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Design Principles for Developing Open Source Urbanism

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Abstract. In Open Source Urbanism (OSU) citizens self-organize and create Do-It-Yourself (DIY) urban designs to address societal problems. Self-organized citizens develop these designs, but there is no support for the design process based on the co-creation and involvement of citizens. The latter are mainly non-experts. Three aspects characterize OSU: (1) OSU initiatives are initialized by citizens; (2) OSU initiatives are the new commons, are collectively created and managed by self-organized citizens; (3) to last, DIY should be accepted by or co-produced with the authorities as they can change the urban environment. This research offers a set of design principles to guide the cultivation of OSU infrastructures in the self-organized setting of urban commons. We derived the principles from an ethnographic study of an Amsterdam-based citizen initiative. This paper offers a set of design principles to guide the cultivation of OSU infrastructures in the self-organized setting of the urban commons. We introduce eight design principles: (1) Co-creation, (2) Trust-building, (3) Motivating, (4) Growing, (5) Showcasing, (6) Bridging, (7) Open-sourcing, and (8) Peer Production. By promoting self-organized, community-led development, our design principles offer guidelines for urban commons communities, academics, and decision-makers to work towards a shared vision of the future of inclusive cities. Building trust and gaining access to expertise are key aspects of OSU cultivation.

Keywords: citizen initiatives · design ethnography · design principles · urban commons

1 Introduction

As cities become increasingly complex, citizen-led initiatives are emerging as powerful tools for shaping urban environments. Among these initiatives are the urban commons, which are places citizens co-created to collectively manage and utilize shared resources in their communities [12]. *Open Source Urbanism*(OSU) is a type of citizen-led initiative that builds on the concept of the urban commons by integrating open-source principles and digital tools into the co-creation of designs in the urban environment [4,17]. OSU practices aim for *urban transformation*, that is "a process where the dominant structures, functions and identity of urban systems change fundamentally e leading to new cultural, structural

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and institutional configurations" [23, p. 160]. OSU has similarities, but also differences, with *Information Infrastructures* (II). OSU and IIs exhibit the same characteristics, for instance, both phenomena are claimed to be self-organised, decentralised, and evolving. At the same time, OSU differs from the formal organisational contexts that build IIs, such as the lack of resources, clear hierarchies, and control are differences, to name a few. OSU digital tools and practices comprise an OSU infrastructure, i.e., a commons-based information infrastructure (II) that facilitates the co-production of urban design and open source design manuals. IIs are "the entirety of devices, tools, technologies, standards, conventions, and protocols on which the individual worker or the collective rely to carry out the tasks and achieve the goals assigned to them." [21, p. 455]. IIs differ from other Information Systems (IS): the former have no specific purpose but rather a generic idea of supporting a Community of Practice with information-related services, while the latter, such as decision support systems or accounting systems, clearly state their purpose and supported tasks [15].

The self-organized nature of infrastructures requires different approaches than conventional design processes. Designing OSU has no lead designers, and often the designers are not experts or educated for the task. Instead, co-design with the community is needed. OSU differs from II as no experts involved, and co-creation among layman is the central design approach. The literature provides various design principles, including these for IIs [15], however, specific principles for OSU infrastructures are lacking. This paper fills the knowledge gap in designing OSU infrastructures by offering a set of eight guidelines derived from a design ethnography study of an Amsterdam-based urban commons initiative. Design principles might support guiding co-designers in cultivating OSU infrastructures. Design principles are "prescriptive statements that indicate how to do something to achieve a goal." [13, p. 1622]. They are not offered as 'blueprints for strict adherence' but serve as inputs for case-specific design decisions [7]. The urban commons and OSU are not explored by scholars of Information Systems (IS). Thus, we lack knowledge of the design principles in such an idiosyncratic setting. To achieve the research goal of deriving design principles, we adopt ethnographic methods.

The rest of the paper is organized as follows. The second section draws on the literature on the commons and the Community of Practice (CoP) theory, discussing the importance of understanding the context of Open Source Urbanism and the need for a community-driven approach to OSU infrastructures development. The third section presents the research approach. Thereafter the case of our design ethnography is presented. The fifth section offers a set of eight design principles for OSU infrastructures. The sixth section discusses the conclusions and recommendations for future research.

2 Literature Background

This section discusses the nature of OSU in greater detail. Next, an analysis of the design ethnography requires tools for the analysis of communities that

share work practices since information infrastructures function in Communities of Practice (CoP) [26], in which members learn from each other by sharing tacit knowledge, such as anecdotes, impromptu comments and opinion exchange, in addition to explicit knowledge.

2.1 What is Open Source Urbanism?

OSU infrastructures occur when citizens self-organize to tackle the issues of their urban environment by creating Do-It-Yourself (DIY) designs. In urban studies literature, DIY urban designs are defined as small-scale, civic-minded design contributions that are designed and constructed by citizens and represent a desire to make improvements to the local urban environment without formal approval of the authorities; however, essentially in a manner that aligns with official urban designs [8]. DIY designs emerge as a response of active citizens to issues in their local environment; they are designed and financed by self-organized citizens and not by public or private companies [11]. Designs can range from alternative energy microstations or Wi-Fi networks to community urban gardens [17]. Active citizens share design knowledge gained during the construction of these designs with the help of design manuals. Design manuals are a written set of rules to follow to create an artefact for achieving a specific goal. The detailisation of design processes in these manuals can be low since most designs are created *ad-hoc* for a specific local environment to solve a problem at hand; thus, they are not designed to be generalizable. Design manuals are shared on the internet, allowing others to use and alternate them to produce context-specific versions of DIY designs.

OSU unites bottom-up citizen interventions and the open source movement and can be defined as open source production of urban commons [4]. Urban commons and the open source movement are self-organized Communities of Practice that collectively manage, produce and consume resources that vary from urban land to information on the internet. The urban commons focus on the collective management of resources in the urban context (e.g., community gardens, housing cooperatives), while open source communities create digital commons (e.g., open source software, Wikipedia). OSU infrastructures function as peer-to-peer networks in which distinctions between producers and consumers of resources are blurred [17]. Such networks create physical entities, i.e., urban designs and open source manuals covering the design processes. Thus, the second crucial aspect of OSU is that resources are created and consumed in infrastructures that unite urban and digital commons.

OSU emerges as a grassroots response to traditional urban development since active citizens self-organize to improve their local environment outside the traditional public-private dichotomy [4]. Claims of citizens for self-governance over DIY designs challenge the paradigm of governmental control and maintenance over the urban equipment [17]. Nevertheless, citizens cannot simply appoint themselves to alternate their local environment. To last, DIY designs must be authorized by urban officials, i.e., some mechanisms of collaboration with the

municipality should be in place. Thus, the third aspect of OSU is that DIY designs should be co-produced with urban authorities.

2.2 Communities of Practice

As with any other kind of Information Infrastructure, OSU infrastructures emerge in and are used by Communities of Practice (CoPs) [26]. The notion of *Community of Practice* (CoP) [18] is an analytical framework for investigating the process of learning through practice. CoPs can be defined as "small groups of people who regularly engage in similar practices and have frequent occasions to interact with each other" [28, p. 549]. CoPs are different from other forms of organization because they are self-organized entities that establish informal membership and leadership [30].

CoPs are characterized by three elements: 1) shared enterprise, 2) mutual engagement, and 3) shared repertoire [30]. CoPs are informal groups of people bound together by an interest in a joint enterprise, for instance, gardening or cooking. Interest in the same domain does not automatically create a CoP. Membership plays a crucial role in CoPs: collective identity and shared competence in the domain of interest distinguish CoP members from outsiders. Mutual engagement connects these people in a community. Over time a CoP develops a unique shared repertoire of community resources, such as routines, jargon, and artefacts [30]. Contrary to formal organizational settings, CoPs are self-organized, which complicates the creation of formal structures with fixed roles and domains of responsibility. Thus, CoP members have to learn from each other during their practice. In this study, we analyzed urban commons as a CoP. Thus, citizens form a CoP to learn how to share responsibilities, tasks, and resources while co-creating DIY designs to solve perceived issues of their local environment.

3 Research Approach

The literature on OSU infrastructures is lacking. This paper addresses this knowledge gap by offering a set of eight guidelines derived from a design ethnography study of an Amsterdam-based urban commons initiative. The research are part of the completed PhD research [33]. The domain of OSU is new in IS discipline, thus, we lack knowledge of the design principles suitable for dealing with the idiosyncratic setting of urban commons. To overcome these barriers, we adopt ethnography, that is "an anthropological research method that relies on first-hand observations made by a researcher immersed over an extended period of time in a culture, with which he/she is unfamiliar" [24, p. 7]. Ethnography is 'one of the most in-depth research methods possible' because it gives the researcher tools to observe interactions and practices of people directly, not relying only on self-reports of their actions [1, p. 40] which is typical for other quantitative methods, such as case studies. Ethnography is a "well suited to providing information systems researchers with rich insights into the human, social and organizational aspects of information systems development and application"

[16, p. 22]. We perceive immersion in an urban commons initiative as necessary to achieve the objective of this study because other methods cannot provide such in-depth knowledge. Ethnography is criticized because immersion in a community's life hardly leaves the researcher space for neutrality. We mitigated this bias in several ways. Firstly, we used various sources of information, such as participant observations, interviews, and documents. Moreover, the CoP members were interested in co-creating an OSU infrastructure for the community, while they did not participate in elaborating design principles. Notably, after completing the fieldwork, we disengaged from the community and conducted data analysis and design principles synthesis as a 'desk research'. Another criticism questions the validity of a theory generation from a single-case ethnography; nevertheless, theories generalized from a single case study are widespread (e.g., [32]). Grounded in one typical case, the offered design principles can be perceived as a departure point for further research.

In ethnography, participant observation is the cornerstone research method which prescribes the researcher to observe but does not disturb the community life [20]. However, some point out that conducting ethnographically inspired research necessarily involves some level of interference in the field being studied; in this way opening opportunities for intervention by the researcher [22]. Thus, ethnography makes possible interventions in the community under scrutiny, however, it provides no tools or approaches for that. Hence, we adopt a method of *design ethnography*in which the ethnographer "is no longer so tentative but rather actively engages with the people in the field" [1, p. 27] which enables an in-depth understanding of a chosen community and allows design interventions. In traditional ethnography, the researcher 'becomes a student of other people's culture' [20, p. 114]; in design ethnography, the researcher also becomes an adviser of the community they engaged with [1]. We define design interventions as the researcher's activities within organizations that aim at solving their practical problems [6]. Design ethnography suits the objectives of this study well, as we aim at co-creating a technology-based artefact with an urban commons community that holds values and performs practices we are not yet familiar with.

This paper derives generalized knowledge (i.e., a set of design principles for cultivating OSU infrastructures) from developing an OSU infrastructure for a real-life case of the urban commons. For this purpose, we conducted the ethnography and four design interventions. We used lessons learned from the design ethnography as input for synthesizing the design principles. The design ethnography took place from July 2018 to December 2020. In total, we conducted four design interventions, one after the other. Each following intervention was chosen based on the reflection on the previous one.

4 Ethnographic Study

The ethnographic case of this study is a self-organised citizen initiative KasKantine (eng. Greenhouse cantina), established in 2014 in Amsterdam, the Netherlands. It temporarily occupies available land plots moving to a new plot every

several years. After each relocation, the construction materials and technological solutions are reused. The main community activity is a donation-based cafe utilising food from supermarkets and vegetables grown in the community garden. KasKantine is not connected to city infrastructures and produces energy and water autonomously, thanks to the DIY design created by the CoP. To give some examples: rainwater filter provides water for non-cooking purposes; greywater filter provides water for plant watering; rocket stoves allow heating and cooking; donated and repaired solar panels provide electricity. We chose this initiative for design ethnography due to several reasons. First, the initiative was commons-based and gained sufficient DIY design knowledge that can be shared in the form of design manuals, thus, meeting the definition of OSU. Moreover, initiatives of this sort are rather rare and exemplify what [32, p. 27] describes as "unusually revelatory, extreme exemplars, or opportunities for unusual research access". Finally, the CoP was open to collaboration with the researcher (in the roles of a volunteer and a design ethnographer).

4.1 Design Intervention 1: Transformation of the Organizational Structure

The first design intervention aimed to create a new organisational structure that would better achieve the community vision. The rationale behind the organisational transformation was to carry out activities that bring more value to the city and neighbourhood. The researcher suggested the following design intervention: KasKantine transforms into a living lab as a testbed for social innovation that fulfils the needs of local communities. The living lab could include self-organised initiatives, private companies, public organisations, and knowledge institutions. The first design intervention did not work out due to several factors (due to space limitations, we name only the crucial ones). First, the lack of trust since the researcher joined the community several months prior to the intervention and was still considered a newcomer. Additionally, the initial top-down design of the intervention played a role. The researcher assumed that an intervention based on the literature should be accepted while the understanding of community life was still lacking.

4.2 Design Intervention 2: Bridging with External Stakeholders

As per the land contract terms, the initiative was obligated to vacate the land by September 2019. Fearing the possibility of the initiative failing, community leaders began exploring the development of an OSU infrastructure to address the challenge of communicating the public value of KasKantine with the municipality. This was necessary to rent a municipality-owned land, and an OSU infrastructure would transform the CoP's tacit knowledge into explicit design manuals. According to the CoP theory, boundary objects play a critical role in supporting collaboration among actors from different social worlds, as they maintain different meanings for heterogeneous groups of actors. During the second design

intervention, the CoP required a boundary object to demonstrate to civil servants that KasKantine aligns with the municipality's goals, such as co-creation with citizens and promoting citizen initiatives. At the same time, for CoP members, it would serve as the foundation of an OSU infrastructure. Due to time constraints, the team quickly designed and developed a simple static website without any interactive features. The content included a brief explanation of KasKantine, its social value for the city, and a brief description of DIY designs, along with accompanying photos and generic models of functioning.

4.3 Design Intervention 3: Creating Design Manuals

In August 2019, the municipality offered a five-year contract that would provide the opportunity to further develop the initiative compared to earlier contracts that lasted one or two years only. Moreover, without the pressure of securing a land plot, CoP members were more driven to cultivate an OSU infrastructure. In this design intervention, the team co-designed two artefacts: a pdf booklet with open-source design manuals and a website providing access to the booklet. The booklet format was preferred, allowing independent collaboration on designs separate from website development. Additionally, the one-file structure of the booklet enabled the updating of design manuals without website modifications. The previous version, developed in a short time frame, was inflexible and not extendable. Therefore, an open-source content management system was preferred for future development and maintenance by the community of volunteers, who might leave the initiative at any time.

4.4 Design Intervention 4: Building the Network of Practice

The fourth design intervention aimed at transforming the built website into a digital platform, i.e., "a specific type of civic technology explicitly built for participatory, engagement and collaboration purposes that allow for user-generated content and include a range of functionalities" [10, p. 3]. The resulting platform featured collaboration functionality, such as channels of communication and collaboration spaces. The platform aimed to connect various like-minded CoPs in Amsterdam and other cities. The design intervention was necessary to allow non-professionals to manage the content. In the earlier version, updating the booklet designs required licensed proprietary software and individuals with specialized skills. Likewise, the previous website version was designed to be modified only by individuals with web-development expertise, such as adding a new page or changing the text on the main page.

4.5 Lessons Learned

This section summarizes lessons learned from design interventions. These lessons lay a foundation for design principles. We discuss five important themes that emerged during the evaluation; these themes will serve as the foundation for five design principles of a design method for OSU.

Trust for Co-designer. Establishing trust is a critical component of the process as the researcher must fully integrate into the CoP to co-design an OSU infrastructure through shared practice and engagement in community life. In the first intervention, trust was lacking between the researcher and the CoP, as the former was viewed as an outsider or newcomer. However, over time, as the researcher spent more time with the CoP and demonstrated a commitment to and understanding of the initiative, trust gradually developed.

Motivation of CoP Members. The degree to which CoP members align with the community vision is crucial for finding the motivation to participate in OSU cultivation. Apart from that, CoP members are more likely to engage in cultivation activities if the objectives of the infrastructure align with their personal motivations for volunteering.

Showcasing Community Vision. The simple artefact from the second design intervention laid a foundation for an OSU infrastructure. This simple website showcased the vision of the CoP to external stakeholders, such as the municipality, and demonstrated how KasKantine produce eco-minded public services with the help of DIY designs.

Use of Open Source. The choice of technologies for infrastructure might create lock-ins if the CoP lacks volunteers skilled in the specific technologies. Open Source Software (OSS) solves this problem. The OSS content management platform allowed the CoP to gradually improve the website from a three-pager providing access for downloading the pdf booklet to a digital platform with a dynamic content system. Applying peer production principles.The pandemic forced KasKantine CoP to cultivate an OSU infrastructure via online collaboration further. This eased the application of CBPP principles: we applied three main principles of CBPP: modularity, granularity, and low-cost integration. The modular design of the OSU infrastructure and fine-grained tasks allowed the CoP to work in an asynchronous and geographically dispersed way.

5 Design Principles

Design principles allow embracing the diversity of commons initiatives while providing flexibility in developing case-specific OSU infrastructures. Design principles are not blueprints to implement but serve as inputs for case-specific design decisions. In this paper, we define design principles as follows: *"generic prescriptions and guidelines that are intended to be manifested or encapsulated in the design and implementation of socio-technical systems"*. The principles were synthesised by confronting empirical case observations and literature.

Design principles are applied by a co-designer, i.e., facilitators of the cultivation of an OSU infrastructure, since every user can contribute to the design process. Co-designers should not steer OSU infrastructures but rather facilitate peer production of the digital infrastructure. Co-designers choose methodologies and tools considering their skills and properties of the specific urban commons. Co-designers are interdisciplinary professionals that can grasp such complex socio-technical systems and facilitate their growth. Although not requiring

formal education in urban design or computer software design, this role demands a deep understanding of self-organized urban commons initiatives' ethos and work practices, as they are substantially different from organisations based on a hierarchical chain of command and contractual obligations. Civil servants, urban practitioners, active citizens, researchers, or policy-makers can play this role. In the ethnographic study, the researcher played the role of co-designer, facilitating the cultivation of OSU infrastructure.

To describe the design principles in greater detail, we use The Open Group Standard framework for design principles (TOGAF) [27]. In accordance with TOGAF, we provide a short name, statement, a rationale behind each principle using the insights from the literature review and empirical studies. Contrary to the TOGAF standard, we omit to specify the implications, as they are represented in statements.

1. Immersing: immerse in the community life to understand a community vision and practices

Co-design with urban commons initiatives differs from other design projects since these are self-organised, therefore, lack hierarchies and contractual relationships. During the ethnographic studies, we found that proposing a solution in a top-down fashion might be ineffective or not work and, more importantly, may cause resistance. Thus, prior to starting the design process, co-designers should gain a deep understanding of the urban commons CoP, to identify what knowledge can be shared as digital commons. Apart from that, community members might be unaware of their innovative ideas that can be of use to others because they emerged through practice, not as a design project with explicit objectives and deliverables. A long-term involvement in communal practices provides a live experience and deep understanding of the urban commons while not disrupting community life. Over time, the shared practice of the co-designer with the CoP members, paired with reflections, can lead to the understanding of the community vision and practices. The primary condition for co-designers to understand the functioning of the community is to keep in mind that urban commons are based on a self-organised voluntarily-driven organizational structure. As the ethnographic study showed, CoP newcomers that are used to market relations initially have trouble adjusting to the self-organised setting.

We recommend being reluctant to identify the initiative goals from formal documents and interviewing external stakeholders because goals, habits, norms and culture of the CoP can be hidden from outsiders [30] and are subject to change over time. Moreover, CoP members themselves might not be able to clearly formulate their common goals, as they can be expressed not explicitly but rather as a fluid and ever-changing set of ideas and intentions that depend on the changes in the local environment and community composition. Due to this, understanding the community and its history is crucial to acknowledge the evolving nature of the urban commons. Instead, co-designers should grasp what problems in the urban environment they attempt to tackle and what designs they co-create to support

their practices. Crucial to identify the problems from the perspective of community members, as the co-designer's perspective may differ.

2. Trust-building: build trust with the community to secure co-creation

Trust between the co-designer and community members is key to securing the relationship paramount for the co-design process. Trust is a basic organising principle for coordinated activities: "whenever actors are simultaneously dependent on and vulnerable to the actions and decisions of others, trust is a relevant organizing principle that warrants consideration." [19, p. 99]. Co-designer is frequently an outsider or newcomer of the CoP, therefore, might hold work ethos and vocabulary quite different from those of CoP members. In order to build trust, the co-designer should secure long-term peer relations with the community. They must immerse in the community life equipped with an open mind, sympathy for their vision, and empathy for their struggles.

In OSU infrastructures, community members must trust co-designers and acknowledge that their intentions are in the collective interest. Trust building is crucial for securing the overall co-creation process because if trust between co-designers and the community is missing, the design activities will bring little to no effect. Trust plays a paramount role in urban commons because self-organised communities operate outside the command and control relations and might resist such structures. Without contractual obligations, they collaborate as peers that cannot coerce each other to perform tasks. Thus, community members negotiate the performance of projects and tasks. The imposition of corporate culture and a hierarchical goal-driven approach might deteriorate peer relations, block or halt the design process, or result in the superficial design of OSU infrastructure that will not function without external support. The latter is undesired as these might result in the existence of nonviable projects that become abandoned when external actors stop supporting the co-creation. Moreover, sources of legitimacy that are standard for bureaucratic structures, such as expertise or social status, are not necessarily automatically recognised in non-hierarchical communities, therefore, other factors play a paramount role, and trustworthiness is a crucial factor.

3. Motivating: look for opportunities to motivate and involve community members

Digital tools, such as source code repositories and wikis, serve as artefacts for knowledge sharing for geographically spread participants. In the case of the urban commons, such artefacts are not necessary, as participants acquire knowledge through practice [2]. Thus, members of urban commons might be unmotivated to support the development of digital tools, as they do not receive direct benefits in exchange for their time and efforts. Building an infrastructure often would take a too high toll on the community, as they are overwhelmed by the everyday activities necessary for the initiative's functioning. Hence, co-creation

requires that community members grasp the future individual and communal benefits to motivate them and secure their involvement in OSU cultivation.

Based on the understanding of the community vision and challenges, co-designers formulate goals of an OSU infrastructure, i.e., how it benefits the initiative development. Essentially, the goals of an OSU infrastructure should mirror issues of the local urban environment. This ensures that the community recognises the developed infrastructure's potential benefits and engages in its co-creation. Apart from that, community members can find individual motivations. Frequently idealism and camaraderie motivate peers to contribute. Alternatively, community leaders can find material incentives, for instance, external funding from public or private organisations. Additionally, material incentives may increase the chance of project completion, as it demands higher accountability than voluntary work. On the other hand, it might bring the 'corporate relations' that erode peer production [29].

4. Growing: grow infrastructure on fertile ground to avoid community resistance

We offer the concept of *the fertile ground* for OSU infrastructures instead of *the installed base* well-known in IIs studies [26]. We claim that this new notion fits better the idiosyncratic nature of OSU. The fertile ground highlights the different mode of production in the urban commons that are self-organised, emerging communities driven by the values and visions of people. The urban commons is the fertile ground where an OSU infrastructure grows if cultivated. Organic growth is a slow, natural evolution. In the self-organised setting with no command and control mechanisms, OSU infrastructure grows only if it organically motivations of the community members. This principle prescribes investigating elements of the fertile ground in detail. For instance, which CoP practices are required for the urban commons management and maintenance. Equipped with these, co-designers can grow an OSU infrastructure by fitting new technologies, tools, and practices in the fertile ground of the urban commons.

5. Showcasing: showcase the community vision for communicating with other city actors

The community vision is a declaration of problems in the local urban environment, as perceived by active citizens, and how the urban commons tackle them by means of the DIY designs and community practice. The vision is the alternative urban futures shaped by the collective imagination of the CoP: this is not necessarily a feasible target but rather an ongoing process and a mission to move forward. Community vision could be fluid and changing due to changes in the 'outer world' (e.g., changes in policies, funding programs, and like-minded communities). Nevertheless, urban commons perform community practice aiming at achieving the vision. The focus of an OSU infrastructure is to materialise DIY knowledge on the co-creation of these in the form of design manuals.

The manuals should be exemplified by practical cases to demonstrate their applicability in the real-life context of a specific urban environment. They show the best practices, inspire other urban commons, and support a dialogue with other city actors. Exemplifying the specific community vision with specific designs and related community practices makes shared design manuals tangible, as real-life examples are easy to grasp, unlike abstract designs. Additionally, manuals with examples shared on the internet help communicate the community vision with other city actors. Finally, it has value as it promotes active citizenship, demonstrating that self-organised citizens can solve arising local challenges outside of the standard public-private dichotomy.

6. Bridging: connect heterogeneous groups of actors to align perspectives

The urban commons must comply with urban environment regulations to be authorized by the urban officials. However, external stakeholders with whom the urban commons collaborate might have different perspectives on the same problems and possible solutions. Therefore, the CoP envisions possible solutions to specific urban environment problems that might differ from external urban stakeholders. The different visions can bring tensions. To avoid that, the community should align their vision with that of external stakeholders; they need to find a narrative acceptable to all involved parties.

The urban commons place can be viewed as a *boundary object*, i.e., an entity that is used by different social groups maintaining different meanings for every group, yet holding a shared identity that allows joint action upon them; Boundary objects facilitate collaboration among parties that have conflicting perceptions of it [25]. Urban stakeholders might collaborate upon the authorisation and development of the urban commons without consensus on its meaning for the CoP and the city. Communicating the community vision with urban stakeholders is challenging: community members shape the vision through the practice and do not necessarily have it in the form of ready-made documentation, while other stakeholders do not participate in the practice. Urban officials cannot easily submerge in the reality of urban commons because their goals and background substantially differ from activism and self-organisation. Live demonstrations of the community practice is not necessarily effective, as they belong to different social bubbles and use various vocabularies and perspectives. Instead, decision-makers can evaluate the vision by assessing reports and presentations.

Bridging is required to align different perceptions and interests of stakeholders. According to the CoP theory, some CoP members act as boundary spanners between the CoP and external stakeholders [31]. Boundary spanners have to learn how to convey their vision to urban authorities, for instance, by learning the jargon and work culture of these. They connect the CoP with the 'outside world' and tweak the vision and even vocabulary of the urban commons. They shape the vision influenced by city regulations and community members. Bridging principle change the CoP, as the 'outside world' provoke changes in the community vision, and this, in turn, leads to changes in the physical environment

of the urban commons. An OSU infrastructure facilitate this process, as infrastructure transform tacit DIY knowledge into documents in explicit, codified form that can be used as boundary objects.

7. Open-sourcing: apply open source solutions to ease IT development and secure community ownership

Open Source Software (OSS) is well-suited for developing OSU infrastructures, as it is free for use and modification [3]. Notably, many OSS is well-documented, which eases the evolution of IT components of infrastructure. Self-organised communities often face the ongoing flux of members, which raises challenges of maintenance and scaling up the infrastructure. Application of OSS might increase the potential volunteer base since many well-developed OSS solutions have grown vast communities of users. Furthermore, OSU infrastructures based on open source principles prevent data misuse because the community chooses the way the design manuals are stored, managed, and shared. To share design manuals as open source, the co-designer suggests an open source license, such as the software license GNU General Public License or the family of Creative Commons licenses [14].

8. Peer production: apply peer production principles to create a Network of Practice

CoPs are loosely connected into *Networks of Practice* (NoPs) [5] that do not coordinate practice with each other but allow to exchange knowledge [9]. Members of an NoP may never meet each other in real life, however, as their practices are similar, they may be interested in sharing knowledge across CoPs [5]. IIs might facilitate knowledge exchange in loose groupings in which "people are not necessarily collocated but are engaged in practices that share a certain degree of similarity" [28, p. 549]. This principle suggests applying principles of Commons-Based Peer Production (CBPP) [3] in the physical realm of the urban commons. The three main principles of CBPP are modularity, granularity, and low-cost integration. Modularity means that potential objects of peer production must have a modular structure allowing peers to work asynchronously. Granularity refers to the degree to which objects are broken down into smaller modules. This principle allows peers to work on modules according to their level of competence and motivation. The principle of low-cost integration refers to a mechanism by which modules produced by peers are integrated into the end product [3]. We must admit that this principle is more rooted in the literature than in practice since we could not fully test and evaluate this principle in the fourth design intervention.

6 Conclusions and Discussion

Open Source Urbanism (OSU) is a type of citizen-led initiative that builds on the concept of the urban commons by integrating open-source principles and

digital tools into the co-creation of designs in the urban environment [4,17]. The digital tools and practices comprise an OSU infrastructure, i.e., a commons-based information infrastructure (II) that facilitates the co-production of urban design and open source design manuals. The literature lacks design knowledge guiding the cultivation of OSU infrastructures. Due to the novelty of the OSU field, a synthesis of design knowledge requires a deep understanding of urban commons involved in OSU practices. Hence, we conducted a long-term fieldwork study within an Amsterdam-based urban commons initiative applying a design ethnography approach. Principles offered in this paper are part of completed PhD research [33].

This paper offers a set of design principles to guide the cultivation of Open Source Urbanism (OSU) infrastructures in the self-organized setting of the urban commons. We introduce eight design principles: (1) Co-creation, (2) Trust-building, (3) Motivating, (4) Growing, (5) Showcasing, (6) Bridging, (7) Open-sourcing, and (8) Peer Production. The design principles proposed in this paper have significant implications for the future of OSU and the co-creation of sustainable and inclusive urban environments. The design principles presented in this paper guide designers to facilitate the co-creation of OSU infrastructure that aligns with the needs of the community and urban environment. OSU infrastructure development requires a co-creation approach that involves community members. OSU represents one of the new alternative approaches to urban development, one that promotes civic engagement by empowering citizens to take control of their local environment and work together to create solutions that meet their unique needs. By sharing design knowledge gained during the construction of these designs, citizens can collaborate and learn from one another, further strengthening community ties and promoting social cohesion.

We highlight that the scope of this study was OSU infrastructure cultivation in the inception stage, i.e., we focused on the bootstrapping problem [15] of OSU infrastructures only, while challenges related to adaptability problem [15], such as adoption, growing user base, and network effect, are outside the scope of this study. Future research can focus on studies of OSU infrastructures in a multi-actor setting, i.e., engaging private companies, decision-makers, and civil servants in cultivating OSU infrastructures. OSU infrastructures are not designed from the top-down, and every user can be a co-designer. This aspect of OSU infrastructures, coupled with possible tensions between self-organized communities and urban authorities, raises questions about the manner of OSU cultivation in such a setting. Especially interesting to investigate an approach that balances different, often even contradictory, interests of various urban stakeholders and maximizes value for city-wide urban development while further enabling citizen-driven initiatives. The second research suggestion concerns the evolution of OSU. This research was limited to constructing design principles for the inception phase of OSU infrastructures, thus, further evolution and growth of these is a possible subject for future studies.

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