to retain: - physical safety - emotional/ - psychological safety - Internet security - not to be hacked	Physical/virtual privacy, confidence, alertness to danger	ICT tools and apps for: Lighting Suitable structure of place, good visibility, Validated networks Sound and light interactivity Monitoring cameras **AR, LT, VT, W, DM**	Social networking – more present Higher usability New users New ways of lighting flexibility of activation system
Legibility	understanding of the place/ease of movement	Readability	Planning - Layout and way-marking **AR, LT, VT, W, DM**	Flow
	Clear Identity of place	Unique features	Artworks, landscaping, facilities	Recognition, significance
Sociability	Participation and inclusion Interaction	Gathering social spaces, play spaces	Clear space/ICT demarcation / timeindependent but spatially localised social interaction **AR, W, DM, LT**	Wellbeing and social cohesion, ownership/ care sense of belonging, e-agora

Spatial quality aspects	User needs	Attributes	Provision/ICT implementation	Added Values
Adaptability	Capacity for change	Future-proof design Flexibility Ephemerality	Regular maintenance and updating **VT, DM**	Co-creation, citizen input, experimentation of solutions, possibly temporary
Functionality	Accessibility Comfort	Welcoming spaces, clear pathways	Social design and facility provision **DM, LT**	System trust
Connectability	Between spaces (permeability), people and information	Secure and highbandwidth provision	Maintaining networks, facilitation **W, DM**	Social cohesion, communication
Variety	Attractors Opportunity of choice	Gaming, social, information layers	Embedded games and play, socially hybrid spaces – e.g. chess/coffee **AR, LT, VT, W, DM**	Enjoyment, play, new users, innovation
(Social) resilience in the face of emergency	Collection and provision of effective and reliable information; Knowledge on where to go; Access to amenities Organisational support for groups	Quick responsiveness Spatial adaptability to user needs ICT-functioning support Accessibility (to both space and technology)	Energy independence or passive energy generation Monitoring devices e.g. air/water quality, waste… **W, DM, VT, LT**	Timely information provision and exchange A direct communication channel e.g. via social media Monitoring available resources
Environmental/ ecological sustainability	Optimal microclimate Water retention Biodiversity Pollution and natural disaster mitigation	Real-time monitoring via sensors Visualising the information in situ	Sensors Screens Apps **DM, VT, LT, in situ sensors**	Raising awareness and knowledge Support policy making and management
Health (physical and mental) and wellbeing	Outdoor physical activity Mental restoration (connection with nature) Knowledge on optimal environmental conditions to carry out physical activity	Challenging and attractive environment for physical activities; Virtual environment to enhance wellbeing; Real-time information; Health-related statistics	Innovative elements that invite one to perform physical activities Screens, Apps Games **AR, VT, LT, DM**	Raising awareness, knowledge, promotion of a healthy lifestyle. Attracting new people outdoors; Fostering visitors' activity; Offering new experiences

Table 2: Overview of the implications of spatial aspects. Source: Cyberparks – WG4 (adapted by Ina Šuklje Erjavec, UIRS)

STATING POINTS FOR CATEGORIZING DIGITAL TOOLS FOR CO-CREATION

The development of digital technologies opened new opportunities for different collaborative processes, many new possibilities to engage and activate people, and for new ways of interacting with the environment. However, to effectively use all the ICT potential it is important to understand co-creation in its broader sense: as a process that includes all stages of POS development and addresses all types of related collaboration activities, such as involving end users (citizens) and other relevant stakeholders, sharing information and local knowledge, collaborating on data gathering, expressing opinions, needs, wishes and values, defining priorities,

visions and aims, working on decision making as well as placemaking with different participatory planning and co-design activities and co-management (Šuklje Erjavec, 2017; Šuklje Erjavec & Ruchinskaya, 2019).

However, an overview of present classifications by various authors showed that there have been very few attempts to holistically examine and classify ICT tools according to their potential for integration into the planning process. One interesting study was made by Houghton, Miller & Foth (2014), who defined three main groups of ICT potentials for planners: Technology for analysis of place, Technology in place, and Technology for community engagement about place. The approach of understanding ICT tools from a comprehensive process of place development, i.e. planning and design, implementation, management and use, is very useful for further development of an ICT typology for needs of urban planners and designers, and to explain the possible added values and benefits of using ICT tools properly. As further next step towards better understanding the possibilities for co-creation, we developed the following structure of the possible use of different ICT tools. It explains the type of function and way of integration in the process of planning and design, place making, place management and community engagement.

For expertise work – technology for supporting spatial development processes
> in the **process** of spatial planning and design, digital tools could be used to better:

- Understand, analyse and evaluate spatial and social state of the art faster, more deeply and comprehensively
- Assess and evaluate proposals more transparently
- Develop more transparent solutions, scenarios and models
- Present solutions more understandably and efficiently for non-experts (hardware and software)
- Perform sharing, co-production, co-creating, co-designing between experts and with stakeholders

For place functioning – technology in place & technology supporting the use of place
> in the **process** of place making, digital tools could increase:

- Responsiveness and adaptability of place
- Communication about place and within place
- Orientation and access to information
- Attractiveness, usability and playfulness of place
- Identity and recognizability of place
- Personalization and individual creation possibilities
- Education possibilities,
- Research possibilities, etc.

> in the **process** of place management, digital tools could increase

- Monitoring – environmental and spatial quality
- Maintenance feedback (sensors, mobile apps, platform)
- Work coordination
- Traffic management
- Cultural content management
- Technical management
- Maintenance management
- Information management, etc.

For community engagement – technology for supporting community engagement

> to raise awareness and increase involvement of the community, digital tools could increase the effectiveness of:

- Information collection, sharing and management
- Social communication, interactivity and networking management
- Public involvement and participation
- Co-creation process management
- Construction of community capacity and common issues and goals

Within the scope of the C3Places Project, a methodological framework was developed to assess the case studies which have been implemented as C3Places Living Labs. The proposed framework is summarised in a Digital Co-Creation Index – a tool to assess, measure and compare digital co-creation initiatives. The index is compiled in three sub-indexes: POS quality Index, to evaluate physical and social aspects; Digital Inclusiveness Index, which explains the extent to which technology enables co-creation; and Social Responsiveness Index, which is linked to stakeholders and community members and addresses their maturity to respond to social challenges and generate public value (for further reading, see the chapter Assessing Digital Co-Creation in Urban Transformations: Case of Vilnius, by Skaržauskienė. On this basis, a conceptual framework was elaborated to convey the penetration of ICT into public spaces. The criteria are structured according to three aspects: spatial quality aspects, user-related aspects, and technological aspects (Fig. 2).

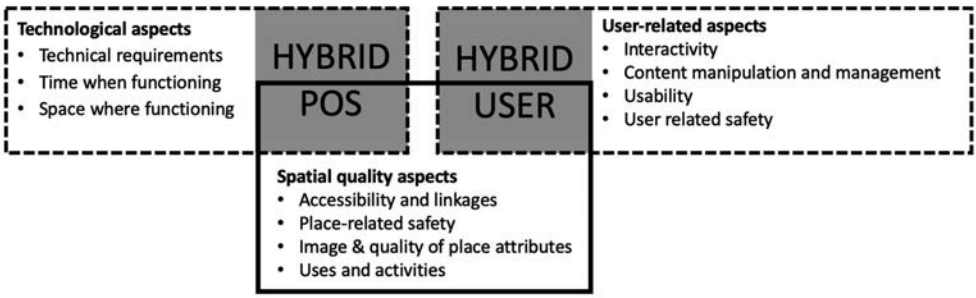

Fig. 2: Three aspects and criteria to consider when selecting ICT for co-creation of public spaces

Spatial quality aspects

The approach to evaluating these aspects is grounded on basic principles of researching, understanding and designing public spaces developed by theorists and practitioners such as W.H. Whyte, J. Gehl, S. Carr and others. Specifically, the criteria, indicators and tools from the Project for Public Spaces "The Place Diagram" (Project for Public Spaces, 2009) and Jan Gehl's "12 Urban Quality Criteria" (2017) were examined more profoundly. In addition, we took into consideration the outcomes of the CyberParks Project and evaluated the performance of the C3Places POS Quality Index (C3Places, 2019) for the Living Labs assessment that we adapted to the current context of POS, with its digital transformation in mind. The main spatial quality aspects which include additional dimensions relevant for ICT penetration into POS, are defined as:

- **Accessibility and linkages –** Legibility, Navigation, Convenience for movement, Interlinking, Level of physical, social and digital accessibility.
- **Place-related safety –** Vandalism, Traffic, Injuries, Environmental safety (monitoring).
- **Image & Quality of place attributes –** Attractiveness, Personalisation and individual creation possibilities, Adaptability, Monitoring, Environmental quality and Ecological sustainability.
- **Uses and activities –** Communication and education possibilities, Access to information, Sociability, Research possibilities, Playfulness, Variety, Responsiveness, Service provision, Health and wellbeing.

User-related aspects

To define criteria for these aspects, our guiding question was: Which characteristics of ICT are needed to satisfy use and successful co-creation experiences? As basis for development of criteria the Social Responsiveness Index and the Digital Inclusiveness Index were used, plus a sub-indices of Digital Co-Creation Index (C3Places, 2019) and literature review of existing classifications and criteria of ICT features to enable satisfactory user experience. We considered criteria for methods and approaches selection from "Participedia" (n.d.) and the work of Kaplan & Haenlein (2014), who focused on collaborative projects, such as one on ICT tools, grouping them along two dimensions: type of knowledge that is created within a collaborative project, and mutual independence of individual contributions. We define user related aspects as:

- **Interactivity –** User's engagement along with the device/ media/ application used, its type of interaction, degree of interaction and type of experience
- **Content manipulation and management –** How is it provided and what is user supply?
- **Usability –** Ease of use, respect for privacy, saving work for future use, customization potential, possibility of choice

- **User-related safety –** security and privacy assurance technology (protection of personal data, anonymity of ideas, etc.) and social resilience

Technological aspects

The guiding question for the technological aspects was: How can digital technology support quality of place and the way the place is used and developed? The main issues to define are:

- **Technical requirements regarding** software, hardware and network communication, and their installation: is there a need for the internet, are any specific operational systems required, i.e. electricity, speakers, etc.?
- **From the time-related point of view:** is the ICT tool functioning permanently or temporarily, continuously or intermittently?
- **From the point of view of functioning place:** is the ICT tool static, located in the POS, portable, to be used in POS, or remotely accessible to be used for distant POS-related activities?

On this basis, we have systemised types of ICT tools and their supporting devices in three main categories which describe where the tool is installed in relation to the open space and how an ICT tool interacts with the user. The subtypes of tools are defined according to POS, user-related functions and specific characteristics. Thus, the developed framework for classifying digital tools for co-creation is addressed in the next section.

FRAMEWORK FOR CLASSIFICATION OF DIGITAL TOOLS FOR CO-CREATION

Place-located ICT tools

These tools are located 'in place' and installed as part of the physical features of the POS. Such digital tools add new functions to existing places or are part of the design of new ones, combining digital and physical layers into a new, hybrid place. The overview of place-located ICT tools is presented in Table 3:

Type	Subtype
Individual digital elements as new types of elements of POS	Digital public displays Public interactive and pervasive displays Multimedia interactive elements Multifunctional tech totems Interactive and responsive sound installations Responsive lighting elements Multimedia pavilions Interactive POS elements: a combination of different digital elements (e.g. screens + speakers + lighting) as artistic installations per se or frames for them, responsive sculptures and fountains, play equipment, etc. Individual elements for energy provision, such as electric vehicle charging stations, solar energy stations, etc.

Type	Subtype
Digital part(s) of POS elements or parts of surrounding buildings and elements	Digital elements upgrading or supporting the functioning of urban elements (these are incorporated into traditional types of POS furniture like benches, tables, fences, lights, playing or sports equipment, etc.) Digital additions for upgrading the functioning, maintenance or experience of the area, like WI-FI hotspot, speakers, QR codes, sensors, beacons, universal intelligent nodes Elements for energy provision to support the use of portable ICT devices that are incorporated into traditional types of POS furniture, playing or sports equipment, etc.) in the shape of plugs, solar panels, etc. Media facades as part of other built structures, e.g. facades, walls, etc. Projection mapping (Digital projectors) Digital projectors as part of other built structures, e.g. facades, grounds, walls, etc. SAR (spatial augmented reality) systems: - Shader lamps (projector-based augmentation) - Mobile projectors - Virtual tables - Smart projectors (projection mapping), etc.
Responsive materials	Adaptive pavements (adapting to the weather, accessibility needs, etc.) Responsive verticals (changing by touch, sound, etc.) Measuring materials (for monitoring use, conditions, etc.) Self-cleaning, self-repairing materials

Table 3: Examples of Place-located ICT tools

Portable ICT tools

Portable ICT are digital tools that bring a user to the public open space and establish a relationship with space, other users and/or other premises. Their main purpose for POS development and co-creation is to develop new forms of uses and activities in the POS by extending human abilities, i.e. adding a digital sense to the five basic human senses and to support a direct feedback from users for better POS development and management. Their structure is presented in Table 4.

Type	Subtype
Smart devices	Smart phones and tablets Smart glasses (e.g. Google Glasses) Smart grid Smart watches (e.g. iWatch), etc.
Place-related mobile APPS	Directly supporting learning about place and its natural and manmade characteristics, adding to the experience of place, support moving through it, activity and movement tracking Collect and share data on environmental conditions, evaluate conditions, etc. Directly support place evaluation and feedback VR and AR apps for opinion and proposal development and sharing, etc. Other apps are discussed in the context of web platforms and apps (Table 3)
GPS-positioning devices	Individual or as part of other smart devices
Other personal VR and AR devices	Head-mounted displays (e.g. headsets, eyeglasses, contact lenses) Multi-projected environments Combination with physical environments or props (e.g. 3D mouse, wired glove, motion controllers, optical tracking sensors)

Type	Subtype
Cameras, recorders	Many different options
E-textiles – aesthetics and performance enhancing	Smart garments, smart clothing, smart textiles, or smart fabrics providing benefits to the wearer, enabling the interaction with the environment and responsiveness to personal activities and condition Wearable computing with microcontrollers, sensors and actuators
Digital health and fitness tools	Devices and apps to encourage healthy habits, fitness and other physical activity tracking, health measurements, Internet-connected fitness systems, environment quality sensors and alarm systems

Table 4: Examples of Portable ICT tools

Remotely accessible ICT tools

Although we also acknowledge in this group ICT tools such as laptops, PCs, screens, mobile phones and other hardware, a variety of these is broad and not directly relevant for the aims of this paper. Therefore, we focused only on web platforms and apps and a group of related tools used for digitally networked interactions, such as distant (not on the spot) society engagement, public consultation, information and opinion collection, exchange and sharing, voting, etc. Their general advantage is that they can at any time reach a much larger number of people who can also choose their own time of use.

In the structure we focus on aspects that are very important to support different co-creation activities for POS development, such as preparing, discovering, debating, deciding, designing, implementing, maintaining, using, and monitoring public open spaces. Table 5 provides a general overview of how different components and tools enable and support different dimensions of remote public involvement.

Type of components/ tools	Examples
Social networking platforms and sites	Pinterest, Facebook, Instagram
Static web sites	Professional portfolios, digital curriculums
Blogs and microblogs	WordPress, Joomla, Drupal, Twitter
Tools for social bookmarking, tagging	Pinboard
Online storage (cloud storage, file synchronisation, personal cloud)	Dropbox, GoogleDrive, iCloud
Social network aggregation	Hoot Suite, FriendFeed
Encyclopaedia	Wikipedia
Survey[4]	Google Forms, SurveyHero, Typeform, SurveyMonky, InvolveMe
Content communities - online databases of multimedia content that allow users to share online multimedia materials, i.e. photos, videos, podcasts, presentations, etc.	Flickr, SmugMug, Picasa, GigaPan Youtube, Vimeo iTunes SlideShare, VoiceThread

[4] https://www.wordstream.com/blog/ws/2014/11/10/best-online-survey-tools

Type of components/ tools	Examples
Internet forum/ Message board Textboards and Imageboards	Quora, SkyscrapperCity
Chat rooms in the form of Web conferencing, Video conferencing, etc. **Instant messaging**	Facebook Messenger, Gmail messenger, WhatsApp
Electronic mailing list, news group	Mailing lists of different organisations, companies, institutions, etc.
Online dictionaries	Urban Dictionary
WEB GIS[5] - Analytical - Animated and real-time - Collaborative (e.g. PPGIS) - Online atlases, etc.	Open Street Map, Google maps, Apple maps, and many different project-specific and city-specific data collection platforms
Web-based simulation platforms and apps for discrete events, continuous events, etc.	Digital participatory platforms: Mobility Testbed, Commonplace, coUrbanize, TransformCity, etc.
Construction and management simulation games, e.g. city building games	Lincity, SimCity, etc.
Augmented reality apps	Pokemon GO, ScentExplore
Virtual social worlds	Second life

Table 5: Examples of Remotely accessible ICT tools: Web platforms & apps

CONCLUSION

As discussed in this chapter, there is already a substantially wide recognition of possible benefits of incorporating digital tools in a development process to improve the quality and functioning of public open spaces, from the perspective of the contemporary user as well as POS developers and managers. However, until now, in the urban planning process and POS design, ICT tools have not been used to any significant extent due to various reasons, but predominantly due to urban planners' and designers' lack of understanding, knowledge, skill and time. To improve the understanding and recognition of various options for using ICT for POS development by urban planners and open space designers, we presented and discussed different aspects of digital tools and their potential to meet people's needs, attract new users and promote the inclusiveness of public open spaces, as well as effectively support the co-creation process for a better performance and use of POS through co-creation activities. Our aim was to explain and justify how different characteristics of digital tools could be useful for all the parties involved in the co-creation process. To this end, we have structured ICT tools into categories according to their area of use within the planning and functioning of POS, and pointed out their key attributes and aspects related to their potential use for all phases of POS development and functioning.

[5] Wikipedia Web Mapping: https://en.wikipedia.org/wiki/Web_mapping

What is needed now is to set criteria for evaluating existing digital tools, their features, added value, as well as advantages and disadvantages in comparison to analogue tools, and align their characteristics with their usefulness for specific steps and phases of the co-creation processes. This is what we plan to explore in our further research within the C3Places Project.

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