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Review

Digital placemaking, health & wellbeing and nature-based solutions: A systematic review and practice model

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ABSTRACT

Technology implementations in the urban environment have the potential to reshape how communities experience places, specifically providing a potential enhancer for nature-based solutions in the city. Urban spaces are facing a number of challenges from climate mitigation to negative effects on communities. In this context, nature-based solutions aim to promote nature as an answer to the current climate challenge, linking positive outcomes for society in a cost-effective way. Urban nature could benefit from the implementation of technology to enhance nature experiences and nature's impact on the community. This study aims to review and synthesise existing literature focusing on the associations between digital placemaking, mental health and wellbeing impact and the use of green and blue spaces while exploring successful case studies. Hundred and seventeen studies met the eligibility criteria, most of them used qualitative methods. The findings provide insights into the potential impact of digital placemaking practices for urban nature on citizens' wellbeing and mental health. Our results indicated an absence of agreement on the concept of digital placemaking, and a lack of blue space research while nature was presented as a context and passive element. Mental health and wellbeing are mostly approached without specifically examining health indicators or assessing the health impact of these practices. Our study proposes a model offering insights into the broad range of best practices for implementing digital placemaking for nature and wellbeing and represents a key contribution to understanding the innovative application of augmenting NBS through digital placemaking impacting the wellbeing of citizens.

1. Introduction

Surroundings impact a person's quality of life. The value and effect of public spaces have been broadly studied, especially by authors such as Gehl, Jacobs and Whyte who defended the importance of adopting a people-first approach to urbanism, which places people at the heart of the design of public spaces. These concepts are the foundation for placemaking (PPS, 2004). To promote connections with environments and create meaningful places, placemaking was first discussed in the 1960s (Abdel-Aziz et al., 2016). It seeks to improve the quality of public spaces for communities, which is imperative for increasing social bonds and wellbeing (Courage, 2021).

Placemaking has been applied to many different concepts and areas, from urban nature and community gardening (Truong et al., 2022), to participatory planning (Huang, 2019), tourism planning (Lew, 2017), as well as the shift from placemaking to place-keeping (Mattijssen et al.,

2017). Part of the debate around placemaking is the use of augmented technology and digital applications to improve communities' relationships with public spaces, specifically those that follow urban greening strategies and nature-based solutions (NBS) (Tsekeri et al., 2022).

Digital placemaking is the implementation of technology in placemaking practices, from using mobile games to explore the environment (Hjorth and Richardson, 2017; Qabshoqa, 2018) to the role of social media in allowing communities to connect in digital and analogue ways with their surroundings (Breek et al., 2018). Digital placemaking has the potential to benefit communities by adding value to public spaces, economic growth, cultural wealth, and overall better community life (Morrison, 2021). It could reconvert urban areas into community hubs, revitalising its heritage and experiences through social media and place branding (Soedarsono et al., 2021; Sugangga et al., 2021). This technological application to placemaking practices can enhance the impact in cities and public spaces, not only generating a stronger sense of place

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and belonging within communities (Halegoua and Polson, 2021) but also making spaces more accessible and inclusive to all (Bedford et al., 2022; Szaszák and Kecskés, 2020).

Despite the benefits of these practices, it is important to also address potential risks and impacts that have been reported on digital placemaking practices, such as gentrification (Bottero et al., 2022; Bronsvort and Uitermark, 2021), the environmental harm from e-waste (Bedford et al., 2022), exposing pre-existing inequalities and exclusions (Halegoua and Polson, 2021), light pollution (Foth and Caldwell, 2018), or projects not genuinely engaging and putting the community first (Foth et al., 2018; Kamols et al., 2021; Monno and Khakee, 2012).

Digital technology affects how we experience our surroundings. From a study by Prescott, (2019), almost all adults aged 16–44 years used the internet daily (99%) in the United Kingdom, while 87% of the population own smartphones (Deloitte, 2021). Most citizens interact with the environment through some type of digital device. Thus, digital placemaking has the potential to shape reality in urban spaces, potentially helping people connect with nature for example through augmented reality (Clowater, 2021). When applied to the management of urban nature spaces, it can benefit from measuring performances, supporting decision-making and connecting communities with the spaces in the world of the internet we are living in.

Specifically, digital placemaking could be a key approach to improving public spaces and urban nature environments, since sixty-eight per cent of the world's population will live in urban areas by 2050 (United Nations, 2018). Since the industrialisation process cities have suffered a loss of public spaces (Paquin, 2019), diminishing the opportunities for engagement with natural environments, which has potential negative impacts on communities' health (Bashan et al., 2021). Despite the positive effects of urban development on issues such as poverty or inequality (United Nations, 2008), urban environments' negative consequences on citizens' wellbeing (e.g., social isolation) have also been illustrated (Marshall, 2021). These concerns were amplified by the COVID-19 pandemic (Zacher and Rudolph, 2021), raising awareness of the importance of urban green spaces in peoples' mental health and wellbeing (Heckert and Bristowe, 2021; Tomasso et al., 2021). Nature is proposed to have a positive effect on citizens' health through increased opportunities for physical activity, greater social interaction, protection from pollutants and stress reduction (Bowler et al., 2010; Hartig et al., 2014). There is extensive empirical literature on the benefits of nature exposure for health (Bratman et al., 2019; Jimenez et al., 2021) however, the wellbeing impact of digital technology as a mediator between nature and citizens has not been fully addressed (van Houwelingen-Snippe et al., 2020).

The need for the inclusion of nature in cities has been highlighted for several years, most recently in a report by the WHO Regional Office for Europe (2021) presenting the beneficial impact on health and wellbeing of nature, specifically the crucial role of green and blue spaces for urban planning and climate change through NBS. The report differentiates green space and blue space, where green space is understood as "urban forests, parks, playgrounds, allotments and urban farming locations" (p. 8), and blue spaces are "coasts, lakes, ponds and pond systems, wadis systems, artificial buffer basins and water courses" (p. 24). Regarding NBS, these practices aim to promote nature as an answer to climate mitigation and adaptation (Nesshöver et al., 2017) in a cost-effective way. The implementation of NBS in international policy and business discourses is spreading and gaining relevance (Seddon et al., 2020). NBS promote the maintenance, restoration and enhancement of biodiversity and ecosystems as a way to address environmental challenges, while also being a design and planning tool (Giachino et al., 2021). Furthermore, they provide several benefits such as the health and wellbeing of citizens (European Commission, 2016). Recent studies have highlighted the value and importance of implementing digital technology in NBS, enriching their potential effects while increasing citizens' awareness (Tsekeri et al., 2022). These innovative and integrative tools could bridge the gaps and limitations of NBS while supporting

decision-making and governance (César de Lima Araújo et al., 2021). Smart technologies applied to NBS are proven to facilitate the management and awareness of these practices, but it is also crucial to address their potential risks (Li and Nassauer, 2021).

The incorporation of digital innovation in the citizens' wellbeing-nature equation would benefit from 'indirect interactions' with nature, which have beneficial evidence for communities increasing their wellbeing and reducing stress levels (Cox et al., 2017). Digital placemaking could assist in establishing these interactions by creating hybrid experiences in a place. Moreover, the increased attention to nature-based technologies and the implementation of digital tools to enhance design solutions for healthy environments (WHO Regional Office for Europe, 2021) support the potential synergies and benefits from the implementation of digital technologies as enhancers and facilitators of urban nature. Technology could act, not only as a tool within NBS but also as an enhancer of its long-term relationships and impacts on the community. Digital placemaking is presented in this study as a novel approach to NBS that could increase the environmental performance and social impact of these practices in the cities while supporting the mental health and wellbeing of their inhabitants. Aside from digital placemaking as an NBS tool, there is scope for it to create positive effects such as co-created activities that augment the sense of belonging within communities, as well as other key contributions that have not been explored yet.

With the present study, we are exploring how digital connectivity can help increase the sense of place in urban nature environments when introducing technology within NBS. Risks of digital solutions in urban greening strategies within NBS and the ability of this technology to connect communities are addressed. The study systematically review and synthesise the existing literature focusing on the impact of digital placemaking on mental health and wellbeing through green and blue space connections, offering an insight into the broad range of best practices of digital placemaking when enhancing the performance and impact of NBS. We introduce an innovative technique, that of digital placemaking, to augment the application of NBS, thus potentially impacting the wellbeing of citizens. A model for implementing digital placemaking for nature connections and psychological wellbeing in communities is also proposed, offering a thorough understanding of the potential of embedding technologies inside NBS to increase their performance, while fostering social inclusion and cohesion in bringing nature into the urban environment.

2. Materials and method

This systematic review was performed and is reported following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (Page et al., 2021). The protocol for the review was registered with PROSPERO an international database of literature reviews created by the University of York (<https://www.crd.york.ac.uk/prospero/>) (registration number: 2022 CRD42022316039).

2.1. Search strategy & study identification

The literature review focuses on published articles in the following databases: Web of Science, Scopus, Emerald, ACM DL (Association for Computing Machinery Digital Library) and Google Scholar. An initial search was conducted between the 30th of November and the 1st of December 2021. The dataset was updated on the 5th of October 2022.

An initial search was conducted (Health and wellbeing AND digital AND "green space" AND placemaking) to create a keyword bank that informed our final search. The final search was grouped into three themes and two tiers (see Table 1). A number of synonyms of digital placemaking, mental health/wellbeing and green/blue space were included to ensure any relevant publications were not overlooked (Jalali and Wohlin, 2012).

The review process followed similar works in cognate disciplines.

Table 1
Search Strings grouped in Theme.

Theme	Search string	Google Scholar	Web of Science	Scopus	Emerald	ACM DL	PubMed	TOTAL	
<i>Digital Placemaking</i>	<i>Tier 1</i>	digital AND place OR placemaking OR place-making OR place making OR place marketing OR digital place* OR environmental placemaking OR environmental place-making OR environmental place making OR smart cities placemaking OR smart cities place-making OR smart cities place making OR digital placemaking practice OR digital place-making practice OR digital place making practice OR creative placemaking OR creative place-making OR creative place making OR social practice placemaking OR social practice place-making OR social practice place making OR digital placemaking and community development OR digital place-making and community development OR digital place making and community development	28400	591406	29800	82	628225	45014	694702
	<i>keywords used in tier1 phrase</i>	Placemaking OR place-making OR place making	694000	276803	63543	251000	549549	26515	1861410
		digital AND placemaking OR digital AND place-making OR digital AND place making	1630000	7778	2078	45000	378033	410	2063299
		Digital place*	1670000	34486	49709	46000	473934	11101	2285230
		Environmental placemaking OR environmental place-making OR environmental place making	53400	29737	5484	77000	560667	4146	730434
		Smart cities placemaking OR smart cities place-making OR smart cities place making	18000	668	295	10000	554085	6	583054
		Creative placemaking OR creative place-making OR creative place making	1860000	2815	1187	43000	565263	159	2472424
		Digital placemaking practice OR digital place-making practice OR digital place making practice	3130	1086	461	36	565290	87	570090
		Digital Placemaking and community development OR digital place-making and community development OR digital place making and community development	3260	252	89	35	581130	16	584782
		Social practice placemaking OR social practice place-making OR social practice place making	87000	8673	3499	142000	572097	1404	814673
	<i>Tier 2</i>	inclusive smart city OR participatory city making OR urban interaction design OR social media OR digital storytelling OR interaction design OR digital nature OR human-technology interaction	22400	669971	642178	929	614211	235242	2184931
	<i>keywords used in tier2 phrase</i>	Inclusive smart city	130000	490	404	2000	492390	43	625327
		Participatory city making	912000	1801	1089	6000	590960	209	1512059
		Urban interaction design	195000	8275	6205	25000	527834	2202	764516
		Social media	918000	199045	220064	121000	262803	37839	1758751
		Digital storytelling	154000	3352	3473	2000	386425	198	549448
		Interaction design	158000	440879	394477	132000	525912	187556	1838824
		Digital nature	1260000	34356	29251	37000	437486	10590	1808683
		Human-technology interaction	18400	383	477	358	498372	266	518256
	<i>Health and Wellbeing</i>	<i>Tier 1</i>	Health AND wellbeing OR health* OR wellbeing AND well-being	626000	7800347	6256914	164000	94476	5653872
<i>keywords used in tier1 phrase</i>		health AND wellbeing	781000	42015	56175	10000	3098	85256	977544
		Health*	650000	7793169	6244808	163000	93719	6356200	21300896
		wellbeing AND well-being	534000	7186	35744	6000	3782	110027	696739
<i>Tier 2</i>		healthy environment OR community wellbeing OR community well-being OR community health OR public health OR social wellbeing OR social-well-being Or wellbeing and healing OR well-being and healing OR stress levels	18400	2030479	1901451	1000	566298	563576	3050725
<i>keywords used in tier2 phrase</i>		Healthy environment	1240000	66969	46891	28000	313103	60827	1755790
		Community wellbeing OR community well-being	1930000	35459	33016	38000	475457	662555	3174487
		Community health	715000	730091	503121	83000	188027	9208214	11427453
		Public health	642000	833690	840440	102000	183665	9040928	11642723
		Social wellbeing OR social well-being	701000	88281	90022	53000	495168	722084	2149555
		Wellbeing and healing OR well-being and healing	43300	1844	2574	695	454927	72053	575393
		Stress levels	63700	545670	617095	90000	407668	330973	2055106
<i>Green and Blue Spaces</i>	<i>Tier 1</i>	urban green space OR public green space OR blue space OR nature-based solutions	26300	35564	26289	4000	569282	6792	668227
	<i>keywords used in tier1 phrase</i>	Urban green space	1740000	11330	9744	8000	349011	1606	2119691
		Public green space	2260000	4994	3845	17000	396836	1652	2684327
		blue space	2290000	22018	14446	10000	342739	4190	2683393
		Nature-based solutions	25300	1694	1649	620	555834	349	585446
	<i>Tier 2</i>	public open space OR community gardens OR green gentrification OR environmental ecology OR sustainable development goals OR urban ecology	30400	236820	160225	2000	570315	141237	1140997
	<i>keywords used in tier2 phrase</i>	Public open space	1960000	8931	6934	51000	447145	1566	2475576
		Community gardens	17900	9008	6109	9000	152152	3594	197763
		Green gentrification	27100	268	185	359	57098	17	85027
		Environmental ecology	716000	177564	97384	11000	290001	131288	1423237
		Sustainable development goals	1830000	33310	40635	47000	505789	4585	2461319
		Urban ecology	1740000	22678	17815	5000	32183	9062	1826738

The process identified relevant articles through the following: (a) literature search in selected databases; (b) export of results into Microsoft Excel to store, remove duplicates and apply exclusion criteria; (c) results from *b* exported into Rayyan software (<http://rayyan.qcri.org>) for title and abstract screening; (d) review of conflicts from *c* by two team members; (e) full-text screening of articles identified as relevant through *c* and *d* by two team members; (f) review of conflicts from *e* by a third team member; (g) quality assessment applied by two team members independently; (h) review of conflicts from *g* by a third team member.

2.2. Eligibility criteria

Articles were considered eligible to be included in the review if they met the following criteria: (a) represented original research published in a peer-reviewed journal; (b) were published in the English language; (c) feature the use of digital placemaking (even if the term was not specifically mentioned but placemaking, location-based technology or digital technology of some sort was cited following our related keywords using in the search strategy); (d) disciplines related to the three main themes of research; (e) relevant book chapters and conference proceedings that are pertinent to our research question. This criterion was applied to all three themes datasets collected and results were compared among themes to remove all duplications. The dataset was updated between September and October 2022 to include the full-year range found during our data collection and analysis – initial landmark study from 2016 as a criterion was removed – and 2022 update during review process. The eligibility criteria process was applied to this data update. A final dataset of 117 records was selected for the systematic review (see [Table 2](#)).

2.3. Data extraction

The following data were extracted from eligible studies: report author, year and source of publication, case study (if available), method/study design, sample characteristics, type of intervention, measure of performance, theoretical approach, key findings and gap in literature for future research. Data extraction was completed using Microsoft Excel by one team member and checked by a second one (BK, MJ, TM). Disagreements were solved by a third team member.

2.4. Qualitative assessment

The quality of eligible studies was assessed using the Mixed Method Appraisal Tool (MMAT) ([Hong et al., 2018](#)). This qualitative assessment for risk of bias and quality of evidence of the studies permits an evaluation of the methodological quality of studies from five categories: qualitative research, randomized controlled trials, non-randomized studies, quantitative studies, and mixed-method studies. This tool was designed for the appraisal stage of systematic mixed studies reviews and allows us to appraise the quality of different methodological studies. The MMAT was applied independently by two team members to each paper and a third team member was included to solve disagreements. Quality assessment was conducted according to the MMAT guidelines for each paper, answering “yes”, “no” or “cant tell” to the methodological quality criteria. Each paper then received a score following a 5-point Likert scale, 5 being the maximum score. The majority of the results received 3 or 4 points (26%; $n = 30$ each), whereas 15% ($n = 18$) of results received the highest score (5 points) for high quality ([Appendix A](#)).

2.5. Data synthesis

Data from the studies were collated and summarised following the Thematic Analysis method ([Braun and Clarke, 2012, 2021](#)). This method allows us to identify and classify data insights into patterns of meaning across the dataset collected. A concept matrix which included the record information (title, author, year, source, and publisher), mention of digital placemaking, health & wellbeing, green & blue space, codes and

themes, research question, case study (if so, city and country), method of the study, sample characteristic, type of intervention, the measure of performance, theoretical approach, key findings, the gap in the literature found and MMAT score was developed. Codes and themes followed the thematic coding process: familiarisation with the data, generation of initial codes, search of themes, review of potential themes, defining and naming themes, and report production. Themes and codes along with the allocation of articles to themes were checked in roundtable discussions.

3. Findings

The thematic analysis of the dataset produced ten key themes as can be seen in [Table 3](#). This section will discuss each of the themes providing further detail on the extant knowledge base, a deeper understanding of the characteristics of digital placemaking and their relationship to mental health/wellbeing and green/blue spaces.

3.1. General observations

The majority of studies were case studies (72%; $n = 84$). Qualitative methods were predominant (90%; $n = 105$), with a split of 4% ($n = 4$) of quantitative and 6% ($n = 7$) of mixed methods for the rest of the records. There was no consistency in publication sources with articles from environment to culture, technology, sustainability, or tourism, proving this concept as a multidisciplinary process with no specific area of concentration. Very few studies investigated the combined effects of digital placemaking, mental health/wellbeing and green/blue space as shown in [Table 4](#).

3.2. Theoretical perspectives on digital placemaking

Despite being the most recurrent theme among all records (72%, $n = 84$), digital placemaking is found to be a complex term, with different terminologies and definitional discrepancies.

From our results, [Relph \(2007\)](#) compares virtual and real places alluding to virtual placemaking, but it would be [Latorre \(2011\)](#) who defined digital placemaking as the integration of social media in placemaking practices (see [Table 5](#)). However, [Basaraba's review \(2021\)](#) studied the multidisciplinary approach of the concept, which emerged as ‘digital placemaking’ in media studies in 2015. Digital placemaking is a complex concept that has been implemented in different fields without being tied to one specific piece of technology ([Chen et al., 2022](#); [Główczyński, 2022](#)). Yet, the first disagreement found in our results on the concept of digital placemaking is to understand if it is a type of placemaking itself or if it is a subcategory of creative placemaking.

Placemaking practices have been applied to a variety of disciplines evolving into different subgroups within the concept. However, the most cited classification is described by [Wyckoff \(2014\)](#) – standard placemaking as the universal term whose types are strategic, tactical, and creative placemaking. Some authors present digital placemaking as a subcategory of creative placemaking ([Basaraba, 2021](#); [Paquin, 2019](#); [Sanaeiipoor and Emami, 2020](#); [Stokes et al., 2018](#)), understanding it is the application of media to creative placemaking – defined by [Markusen and Gadwa \(2014\)](#) as the use of arts, creative and cultural thinking to improve the interest of a place. However, most authors identify digital placemaking as an independent category that could be defined as the implementation of technology in these practices that enables communities to interact with hybrid digital-physical places ([Foth, 2017b](#); [Fredericks et al., 2018](#); [Halegoua and Polson, 2021](#); [Labayen and Gutierrez, 2021](#); [Pavlovskaya, 2016](#); [Toland et al., 2020](#); [Wang, 2019](#)).

We have found terminology disagreements among different scholars, who do not mention digital placemaking itself but define ‘applications’ of placemaking that implement technology, understood as digital placemaking. Furthermore, some authors mention these terms in their work without defining them ([Alvarez et al., 2017](#); [Besek, 2021](#);

Table 2
Study selection chart.

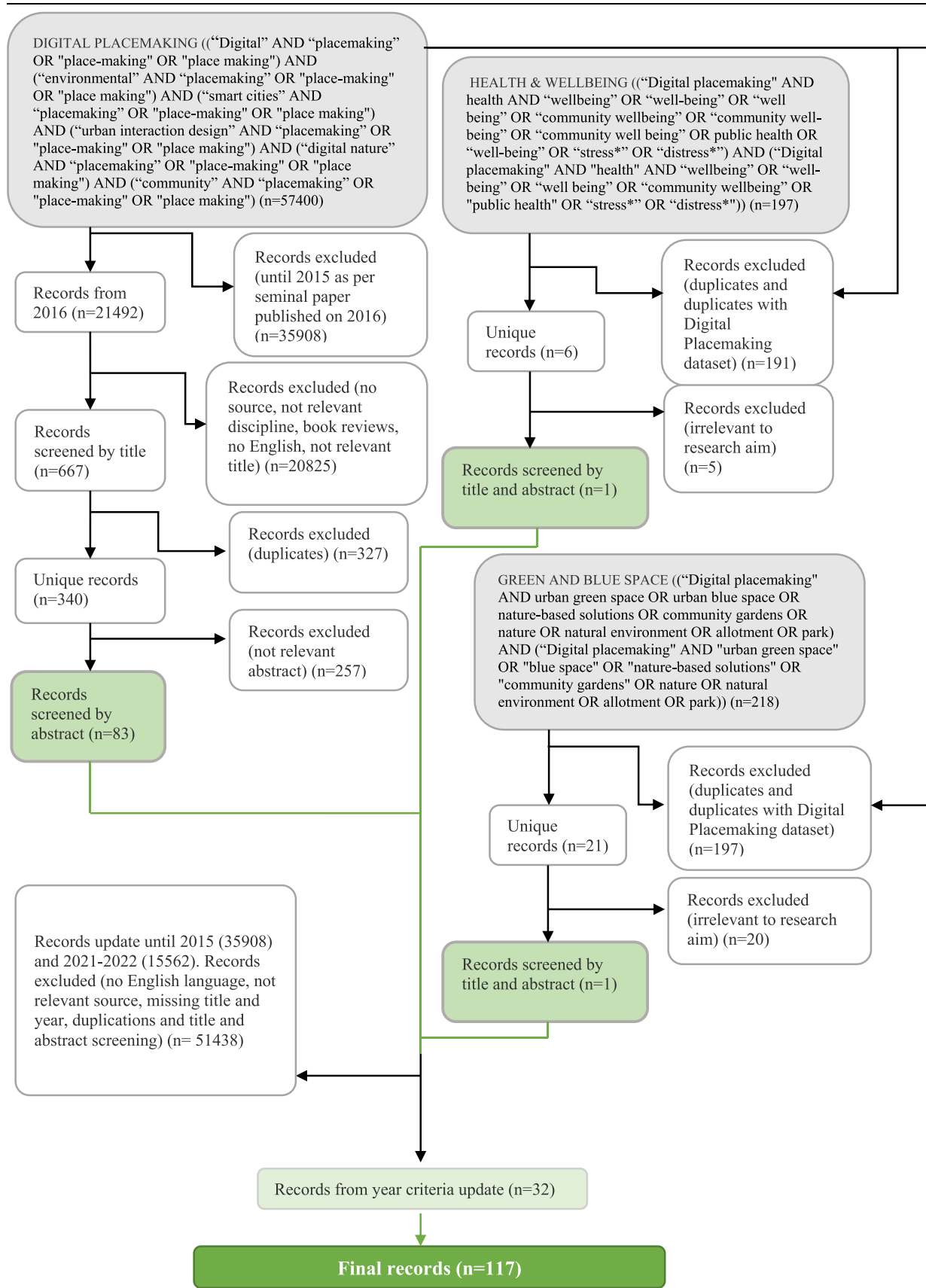


Table 3
Themes and codes from Thematic Analysis.

Theme	Times in dataset (TID)	%	Codes	TID			
placemaking	84	71,79	digital placemaking	37			
			placemaking	28			
			creative placemaking	4			
			virtual placemaking	3			
			healthy placemaking	2			
			smart placemaking	2			
			smart placemaking	2			
			green placemaking	2			
			Radical placemaking	1			
			ethical placemaking	1			
			hybrid placemaking	1			
			mobile placemaking	1			
			community engagement	54	46,15	community engagement	49
						community engagement	3
participation	2						
citizen engagement	2						
hybrid reality	39	33,33	hybrid space	12			
			augmented reality	9			
			location-based mobile	6			
			virtual reality	5			
			geo-location	2			
			immersive digital experience	2			
			expanded reality experience	1			
			digitalisation	1			
			GIS	1			
			sense of place	38	32,48	sense of place	24
identity	8						
place attachment	5						
inclusion	12	10,26	place branding	1			
			inclusion	9			
			accessibility	2			
social media	18	15,38	social justice	1			
			social media	14			
			mobile media	2			
smart city	17	14,53	digital media	2			
			smart city	11			
			smart cities tech	6			
co-creation	13	11,11	co-creation	11			
			co-governance	2			
wellbeing	17	14,53	wellbeing	4			
			social wellbeing	3			
			health indicators	2			
			mental health	2			
			place wellbeing	2			
			community wellbeing	1			
			wellness of city residents	1			
			stress	1			
			healthy living	1			
			nature in cities	14	11,97	nature in cities	4
contrast tech-nature	2						
nature-based solutions	3						
Green planning	1						
Urban Agriculture	1						
therapeutic green space	1						
Green infrastructure	1						
Blue space	1						

Bicquelet-Lock, 2021; Breek et al., 2018, 2021; Busse, 2021; Chaudhry et al., 2019; Cilliers et al., 2015; Clowater, 2021; Edwards et al., 2020; Globa et al., 2019; Gobbo and Benedetti, 2021; Harner et al., 2017; Houghton et al., 2015; Hunter et al., 2022; Macintyre et al., 2019; Marshall, 2021; McArthur and Xu, 2021; Ozduzen et al., 2021; Rzeszewski and Naji, 2022; Soedarsono et al., 2021; Truong et al., 2022; Wright, 2021; Zhang and Gong, 2021). The absence of an explicit clarification of these concepts presented from the results of the analysis, as well as the different terms employed, emphasizes the confusion and lack of consensus on digital placemaking. Table 5 presents a variety of

Table 4
Studies by area of interest mentioned.

Areas of interest mentioned	n° articles
Digital placemaking	96
Health & Wellbeing	29
Green & Blue Space	25
No Digital Placemaking	21
No Health & Wellbeing	88
No Green & Blue Space	92
Placemaking, health & wellbeing, green & blue space	8
Digital placemaking, health & wellbeing, green & blue space	4

approaches and views on the concepts, collating the different definitions for placemaking, and its variations as described by the authors in the dataset. There are two sections, placemaking definitions, and digital placemaking definitions along with its concept variations found in the dataset.

Besides the term digital placemaking, our analysis of findings has produced two additional groups. One group links hybrid realities to placemaking such as virtual placemaking (Devine, 2017; Qabshoqa, 2018; Relph, 2007), radical placemaking (Gonsalves et al., 2021), hybrid placemaking (Bilandzic and Johnson, 2013), and smart placemaking (Najafi et al., 2021; Sepe, 2015), focusing on the creation of hybrid realities that could create a sense of immersion. The second group investigates social media use through mobile media in placemaking (Breek et al., 2018; Latorre, 2011; Polson, 2015; Waite, 2020).

Regarding theoretical contributions, Foth, (2017a,b) applied Lefebvre's theory of "the right to the city" (Lefebvre, 1996) to placemaking in the digital era as a way to bring social change and renew the urban environment, which proves the potential benefit of digital placemaking for social and behavioural change to create inclusive environments. Gulsrud et al. (2018) employ Tuan's theory, (1977) and Williams' theory, (2014) on emotional attachment to a place, placemaking potential to create diverse identity spaces to understand the use of technology to create climate resilience. Toland et al. (2020) re-evaluated the term *digital placemaking*, analysing the evolution of its definition to propose the term DigitalXPlace. Furthermore, scholars called for further research to understand sustainable ways of digital placemaking (Foth, 2017b) and detailed digital placemaking strategies that incorporate the community view and outcomes (Keegan, 2021).

3.2.1. Key characteristics

From our findings, digital placemaking is described as having a set of key characteristics and other additional characteristics (see Table 6).

The systematic review identified hybrid realities as a theme within the concept of digital placemaking, as the implementation of technology in urban environments allows citizens to experience physical-digital realities (Kostopoulou and Fatah gen Schieck, 2021; Wang, 2019). Location-based technology is found as an essential element of hybrid realities, which is also understood as a key characteristic of digital placemaking (Clarke, 2021; Keegan, 2021; Macintyre et al. 2019; Pang et al., 2020; Witteborn, 2021). Results of the review showed that hybrid realities include location-based technology and games (Bilandzic and Johnson, 2013; Frith and Richter, 2021; Gobbo and Benedetti, 2021; Harner et al., 2017; Hjorth and Richardson, 2017; Pang et al., 2020; Pavlovskaya, 2016; Qabshoqa, 2018), augmented realities (Abdel-Aziz et al., 2016; Boffi, 2021; Clowater, 2021; Her, 2021; Hjorth and Richardson, 2017; Hunter et al., 2022; Sanaeipoor and Emami, 2020), immersive digital experiences (Globa et al., 2019), virtual reality (Kuchelmeister et al., 2020; Rzeszewski and Naji, 2022; van Houwelingen-Snippe et al., 2021), and digital pop-up artefacts (Fredricks et al., 2018). All of them help create realities that combine the physical and digital world with different intensities – virtual reality refers to a fully immersive experience in the digital environment, in contrast to digital pop-up artefacts that combine analogue and digital media for community engagement.

Table 5
Definitions of digital placemaking within the data set.

PLACEMAKING DEFINITIONS					
Authors	Own Definition?	Cited Author	Definition		
Abdel-Aziz et al. (2016).	No	Project for Public Spaces, (2015)	Place-making is the act of creating great places by making a public space a living place		
Biedermann and vande Moere, (2021)	No	Sweeney et al. (2018)	Placemaking describes the philosophy and the practical process of reshaping a neighbourhood, city or region with the aim to establish a sense of place within a community (Sweeney et al. 2018).		
Boros and Mahmoud, (2021)	No	Wyckoff, (2014)	Placemaking is an inherently people-centered approach to the planning, designing and management of public spaces in cities, as it emphasizes the relationships between individuals, communities, and urban spaces (Wyckoff, 2014)		
Brunnberg and Frigo, (2012)	No	Kent and Madden, (2003)	Visionaries within urban planning and design such as Jane Jacobs and William Whyte dedicated significant effort advocating the importance of lively and attractive public spaces in cities (Jacobs 1961, Whyte 1980). Their work is foundational for the concept of placemaking (Fred and Madden 2003). In urban planning, the practise of placemaking is an inclusive and community-driven approach for the design of human spaces, and it focuses on the entire process of creatin meaningful public places in urban environments.		
Cilliers et al. (2015).	No	Project for Public Spaces, (2015)	Place-making is the process by which people transform the locations they inhabit into the places where they live (PPS (Project for Public Spaces)PPS, 2004). Place-making is a broad concept that includes various dimensions of development. It is mainly focused on public spaces, which are an extension of the community. When cities and neighbourhoods have thriving civic spaces, residents have a strong sense of community, therefore place-making aims to create places to socialize and interact.		
Courage, (2021).	Yes		Placemaking is an approach and a set of tools that puts the community front and centre of deciding how their place looks and how it functions. There is a community imperative in placemaking.		
Freeman et al. (2019).	No	(Pierce et al., 2011)	A common understanding of placemaking is "the set of social, political and material processes by which people iteratively create and recreate the experiences geographies in which they live.		
Grace et al. (2020)	Yes		This space reflects where living, learning, working and recreating functions collectively meet to form more integrated smarter natural solutions centred around creating new places and also improving existing places.		
Her, (2021)	Yes		Placemaking is one approach to revitalizing underused areas, whether rural, deprived, unused, or abandoned.		
Houghton et al. (2015).	No	Friedmann, (2010)	A collaborative, people-centered, planning process as suggested in Friedmann's, (2010) discussion of placemaking.		
Keegan and Schifanella, (2022)	No	Mateo-Babiano and Lee, (2020)	Placemaking concerns the continuous acts and functions of making places better. Moreover, scholars envisage an extension beyond physical locations and posit that places include socio-economic, ecological and political dimensions (Mateo-Babiano and Lee, 2020).		
Kolotouchkina et al. (2021)	No	Lepofsky and Fraser, (2003)	Placemaking is an extension of the notion of citizenship, a mechanism allowing people to make claims on place, and to participate in the production of its meaning (Lepofsky and Fraser, 2003)		
Latorre, (2011).	Yes		Placemaking is a sacred multi-faceted approach that capitalizes on a local community's assets, inspiration, and potential.		
Peacock et al. (2021).	Yes		We collectively define placemaking as a practice of reimagining public spaces with the input of citizens.		
Sepe, (2015)	No	Cabe, (2000)	Placemaking can be defined – paraphrasing the definition of urban design reported by Cabe – as 'the art of making places for people. It includes the way places work and matters such as community safety, as well as how they look. It concerns the connections between people and places, movement and urban form, nature and the built fabric'.		
Strydom et al. (2018)	No	Beza, (2016); Boeri, (2017)	Placemaking may be described as a collective effort by individuals living within a specific setting (Boeri, 2017, p. 2). A collective effort refers to the action of individuals/groups to re-imagine their surrounding environments (Beza, 2016, p. 245).		
Tomitsch et al. (2015).	Yes		If deployed in modalities cognisant of local socio-cultural contexts and in ways that seek to be inclusive of the input of citizens, we may begin to see smartness reflected in rising levels of social wellbeing and connectedness. These are ultimately the crucial human components in placemaking. Such a holistic and responsive approach to embedding urban screens and media architecture is redolent of what we might describe as a more ecological framework for placemaking.		
Toomey et al. (2021)	No	Williams, (2014); Cresswell, (2014); Toomey et al. (2020)	Place-making has been described as a type of "performance" of recreational, civic engagement, or livelihood-based activities enacted in a given place and can also be understood in relation with broader social, economic and political contexts beyond the localised scale (Cresswell, 2014; Williams, 2014; Toomey et al., 2020).		
Wyckoff, (2014).	Yes		For the time being, the simplest definition will suffice: "Placemaking is the process of creating quality places that people want to live, work, play and learn in." Later I will define "Strategic Placemaking," "Creative Placemaking," and "Tactical Placemaking" and explain how each differs from the standard "placemaking."		
DIGITAL PLACEMAKING DEFINITIONS					
Authors	Own Definition?	Cited Author	Type of placemaking	Definition	Independent vs Subcategory of Creative placemaking
Keegan, (2021)	No	Calvium, (2018)	Digital placemaking	Calvium has published numerous articles on the topic of digital placemaking and considers it to be 'the augmentation of physical places with location-specific digital services, products or experiences to create more attractive destinations for all' (Calvium, 2018).	N/A
Bangratz and Förster, (2021)	No	Foth, (2017b)	Digital placemaking	"Digital placemaking" as an "extension of urban guerrilla placemaking". Despite all justified scepticism, there is the hope that "desirable urban futures for the common good can be created if only the artful integration of people, place and technology is achieved" (Foth, 2017: 1).	N/a
Basaraba, (2021).	No	Richards and Duif, (2018)	Digital placemaking	Applications of 'digital place-making' that involve the combination of resources (tangible and intangible),	Subtype CPM

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Table 5 (continued)

Bilandzic and Johnson, (2013).	Yes		Hybrid Placemaking	meanings (emotions) and creativity to capture public attention through narratives (Richards and Duif, 2018). We introduce the term hybrid placemaking to refer to an evolving future research area that combines the opportunities of social, spatial and digital means to facilitate social interaction, and regards those means as equally important, complementary factors for the design of interaction affordances in a space.	N/A
Boffi, (2021).	No	Tomitsch, (2016)	Digital placemaking	Tomitsch recently introduced the definition of “digital place-making” [Tomitsch, 2016] to highlight that acts of place-making can also be deployed through digital touchpoints or a mix of digital and physical ones.	N/A
Bronsvort and Uitermark, (2022)	Yes		Digital placemaking	Representations of places on digital platforms are important in themselves as they shape the experience of place and define who belongs.	N/a
Calderon and Takeshita, (2021)	Yes		Creative placemaking	Creative placemaking is, at its core, about unleashing the unlimited power of arts and culture to advance community wellbeing.	N/a
Chen et al. (2022)	No	Basaraba, (2021); Foth, (2017a); Caldwell and Fredericks, (2017)	Digital Placemaking	Digital placemaking is a complex and multifaceted landscape (Caldwell and Fredericks 2017). It provides an outlet for creativity and for communities to appropriate and cus-tomize the urban environment. It has also been appropriated by government and designers to activate, rejuvenate, and engage people in public spaces (Foth 2017). Digital placemaking is constantly evolving and iterating in media studies since it is grounded on the continuous bursting and innovation of digital technology, from social media to immersive environments like virtual reality (Basaraba, 2021).	N/A
Chew et al. (2020)	No	Foth, (2017); Fredericks et al. (2015); Hespanhol, (2018)	Digital placemaking	Therefore, digital placemaking looks at configuring and re-configuring the built environment with digital technology to support the meaningful interpretation of public space by individuals and for communities. (Foth et al., 2017; Fredericks et al., 2015; Hespanhol, 2018). With interactive urban play, we are then seeing to enrich the identity of places, with playfulness and playability as the means to advance the goals of digital placemaking.	N/A
Cilliers et al. (2015)	Yes		Green Placemaking	When linking green-planning interventions with place-making approaches, the natural environment is enhanced, and further contributes to sustainable development objectives. Place-making (focusing on social functions) and green planning (focusing on environmental functions) have a vice versa benefit, as illustrated in the case studies.	N/A
Clarke, (2021).	No	Morrison, (2021)	Digital placemaking	Digital placemaking concerns the interplay between physical and digital worlds in public space. It considers places as hybrid physical–digital and addresses the ways in which offline and online spaces, the public realm and the private infosphere have become entangled. For Dr Jo Morrison, Director of Innovation and Research at mobile app developer Calvium, and consultant on the Pathfinder, digital placemaking is about ‘using location-specific digital technology to foster deeper relationships between people and the places they inhabit’. It involves the ‘augmentation of physical places with’ digital layers, ‘services, products or [interactive] experiences’, and has the potential to ‘enhance or even radically transform an individual’s experience of their time’ in a location.	N/A
Devine, (2017).	Yes		Virtual placemaking	Virtual worlds are undoubtedly real places in their own right to the people who spend time in them, and virtual game worlds provide important practical examples of virtual place-making for heritage visualisers	N/A
Eckenwiler, (2021).	Yes		Ethical placemaking	Interpreted ethical placemaking – grounded in an ecological conception of persons – as a core component of an enabling, capabilities-oriented, conception of justice.	N/A
el Khafif et al. (2021)	No	Markusen and Gadwa, (2010)	Creative placemaking	The following is the most cited definition of creative placemaking: “In creative placemaking, partners from public, private, non-profit, and community sectors strategically shape the physical and social character of a neighborhood, town, city, or region around arts and cultural activities. Creative placemaking animates public and private spaces, rejuvenates structures and streetscapes, improves local business viability and public safety, and brings diverse people together to celebrate, inspire, and be inspired” (Markusen and Gadwa, 2010, p. 3).	N/A
Foth, (2017a)	Yes		Digital placemaking	The most genuine form of digital placemaking does not limit people to just providing feedback to city governments as part of conventional community consultation processes,	Independent

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Table 5 (continued)

Fredericks et al. (2018).	No	Tomitsch, (2016)	Digital placemaking	it regards them as co-creators in a collaborative form of city making (.) Digital placemaking can play a role in facilitating a dialogue across citizens, communities, government, businesses, civic groups and non-profits. The use of digital technologies and media for shaping urban experiences that are citizen-centric, both in their conception and implementation, is also referred to as 'digital place-making' (Tomitsch, 2016)."	Independent
Frith and Richter, (2021)	No	Halegoua, (2020)	Digital placemaking	Digital placemaking – defined 'as the use of digital media in cultivating a sense of place for oneself and others' (Halegoua, 2020: 16)	N/a
Glówczyński, (2022)	Yes		Digital Placemaking	Therefore, digital placemaking mechanisms are considered here as human- and data-driven processes mediated through spatial media and resulting in reshaping places under the conditions of digital platform ecosystems. It is both a positive process in terms of shaping digitally mediated sense of place, performing self-identity and a negative emphasizing of inequalities, relations of power, place control and struggle, especially with regard to data availability and visibility	N/A
Gonsalves et al. (2021).	Yes		Radical placemaking	Radical Placemaking sits at the confluence of people, place and technology to explore how marginalised communities can create hybrid digital-physical urban experiences.	N/A
Gulsrud et al. (2018).	No	Eggermont et al. (2015) Buizer et al. (2016) Kabisch et al. (2016)	Green placemaking	A green placemaking approach to UGI governance and climate resilience can be seen as integrating socio-cultural and scientific knowledge to successfully promote and achieve higher levels of urban biodiversity (Eggermont, 2015; Buizer et al., 2016; Kabisch et al., 2016).	N/A
Halegoua and Polson, (2021)	Yes		Digital placemaking	We propose that at its core 'digital placemaking' describes the use of digital media to create a sense of place for oneself and/or others – to embrace digital media affordances in order to cultivate or maintain a sense of attachment to place.	N/a
Hardley and Richardson, (2021)	Yes		Digital placemaking	Placemaking as a hybrid experience that coalesces digital and material worlds, perceptions, and negotiations of the public-private relation in domestic contexts and the corporeal intimacy of mobile phone use.	N/a
Karge, (2018).	No	Toolis, (2017)	Critical placemaking	Placemaking targets community building, life quality, empowerment and civic engagement. As an empowerment tool, placemaking can contribute to reclaiming the public space affected by privatization and is thus called critical placemaking by Toolis (2017).	N/A
Labayen and Gutierrez, (2021)	Yes		Digital placemaking	The term 'digital placemaking' mostly describes the use of multimedia platforms and digital apps that link urbanites' activities to a sense of belonging and the potential to intervene in urban development.	N/a
Latorre, (2011).	Yes		Digital Placemaking	We refer to this as Digital Placemaking. It's the integration of social media into Placemaking practices, which are community-centered, encouraging public participation, collaboration, and transparency.	N/A
Li and Alencar, (2022)	No	Halegoua and Polson, (2021)	Digital Placemaking	Digital place-making can be defined as the use of digital technology to build a sense of belonging and attachment to certain places for oneself and/or others (Halegoua and Polson, 2021, 573).	N/A
Markusen and Gadwa, (2014).	Yes		Creative Placemaking	In creative placemaking, partners from public, private, non-profit, and community sectors strategically shape the physical and social character of a neighbourhood, town, tribe, city, or region around arts and cultural activities. Creative placemaking animates public and private spaces, rejuvenates structures and streetscapes, improves local businesses viability and public safety, and brings diverse people together to celebrate, inspire, and be inspired.	N/A
Najafi et al. (2021).	No	Pavlovskaya, (2016)	Smart placemaking	Smart placemaking, defined as the augmentations of physical place with smart technologies, offers a range of powerful opportunities to add value to public spaces, in ways which can translate into health promotion in society and improved living environments for all [Pavlovskaya, 2016].	N/A
Ng, 2016	Yes		Healthy placemaking	Healthy place-making treats cities as an integral part of the natural landscape. Human settlements should "grow" naturally out of the ecosystem, providing their residents with plenty of opportunities to contact nature through a network of blue-green (water and open space) infrastructure.	N/A
Norum and Polson, (2021).	Yes		Digital placemaking	Interweaving of meaning-making in relation to place, occurring through social relations, communication, embodiment, and personal and shared experience enacted	N/a

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Table 5 (continued)

Pang et al. (2020)	No	Sun, (2015) Foth, (2017b) Sun et al. (2017) Peacock et al. (2018)	Digital placemaking	via a digitally mediated platform, that we explore here as digital placemaking. Digital placemaking augments physical places with location-specific services to create informal, playful, and meaningful opportunities for participation (Sun, 2015; Foth, 2017; Sun, Mclachlan, and Naaman, 2017; Peacock, Anderson, and Crivellaro, 2018).	N/A
Pang et al. (2020)	No		Digital placemaking	Our design of City Explorer focused on digital placemaking by augmenting physical places with location-specific services to create informal, playful, and meaningful opportunities for participation.	N/A
Paquin, (2019).	No	Tomitsch, (2016)	Digital placemaking	Digital placemaking involves a redefinition of the notion of space, from the physical to an augmented one: it is a “process of using digital media or shaping experiences that are citizen-centric, in modes of “augmenting” and positively reinforcing urban place.”(Tomitsch, 2016: 340).	Subtype CPM
Pavlovskaya, (2016).	Yes		Digital placemaking	Digital place making involves the production of place through its representations on the internet. In the age of information technologies, images of a place circulated on the internet acquire a particular importance.	Independent
Polson, (2015).	Yes		Digital Placemaking	Digital place-making, in that it allows for communication and behaviour expectations to be set up and connections to be made in advance, in the semi-private spaces where participants meet online, seems to open up opportunities for women to more comfortably and equitably access the corresponding offline spaces.	N/A
Polson, (2015).	Yes		Mobile Placemaking	If our experience of places are constituted more through relationships and communicative interactions than by geographic location, then online interfaces that both produce and manage offline interactions can be understood as platforms for mobile place-making.	N/A
Qabshoqa, (2018).	Yes		Virtual placemaking	A place can be constructed virtually. This place is not limited to a physical presence but can be formed and realised using digital technologies. Also, It triggers human insights and allows activities whether it is virtual or physical. The construction of this place is Virtual Placemaking. The virtual placemaking can be achieved in the urban environment through Gamification.	N/A
Qi et al. (2021)	No	Peacock and MacKenzie, (2016)	Digital placemaking	Digital placemaking refers to the use of extensive applications of digital and mobile technologies to reorganise urban spaces, and transform people's life experiences and modes of interactions within and across places (Peacock and Mackenzie, 2016).	N/A
Relph, (2007).	Yes		Virtual Placemaking	I have suggested that the real post-modern world poses serious difficulties for authentic place-making and perhaps the best that can be done is to develop physical settings that aim to encourage the emergence of different types of activities and meanings as the setting is lived and worked in. Something similar should apply to virtual place-making – establish a foundation or framework that can then be adapted and modified through participation to create a strong spirit of virtual place.	N/A
Sanaeiipoor and Emami, (2020)	No	Halegoua, (2020)	Digital placemaking	Digital placemaking, as the intersectionality of placemaking practices with social media (Halegoua, 2020), is used to install digital technologies in the urban realm to enhance culture. Digital placemaking facilitates a range of public-related goals such as urban regeneration programs, sharing technology-based knowledge and running cultural events.	Subtype CPM
Sanaeiipoor and Emami, (2020).	Yes		Digital placemaking	Digital placemaking by installing or utilizing digital technologies in the public space can enhance public awareness about their place (especially in environmental or social issues), facilitate urban regeneration programs, promote societal role of art in urban realm, and broad knowledge of civic participation in digital era.	Subtype CPM
Sepe, (2015)	Yes		Smart Placemaking	The use of technological tools serves the purpose of increasing the potential for innovation and regional competitiveness of Pompeii for both locals and visitors, and of avoiding simplification of information or marketing. I have illustrated the smart approach to placemaking, and the new DIV@TER multimedia platform currently being developed.	N/A
Sharma and Jaggi, (2022)	Yes		Digital Placemaking	Digital placemaking as a construct in this study. This definition is a deductive synthesis of our reading of the literature of digital placemaking cited in this article and aligning that reading with the theoretical perspectives of participatory communication. (...) The concept of digital	N/A

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Table 5 (continued)

				placemaking can be understood as a process on digital communities involving an organic interaction among the digital placemakers as they participate towards a common cause of sustaining the local culture of geographic spaces while engaging through the key strategies towards the process	
Stokes et al. (2018)	No	Markusen and Gadwa, (2010)	Creative placemaking	Placemaking movement has expanded beyond branding and architecture to include creative activities that deepen our sense of place and attachment to it.	Subtype CPM
Stokes et al. (2021)	No	Halegoua and Polson, (2021); Halegoua, (2020); Tomitsch et al. (2015)	Digital Placemaking	Digital place-making can feel temporary, yet the goal is to create ‘a sense of permanence, pause, or investment infixity within the forces and scapes that shape spatiality’ (Halegoua, 2020: 5), and, as the editors explainin the introduction to this special issue, it involves digital practicesto create ‘emotional connections toplace’ (Halegoua and Polson, 2021). Forms of digital placemaking include large screens embedded inpublic space (Tomitsch et al., 2015), scavenger hunts with cellphones, and place-based storytelling	N/A
Sugangga et al. (2021).	Yes		Digital placemaking	The term of placemaking related to ICT is popularized as digital placemaking.	N/A
Toland et al. (2020).	No	Aurigi and De Cindio, (2008) Latorre, (2011); Fredericks et al. (2016)	Digital placemaking	The term is being used to describe ways in which digital technologies might be used to extend traditional placemaking strategies, such as expanding community engagement or enhancing collaboration and communication amongst stakeholders (Aurigi and De Cindio, 2008; Fredericks et al., 2016; Latorre, 2011), as well as crowdsourcing information and mobilising participation.	Independent
Vallicelli, (2018).	Yes		Digital placemaking	Digital placemaking shifts the design target from mere buildings to places, making digital work an urban practice that extends beyond the office or coworking environment.	N/A
Waite, (2020).	No	Frith, (2015); Licoppe, (2013)	Mobile media in placemaking	In the context of place, and place-making, however, a relevant genre of technologies are “locative media” (Frith, 2015). The term refers to mobile media that are networked, and which allow users to know the location of themselves and others in “mutual proximity” (Licoppe, 2013, p. 123).	N/A
Waite, (2021)	No	Waite, (2020)	Digital Placemaking	Digital place-making distils these ideas to extend the mutual construc-tion of place advocated by Seamon and Massey to the digitally mediated, but ultimately territorially embedded, interactions that are routinely enacted online (see Waite, 2020).	N/A
Wang, (2019).	Yes		Digital placemaking	Digital technology is closely integrated into the process of how people and space interact and how people are socialized in the hybrid physical–digital environment.	Independent
Wang, (2022)	Yes		Digital Placemaking	Through systemically mediating ordinary people’s placemaking actions across the temporal and spatial scales, digi-tally enforced placemaking as a medium and approach creates new forms of relations that gradually change the means we interact with the world.	N/A
Wilken and Humphreys, (2021).	No	Halegoua, (2020)	Digital placemaking	Halegoua, (2020) suggests that our persistent mobile use in fact leads to renewed forms of ‘digital placemaking’ – ‘the use of digital media in cultivating a sense of place for oneself and for others’ (p. 16). Halegoua refers to digital placemaking in urban contexts as forms of ‘re-placemaking the city’.	N/a
Witteborn, (2021).	Yes		Digital placemaking	Digital placemaking practices are repeated acts across time and space, mediated through technological devices, networks, and numerical entities that create and augment a digital, physical, social, and symbolic location for individuals and groups of people.	N/A

de Souza E Silva, 2006 on hybrid spaces was frequently cited to describe the digital overlay across the actual environment (Frith and Richter, 2021; Hjorth and Richardson, 2017; Wang, 2019, 2022). Qabshoqa (2018) and Kostopoulou and Fatah gen Schieck (2021) applied the idea of overlaying realities through urban gamification and local augmentation of memories respectively, with the potential to positively redefine public spaces (Abdel-Aziz et al., 2016). These technologies do not aim to replace reality (Her, 2021), but to enhance its experiences and renew the excitement for physical space engagement and connections (Clowater, 2021; Kostopoulou and Fatah gen Schieck, 2021; Wang, 2019). The proliferation of technology in our daily life has shaped how we come to know the physical world (Clowater, 2021; Frith and Richter,

2021). Potential risks and negative effects of hybrid realities are the possible cause of displacement (Kostopoulou and Fatah gen Schieck, 2021), private data collection (Hjorth and Richardson, 2017), or increasing disparities within communities (Birnbaum et al., 2021).

The second key theme found is sense of place, in that individuals spend time living and emotionally interacting with space beyond being physically in it (Abdel-Aziz et al., 2016; Birnbaum et al., 2021; Freeman et al., 2019). Scholars understand it as one of the objectives of place-making (Chen et al., 2022; Fredericks et al., 2018; Rutha and Abbas, 2021), and it is usually presented as linked to place attachment (Birnbaum et al., 2021; Freeman et al., 2019; Kale, 2019; Polson, 2015; Rutha and Abbas, 2021; Toomey et al., 2021) and identity (Agyekum and

Table 6
Key themes in digital placemaking.

Area	Theme	Identified as	N° times data
DIGITAL PLACEMAKING	Placemaking	KEY CHARACTERISTIC	84
	Community		54
	Engagement	ADDITIONAL CHARACTERISTICS	39
	Hybrid Reality		38
	Sense of Place		12
	Inclusion	17	
	Smart City	13	
	Co-Creation	18	
	Social Media		

Newbold, 2019; Breek et al., 2018; Harner et al., 2017; Relph, 2007; Soedarsono et al., 2021). Most authors referred to Tuan's theory (Basaraba, 2021; Devine, 2017; Gulsrud et al., 2018; Harner et al., 2017; Rutha and Abbas, 2021; Rzeszewski and Naji, 2022; Toomey et al., 2021), which studies the human emotions and relationships to a specific place (Tuan, 1977), also presented as one of the foundations of placemaking (Clark and Lupton, 2021; Devine, 2017). Sense of place layers the physical space with meaning and cultural symbols (Foth et al., 2021), bringing a variety of benefits to communities, such as enabling community building (Breek et al., 2018), creating sense of ownership and entitlement (Kale, 2019), and development of community and individual identity (Chen et al., 2022; el Khafif et al., 2021; Harner et al., 2017; Kale, 2019). Scholars have reflected on the creation of sense of place in digital environments, fostering emotional online connections to create meaningful locations (Clowater, 2021; Halegoua and Polson, 2021; Harner et al., 2017; Johnstone et al., 2016; Norum and Polson, 2021; Relph, 2007; Sanaeipoor and Emami, 2020; Witteborn, 2021). There is evidence of the potential benefit of sense of place through digital placemaking in communities, especially when looking into how digital networked technologies could foster a sense of connectedness (Johnstone et al., 2016).

A third key theme was community engagement. Defined as a process of involving people to collaborate in decisions and outcomes to benefit their communities (Clarke, 2021; Foth, 2017b; Fredericks et al., 2018; Freeman et al., 2019), it is also described to empower communities (Fisher et al., 2018) and improve social cohesion among members (Najafi et al., 2021). It includes community participation (Alvarez et al., 2017; Courage, 2021; Harner et al., 2017; Toland et al., 2020; Witteborn, 2021; Zhang and Gong, 2021), and citizen engagement (Basaraba, 2021; Paraschivoiu and Layer-Wagner, 2021). It is also defended by Sanaeipoor and Emami (2020) as "necessary for placemaking strategies to succeed" (p. 91). Our findings showed studies that reflected how community engagement could benefit from technology (Abdel-Aziz et al., 2016; Bilandzic and Johnson, 2013; Breek et al., 2018; Clarke, 2021; Fisher et al., 2018; Harner et al., 2017; Paraschivoiu and Layer-Wagner, 2021; Sanaeipoor and Emami, 2020; Toland et al., 2020; Tomitsch et al., 2015), exploring the potential positive effect in easing the ability to connect communities and enhance engagement through bottom-up initiatives. Sanaeipoor and Emami (2020) explored community engagement framed within smart city theory where participation is key, while Paraschivoiu and Layer-Wagner (2021) applied citizen engagement theory with behaviour change through gamification to address climate change. However, we have found a lack of specifications regarding how to engage with communities successfully within the dataset, particularly when involving placemaking and active living projects for communities (Pang et al., 2020).

The final key theme identified through our thematic analysis is inclusion. Digital placemaking brings inclusivity to individuals with movement restrictions (Clarke, 2021; Karge, 2018; Szaszák and Kecskés, 2020), marginalized communities whose narratives have been ignored (Foth, 2017b; Gonsalves et al., 2021; Stokes et al., 2021), and facilitates general information accessibility (Her, 2021; Sugangga et al., 2021). It

allows citizens to connect with the same level of opportunities as the rest of the community. Therefore, inclusion is crucial for placemaking (Foth, 2017b) and the implementation of technology could open new barrier-free opportunities for communities (Clarke, 2021). Szaszák and Kecskés (2020) studied the implications of technology to create disability-inclusive placemaking in Hungary, showcasing a lack of digital replacement in less basic levels of the spatial Maslow pyramid. Even though inclusion is mentioned as an essential aspect of placemaking, studies tend to overlook it. This could be a consequence of targeting specific groups or economic activities which leads to a loss of diversity (Chen et al., 2022). There is a lack of exploration and tests of solutions and innovations to make nature accessible for those with limited access using other types of technologies rather than GPS or GIS as well as an exploration of the effects of different types of digital nature in older adults' wellbeing (van Houwelingen-Snippe et al., 2021).

3.2.2. Additional characteristics

From our results, we have found themes that were approached and described in the dataset understood as additional characteristics since they are not presented as essential to digital placemaking but enhance and benefit their application. These themes add potential value to digital placemaking practices.

Smart cities are found in our results as a theme linked to hybrid realities but expanded to cyberinfrastructures in cities (Freeman et al., 2019). Smart cities' final goal is to employ technology to benefit citizens' life (Wang, 2019), usually including ICTs in the urban environment (Chaudhry et al., 2019; Grace et al., 2020; Sanaeipoor and Emami, 2020; Szaszák and Kecskés, 2020), and Internet of Things (IoT) (Freeman et al., 2019; Peacock et al., 2021; Sanaeipoor and Emami, 2020). This theme could collect data from citizens through technology (Peacock et al., 2021; Sanaeipoor and Emami, 2020; Vallicelli, 2018). Grace et al. (2020) combine the smart city paradigm with the biophilic city paradigm to create the smart-natural interface, constructed by five spaces: connectivity, vision, placemaking, monitoring and smart citizen-led. We have found smart cities are not a requirement for digital placemaking, but they would facilitate its development.

Co-creation as a theme is found to be highly linked with governance practice for consultation and planning decisions, which uses community participation as a tool. Some authors refer to it as co-governance (Gulsrud et al., 2018), collaboration in city-making processes (Bicquelet-Lock, 2021; Fredericks et al., 2018; Toomey et al., 2021), or co-design (Sanaeipoor and Emami, 2020), as it describes bottom-up initiatives. This theme is linked to smart cities, as digital technologies embedded in the urban area are presented to include citizens' opinions and inputs in the decision-making. Therefore, technology is implemented as a tool to engage citizens in co-producing with organisations and institutions different solutions for their urban environment. Grace et al. (2020) described smart city governance to include co-creation processes and Bicquelet-Lock (2021) recognised collaboration and co-production with communities as a key step in healthy placemaking.

Social media is identified as an independent theme since it was the primary tool researched in digital placemaking to understand the community's sentiment toward a place. Described as an instrument to enable information exchange and social interactions, it increases the social relationships in communities (Breek et al., 2018). It has the potential to stimulate offline interactions through online relations (Breek et al., 2018; Waite, 2020). Recently, Keegan and Schifanella, (2022) presented how the contributions of social media to placemaking have received little attention in the literature. Some authors mentioned the negative effects of social media on wellbeing such as isolation (Shankardass et al., 2019), and the commodification of culture and gentrification (Bronsvort and Uitermark, 2021).

3.3. Mental health and wellbeing implications in digital placemaking

Only 15% (n = 17) of records are coded into the mental health and

wellbeing theme, referring to community wellbeing (Calderon and Takeshita, 2021; el Khafif et al., 2021; Marshall, 2021), wellness of city residents (Gulrsud et al., 2018), stress (Clark and Lupton, 2021), healthy living (Najafi et al., 2021) or place wellbeing (Kale, 2019). A specific type of placemaking that focuses on the health impact of public design (Bicquelet-Lock, 2021; Ng, 2016) is also found.

Wellbeing is the most common term used, usually impacted by pleasure and sensory engagement (Kale, 2019) or social isolation (Marshall, 2021). It is a broad concept that combines health, positive affective states, health behaviours, and social engagement, among other wellness indicators (Shankardass et al., 2019). Wright (2021) describes placemaking and wellbeing as aiming to benefit people in an integrative way.

We have identified three main categories in this theme: connected with nature and social resilience (Beam et al., 2018; Gulrsud et al., 2018; MacIntyre et al., 2019; van Houwelingen-Snippe et al., 2021), with sense of place and place engagement (Kale, 2019; Shankardass et al., 2019), and the physical and psychological benefits or social relationships (Courage, 2021).

Beam et al. (2018) referred to biophilia theory (Kahn, 1997) to understand the human need to bond with nature and the crucial benefits to health, wellbeing, and resilience. Regarding urban environments, Marshall, (2021) and Eckenwiler (2021) outlined the negative health impact on their citizens such as isolation, depression and mobility restriction. NBS could help mitigate the current climate challenges and negative effects of urban environments while bringing benefits to the health and wellbeing of communities (MacIntyre et al., 2019).

Looking into the potential benefits of technology for wellbeing, some authors aim to explore the effects of the increase of digital networks in individuals' lives through digital innovation but without alluding to digital placemaking (Clark and Lupton, 2021; el Khafif et al., 2021; Shankardass et al., 2019; van Houwelingen-Snippe et al., 2021). Furthermore, natural environment digitalization and its potential effects on wellbeing are mentioned by some authors as potential areas to explore (Keegan, 2021; MacIntyre et al., 2019; van Houwelingen-Snippe et al., 2021).

Neither specific best practices have been found for the implementation of technology in urban environments for citizens' mental health and wellbeing through NBS, nor how to enhance its performance and impact through digital placemaking.

Most scholars approach this theme in a broad sense, without specific case studies that look into precise health indicators on digital placemaking, only two studies included health indicators applied to sense of place (Agyekum and Newbold, 2019; el Khafif et al., 2021). The evident lack of studies examining specific health indicators in digital placemaking is proven by the need for the standardisation in NBS evaluation that includes health and wellbeing metrics (MacIntyre et al., 2019) and the wellbeing impact of digital and physical place interactions including geosocial data, health and social planning interventions (Shankardass et al., 2019) as areas for future research.

3.4. Green and Blue space implications in digital placemaking

The final theme is related to green and blue spaces (12%; n = 14), which include nature in cities (Ng, 2016), therapeutic green space (Kale, 2019), NBS (Gulrsud et al., 2018; MacIntyre et al., 2019), green planning and infrastructure (Cilliers et al., 2015; Truong et al., 2022) and green agriculture (Lyle et al., 2015).

The first result and most clear within this theme is that digital placemaking has not been explored through blue spaces, with only one study addressing blue spaces from an analogue placemaking approach (Toomey et al., 2021).

Findings focused on green spaces emphasised the eco-benefits of nature for wellbeing and health in cities (Gulrsud et al., 2018; Kale, 2019; Ng, 2016), which could be achieved through green implementations such as green corridors, urban green infrastructure (Truong et al.,

2022) or green walls (MacIntyre et al., 2019). Regarding this, Cilliers et al. (2015) introduced the term 'green placemaking' as the application of green planning approaches to placemaking, creating sustainable and competitive public spaces. The authors encouraged the benefits of combining these two practices as it allows the integration of placemaking's social functions with green planning's environmental functions.

The NBS approach is only mentioned in three studies within the dataset. It is approached connected to climate resilience in the city, where technology is used as a strategy for socio-ecological principles (Gulrsud et al., 2018); as a tool for NBS in urban design (Boros and Mahmoud, 2021); and highlighting the positive frame that NBS are described in while exploring different interventions in cities, presenting the potential benefit of introducing digital innovations such as digital placemaking (Author et al., 2019). Boros and Mahmoud (2021) allude to the different placemaking tools provided in literature for community engagement that can be used with NBS, while non-human elements and ecological systems in placemaking have been ignored traditionally. This supports our research and model developed to understand digital placemaking practices in urban nature spaces where nature's role is a key element.

Nature is mostly described as the context where a project happens or partially happens, but there are no specific mentions of specifications or technological representations of nature. Only Edwards et al. (2020) and van Houwelingen-Snippe et al. (2021) referred to the use of technology as a potential benefit for future research, whereas Grace et al. (2020) 'smart-natural' city interface briefly mentions placemaking as one of the spaces in this interface without understanding on how to implement it or the effect of this specific characteristic in the community. Moss et al. (2021) present how nature has been absent in most smart cities' strategies, therefore being essential to understand how it is addressed in the urban digitalisation, what part nature plays in this context and what goal is targeted. These authors describe urban nature as being mediated by technological devices, even if it has not been acknowledged in literature and policies. The particular impact of digital placemaking in communities, specifically its wellbeing and mental health effect on NBS, is an area that has been overlooked in the literature. However, existing and future NBS studies and projects should assure to cover the social impact of these practices and the opportunities that technology and digital placemaking bring to NBS performance.

3.5. Combined areas

The results of our analysis showcase that only three studies mentioned digital placemaking, health/wellbeing and green space (Keegan, 2021; MacIntyre et al., 2019; Toland et al., 2020) without specific investigation of the combination of these three areas of interest but suggesting to further explore them to understand digital placemaking implications for communities and the environment.

Four results combine mental health/wellbeing and green space with 'digital' placemaking –presenting placemaking but mentioning the implementation of technology in some ways (Edwards et al., 2020; Grace et al., 2020; Gulrsud et al., 2018; Najafi et al., 2021). Gulrsud et al. (2018) expand green placemaking as a type that integrates socio-cultural and scientific knowledge to promote urban biodiversity, combining technological strategies with climate adaptation solutions in the case study analysed. This concept is found as the only placemaking term that combines technology and urban biodiversity mentioned to affect the wellbeing of citizens briefly. Finally, one record explores healthy placemaking – without specific digital implications – with green space and mental health/wellbeing (Ng, 2016).

Besides the gaps described, we can demonstrate there is a lack of understanding of the impact of digital placemaking on the mental health and wellbeing of citizens through green and blue space and NBS. There is no mention of blue space in the data set analysed, focusing on green space. Even though some articles present these three areas, they are

explored broadly and partially, offering an incomplete concept of digital placemaking, without analysing specifically its potential use in NBS involving green and blue spaces as well as its particular mental health and wellbeing social impact and bonds within communities.

4. Discussion

The aim of the study was to understand the relationships among digital placemaking, urban nature and mental health while introducing digital placemaking as a new technique to augment NBS in urban nature environments impacting the health and wellbeing of the citizens. The review of 117 studies adds to the debate from Basaraba (2021), Courage et al. (2021), and van Houwelingen-Snippe et al. (2021) by focusing on the mental health and wellbeing social impact of digital placemaking when connecting with nature through NBS. The data synthesis conducted for this review indicated a lack of agreement on the concept and characteristics of digital placemaking (Basaraba, 2021; Chen et al., 2022; Courage, 2021; Karge, 2018; Keegan, 2021; Sanaeipoor and Emami, 2020), especially when considering mental health and wellbeing effects (Najafi et al., 2021; Shankardass et al., 2019; Wright, 2021), combined with green and blue space (Edwards et al., 2020; MacIntyre et al., 2019). The findings reveal a lack of studies involving digital placemaking and blue spaces as well as a lack of application for NBS. Therefore, we advance upon and contribute to this debate by presenting this review and model.

Our study results identified four key characteristics in digital placemaking practices – hybrid reality, sense of place, community engagement and inclusion. From them, only hybrid realities were presented as unique, whereas the other key themes were mainly studied in placemaking but highlighted their potential benefit from technology. We can confirm digital placemaking's unique characteristic is the ability to create physical-digital experiences that can improve sense of place, engagement and inclusion of communities.

Problems or challenges derived from digital placemaking are usually presented briefly in the dataset, alluding mainly to privacy concerns (Hjorth and Richardson, 2017; Kostopoulou and Fatah gen Schieck, 2021; Li and Alencar, 2022; Pang et al., 2020; Peacock et al., 2021; Wilken and Humphreys, 2021), exposing and amplifying community inequalities (Bronsvort and Uitermark, 2021; Halegoua and Polson, 2021; Witteborn, 2021), gentrification (Foth, 2017b; Karge, 2018; Sanaeipoor and Emami, 2020) and a lack of community purpose and environment disconnection (Chen et al., 2022). Despite these limitations, digital placemaking is presented with positivity but further understanding of the risks from these practices would benefit a deepen explanation of this concept.

By supporting mental health and wellbeing through NBS and digital placemaking practices, a potentially positive impact on the social sphere of the community could be achieved. There is evidence supporting the positive effect of digital placemaking on mental health and wellbeing, but we have found a lack of application of specific health indicators to digital placemaking, as well as the specific study of the wellbeing impact of digital spaces (MacIntyre et al., 2019; Shankardass et al., 2019). Future studies involving NBS should include specific metrics and technologies to measure environmental performance and social impact – specifically mental health and social cohesion indicators – of these practices in order to provide strong evidence of their benefits.

The findings of this review highlight absence of blue space mentions involving digital placemaking, opening this area for further research. We have found a misconception of nature as only green space, neglecting the potential of blue spaces for the mental health and wellbeing of communities. Recent investigations demonstrating the neglected role of nature in smart cities (Grace et al., 2020; Moss et al., 2021) support our study results by presenting nature environments are a context, without understanding it as an active element for investigation involving performance and impact. The implementation of NBS in cities through digital placemaking would benefit from further investigations

on environmental performance and community effects and impact. Accordingly, future studies need to consider additional methods of data collection and analysis on this matter, such as walking or swimming interviews, auto-ethnographies or netnographic studies.

The digital placemaking approach to NBS has not been thoroughly explored, as shown in our review results. Therefore, we propose a novel approach to NBS through our review and model. Our proposed approach to digital placemaking follows (Foth, 2017a) understanding of placemaking as beyond the commercial aspect but as a strategy that fosters social change and urban renewal through democratisation. The augmentation of spaces through digital placemaking is proven to be an enhancer of public space experiences (Latorre, 2011; Wang, 2019), and could benefit NBS practices in urban nature environments (Boro and Mahmoud, 2021; MacIntyre et al., 2019), generating sense of place and place attachment (Breek et al., 2018; Halegoua and Polson, 2021), as well as creating inclusive and accessible places to the community (Szaszák and Kecskés, 2020). This technological application for urban nature can expand its effects and political agenda of urban digitalisation (Moss et al., 2021), creating long-term relations and adapting these practices to the world of digital we are living in.

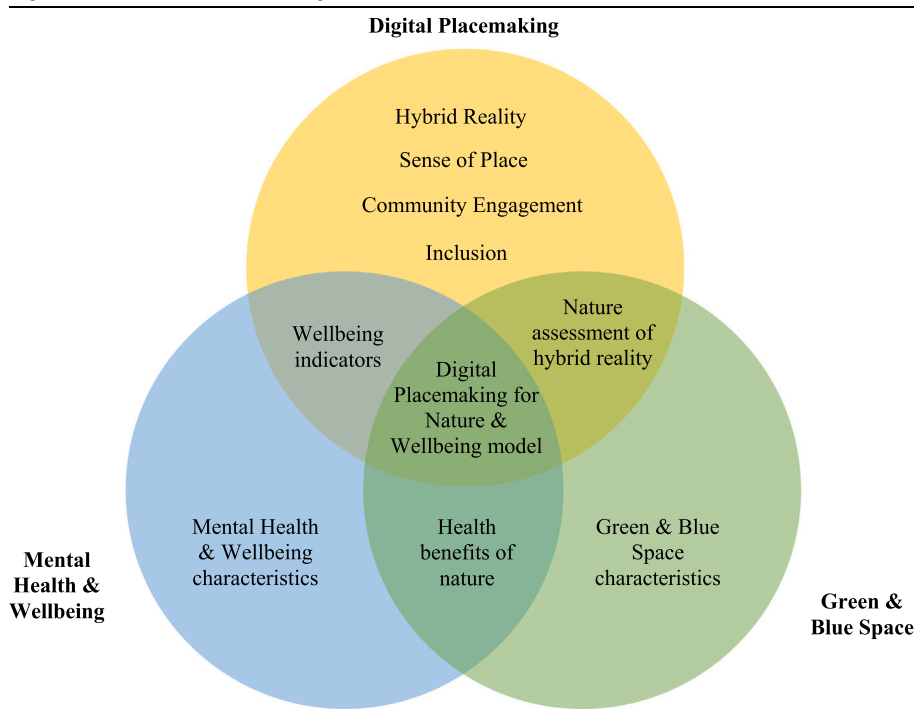
The present review has discovered a litany of studies in the past which have shown evidence of the potential application of digital placemaking practices in urban spaces. Despite the concept confusion and lack of consensus found in the digital placemaking literature, we have collated a number of characteristics of these practices that aim to contribute to clarifying the concept of placemaking and its potential application to NBS for wellbeing. For a thorough understanding and informed view on the adoption of these practices, we propose the following study and model, which aims to inform about potential applications and risks of digital placemaking practices when connecting citizens with nature and impacting their wellbeing. The Digital Placemaking for Nature & Wellbeing model brings together the findings from the digital placemaking literature, applied to urban nature and NBS while connecting with wellness.

The proposed Digital Placemaking for Nature & Wellbeing Model (see Table 7) is an overview of the current landscape in the respective areas. It will advise researchers and practitioners on how to fully implement digital placemaking for NBS performance and wellbeing impact, focusing on its mental health and wellbeing influence through connecting with nature. The model aims to serve as a help and guideline to avoid overlooking essential aspects of digital placemaking when applied to urban nature environments for health and wellbeing. This model will be further developed and examined in the future stages of this research.

The model is formed by three interrelated spheres. The digital placemaking sphere includes the four main characteristics from our review, creating a type of hybrid environment which promotes sense of place and community engagement in the public space, while assuring it is inclusive and accessible to all. These characteristics need to be assessed and planned when designing the project to assure it covers all the essential elements of a digital placemaking practice. Following Tomitsch et al. (2015), a holistic and responsive approach to technology implementations in placemaking practices in the city can reflect rising levels of social wellbeing and connectedness. The ecological framework of placemaking they propose is advanced by the informed results in our review to understand the key elements of digital placemaking to be assessed during the development of a project. Moreover, these characteristics are also informed by Edwards et al. (2020) guidelines for technology and people, where the design should be rooted in the context where it is developed, integrating social dimensions and encouraging intimate experiences.

The green and blue space sphere focus on the natural aspect – digital and analogue – of the hybrid reality. This section ensures the project includes and promotes nature connections in the urban environment, specifically since urban nature is being mediated by technological devices (Moss et al., 2021). It is crucial to measure the density, aspect and

Table 7
Digital Nature & Health Placemaking Model.



characteristics of the ‘nature’ element in digital placemaking, which will affect the type of strength of its connection with psychological wellbeing and the overall experience in the public space. Nature needs to be addressed in depth, beyond just a non-human element and a context where the digital placemaking project is developed (Chen et al., 2022). Therefore, an assessment of the “nature” element in the hybrid environment created is essential for the correct development and goal achievement of the Digital Placemaking for Nature & Wellbeing model. MacIntyre et al. (2019) encourage the importance of community engagement with green spaces when implementing NBS. To enhance this engagement, it is essential to understand how the hybrid environment is going to interact with the natural space and how it is going to be portrayed (Moss et al., 2021). NBS should be strategically designed to ensure climate mitigation and citizen engagement activities (e.g. Gulsrud et al. 2018). The way nature is portrayed through technological applications is key to the potential effects on wellbeing (van Houwelingen-Snippe et al., 2020).

The third sphere reflects the mental health and wellbeing impact of this digital placemaking experience. Mental health and wellbeing of the community will be assessed before their interaction with the experience. Specific health indicators and metrics that appraise the experience from a community or an individual level will also be implemented during and/or after the experience, depending on the scope of the project. This health and wellbeing evaluation is crucial to understand the impact of the hybrid environment (MacIntyre et al., 2019; Shankardass et al., 2019).

The three spheres are interconnected and affect each other in the development of the different aspects. This Digital Placemaking for Nature & Wellbeing model aims to bridge the different gaps found in our review to propose a guide to support placemakers in developing digital applications for urban nature spaces with a wellbeing impact approach. This technological application to enhance physical experiences and connect citizens with nature is informed by the results from our review, which defend and proves the value of digital placemaking for NBS. The model presents an application of digital placemaking for NBS that helps both to measure its impact and to enhance the experience and performance created for the community.

4.1. Limitations

This review presents some limitations. A common limitation to most reviews is the inclusion and exclusion criteria applied such as English as the only language accepted, search strings used as well as the databases. Since the digital placemaking concept is multidisciplinary and lacks consensus on definitions and applications, the keywords included aimed to avoid overlooking suitable studies, but it is possible that different studies could have been identified when using different search terms or databases. Additionally, grey literature was excluded from the review. Finally, the data synthesis process through reflexive thematic analysis informed by the research question and aims, which in turn would exclude outlier themes.

5. Conclusion

In systematically reviewing the above literature, hitherto unknown links are made between digital technology in placemaking, their mental health and wellbeing impact, and its use with nature and NBS. The review outcome offers a useful overview of key studies, which allow us to understand further the way technology – specifically digital placemaking – can enhance the performance and social impact of NBS, not only in green and blue spaces increasing its overall efficiency but also for nature amplifying its impact in the community. The results pointed to a lack of agreement in the reviewed academic literature on digital placemaking’s impact and use in urban environments. The study identified four key characteristics of digital placemaking as well as a general and incomplete approach when assessing the mental health and wellbeing impact and their connection with green and blue space. This paper contributes to understanding the concept of digital placemaking and its potential use to increase citizens’ health when connecting with nature while highlighting the benefits of bringing green and blue space back into the urban environment. It also contributes to presenting an innovative application of digital placemaking for NBS to impact citizens’ wellbeing. Our study offers a platform for understanding the opportunities of embedding digital placemaking practices in and for NBS’s social impact while stimulating prospective research debates on this topic to promote

the implementation of green and blue space strategies into the urban environment to enhance citizens' wellbeing through digital placemaking. Moreover, our research offers insight into the broad range of best practices for implementing digital placemaking practices in the urban environment through our Digital Placemaking for Nature & Wellbeing model. The findings highlight the need for further research that acknowledges the complex nature of digital placemaking in combination with mental health/wellbeing and green/blue space. An enhanced understanding of this area will help maximise the impact of digital placemaking on urban citizens' wellbeing and the climate resilience of the city.

Future studies could focus their attention on the implementation of digital placemaking for communities. A better understanding of health indicators and wellbeing metrics would benefit from assessing the impact of digital and physical place interactions. There is also an opportunity to investigate blue space's effect through digital placemaking. Moreover, there are emerging debates that offer a platform for further debate in new areas where digital placemaking might be able to fit, such as participatory design methods for sustainable placemaking practices (Clarke et al., 2019), positive design for NBS (Birkeland, 2022), or planning for health and wellbeing (Liaros, 2022).

As explored in this study, digital placemaking presents an innovative technique to augment the application of NBS. Neither has been applied in the mental health and wellbeing sphere nor the green and blue space environments. Hence, our systematic literature review addresses this gap, representing a key contribution to the three areas of interest in our study.

CRedit authorship contribution statement

MFF, BK, MJ, TM: conceived the idea, MFF, BK, MJ, TM designed the study. MFF: obtained the data. MFF, BK, MJ, TM: analysed the data. MFF, BK, MJ: wrote the paper.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.ufug.2022.127796](https://doi.org/10.1016/j.ufug.2022.127796).

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