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A design space for event-centric displays in public libraries

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We present a design space for displays in public libraries; more specifically public displays related to events taking place in the library. The design space is developed from the perspective of the librarians and is intended to support libraries in rethinking, developing, and employing displays to communicate and support the events they host. It is based on a study of 18 concepts co-designed in eight participatory workshops scaling participation to a total of 88 professional librarians. By analyzing the concepts through inductive and iterative analysis, we have defined a design space consisting of 12 aspects, categorized in four themes: interaction-, content-, event-, and display-centric. We argue that the design space can both serve as (1) an analytical tool for understanding and categorizing information displays and identifying overarching design considerations and (2) a generative framework to inspire design across a wide variety of libraries.

KEYWORDS

public library, HCI, design, public displays, design space

1 Introduction

Libraries are a centerpiece of urban communities and a hub for accessing, sharing, and developing knowledge in cities. Before the advent of digital systems, the library could even be said to be a crucial socio-technical infrastructure for making cities "smart." Over the past two decades, we have witnessed a radical shift in the role and use of public libraries and digital library systems (Yoo et al., 2019b). While libraries have traditionally acted as third places focused on provision of knowledge, first and foremost via collections of books and other media, public libraries are increasingly places of knowledge co-creation with local community members (Serholt et al., 2018). In this shift, public knowledge institutions still need to "respect the sense of place," or *genius loci*, the shared socio-cultural meanings that are attributed to a specific place by its community members (Dalsgaard et al., 2008a). To support this, many libraries explore ways of encouraging participation through community-generated content contributions in ways that are distinct and meaningful to the communities of which they are part (Dalsgaard et al., 2008a; Yoo et al., 2020a). Notable trends in this changing role of libraries include a move from focus on collections toward placemaking and community activities in libraries (Berndtson, 2013; Gröschel et al., 2018; Yoo et al., 2020a). This event-centric development is often driven both by decision makers in libraries and municipalities in an effort to spur citizen engagement, and by library patrons who seek out new ways of engaging with library services.

In practice, this means that public libraries now host an increasing number of events, from conferences and debates to concerts and makerspace workshops (Serholt et al., 2018; Yoo et al., 2020a). Not only are these events a space for patrons to meet, share and co-create knowledge, but they are also an opportunity for the libraries to fulfill their role of curating information and facilitating access to knowledge. As part of this, librarians, event organizers, and attendees collect and create a broad variety of event-related and place-specific content. To convey this content to the community and invite patrons to engage with it, librarians rely on a variety of communication media such as leaflets, websites, social media posts, or posters, and increasingly public digital displays (Serholt et al., 2018). The increasing emphasis on events, their organization, and communication have changed the daily tasks and workflows of librarians (Lynch and Smith, 2001; Cooper and Crum, 2013). One major challenge facing librarians is to bridge the spatial nature of libraries, with collections being thematically organized in the library space, with the temporal nature of events, and their unfolding in very specific spaces of the library (Yoo et al., 2020a). Whereas library services typically focus on providing access to a collection of media, there is a lack of support for event-centric information in libraries. This resonates with Reich and Weiser (1994)'s proposition that we need to move away from completely placeless, universal information systems, in favor of more place-centric systems. In this paper, we explore how the design of public displays in the library can put forward event-centric information, and support knowledge co-creation. This can include traditional display of announcements about various kinds of public events taking place in the physical library space, but also novel ways of conveying and interacting with information and experiences about upcoming or past events. In the terminology of this special issue on *Scaling Up Co-creation in the Smart and Social City*, we consider this work to contribute to furthering our knowledge about the themes of *combining digital and non-digital co-design and participatory design tools for scaling up participation* and *methods for enabling inclusive citizen participation*.

To map out the potentials for displays to support events and knowledge co-creation in libraries, we propose *a design space for event-centered displays in public libraries* based on a study of how librarians envision the communication of events and interaction with digital content in the physical space of public libraries. The aim of the design space is to support designers and library staff involved in developing event-centric services in public libraries. The development of our design space is original in building upon a long-term research collaboration spanning libraries across Europe and the direct involvement of librarians in its creation. We conducted a series of eight co-design workshops that involved 88 librarians to understand their expectations and emerging interests around the use of displays in public libraries. From the workshop outcomes, we identified 18 design concepts focusing on the design and use of public displays. Based on these concepts, we developed the design space, which reflects librarians' preferences and expectations regarding the design and use of event-centric displays in public libraries. Expanding on prior work on designing digital systems for public spaces, a key contribution of our work is to provide design insights from the perspective of librarians as a "keystone species" in the information ecology of libraries (Nardi and O'Day, 1999), who play a crucial role in facilitating and curating community-based co-creation of knowledge, and of sustaining this as a collective resource over the course of time. Unlike more tech-centric public display design spaces, ours covers content displayed and the stakeholders tasks involved in maintaining the displays.

2 Background

The design space presented in this article is anchored in a research collaboration with librarians, event organizers, and library workers from three public libraries in Denmark, Sweden, and France. These public libraries were partners in the PLACED research project (http://placedproject.eu/). Prior to the COVID-19 pandemic, the French library, located in Lyon, is the largest municipal library in the nation, welcoming more than one million visits every year and hosting more than 4,000 events. The Swedish library, Lundby, is a network of branch libraries, located in an area of Gothenburg facing rapid growth, with more than 350,000 visitors and around 400 events per year. The Danish library, Dokk1—the main library in Aarhus, combines library and citizens' services. It is the largest library in Scandinavia, with 1.3 million visitors every year, and is the venue for around 5,000 yearly events and activities for residents. In combination, these libraries represent not just a difference in sizes and cultures, but also in terms of their push toward event-centric services, which the Danish library has focused markedly on from its recent creation. In all three cities, library staff and decision makers collaborated with researchers in the project from local universities (University of Lyon, Aarhus University, Chalmers University of Technology) to explore the potentials of employing new digital services to support planning, participation, documentation, and knowledge dissemination related to events.

The libraries seek to reach their public through patron involvement in a range of services and activities. This translates into an organizing an increasing number of events, some participatory, others not, and librarians dedicating more time to organizing, coordinating, and publicizing events in addition to more traditional tasks of curating and providing access to information. This duality creates tensions between well-understood missions, and new ones, with less established practices (Yoo et al., 2019a). One challenge consists in reaching out to patrons to communicate about events. Both about upcoming events, but also about past ones, since many of these events still offer relevant and useful information in the form of video recordings, reading lists, or content co-produced by participants. Our reflections on a design space for event-centric displays in public libraries stem from such challenges faced by the librarians from our various partner libraries and others across Europe and North America. We conducted eight workshops, described in detail below. Five workshops were part of our participatory design project, and three part of broader discussions, education and dissemination efforts. These latter three workshops involved a total of 76 librarians: 25 librarians attending a professional training in a library school, 26 music librarians attending a national conference, and 25 librarians and students in library science during a Summer School in North America.

3 Related work

3.1 Design for public displays

Public displays are becoming ubiquitous in public and semi-public space. In Human Computer Interaction (HCI), a key concern with public displays relates to interactivity and engagement. Considering that interaction times are short, interaction needs to be straightforward to understand (Kukka et al., 2013) and to provide a benefit that justifies the effort to engage (Colley et al., 2015). Prior work has shown that conveying tangible benefits is crucial for user engagement (Müller et al., 2009; Alt et al., 2012). Rather than interacting directly with public displays, mobile phones can act as useful mediators, providing richer, bidirectional interaction (Ballagas et al., 2004, 2006; Boring et al., 2009). Using personal devices can also mitigate privacy concerns that arise when inputting (private) information in a public environment (Alt et al., 2011). When personal devices are thought as a medium to interact in public spaces, then information exchange, social support and regulation become central consideration for design (Eriksson et al., 2007). In this context, public displays can also awake curiosity of users toward collocated people and the application itself (Seeburger and Foth, 2012; Yoo et al., 2020a).

Display blindness has been an important concern in the literature. It occurs when there is the expectation that no interesting content is to be found on the display, that it is advertising in nature rather than informative (Müller et al., 2009). In a recent review of public interactive displays for providing information and collecting feedback in public spaces, Parker et al. (2020) demonstrate that similar to all public displays, interactive displays suffer from the same problems of display blindness (Hespanhol and Tomitsch, 2015; Hespanhol et al., 2015). Rather than trying to increase the attention grabbing factors of the display, they argue for investigating other ways in which content can be more relevant. This suggests that the use and value of displays in public displays in library can be improved if relevant information is provided to patrons. Our work leverages librarians' expertise and builds upon them as information providers in exploring the design space of public displays in public libraries. We complement previous work by giving voice to librarians themselves, for conveying situated information about events in libraries, something that is not necessarily task oriented but still of relevance to patrons.

3.2 Displays in public libraries

Libraries have been early adopters of digital technology (Wilson, 2006) from supporting the exploration of collections, to computer access and training, and later, access to digital collections, e.g., ebooks. In this paper we are particularly interested in the role of displays in public libraries, as they have become increasingly common as means for communication, and especially related to events taking place at the library. Research at the intersection of Design, HCI and Library Sciences has mainly focused on digital archive services (Serholt et al., 2018). A central question relates to search and ways to go beyond keyword based exploration, for instance by exploring the affordances of tangibles and large interactive displays. Thudt et al. (2012) sought to support serendipitous search with large displays and playful exploration, while Hinrichs et al. (2016) explored the use of tangibles for collaborative search. Researchers have also explored how digital tools could augment children's exploration of libraries, e.g., by combining tangibles and large touch screens (Detken et al., 2009), or augmented floors and tabletops (Eriksson and Lykke-Olesen, 2007; Lykke-Olesen and Nielsen, 2007; Eriksson, 2010). These unique installations enable multiple users to interact together, fostering collaboration. They also leverage library space in ways that traditional search stations do not.

We share with this research an interest for the relationship between the location of displays, the library space, and the activities they enable. Physical collections are not the only type of resource that libraries have to offer. Digital resources are becoming increasingly rich and abundant. With InfoGallery, Rohde et al. (2006) sought to promote awareness of libraries' digital collections on large public displays, as such content has little presence in the physical space of library. With libraries hosting more public events, communicating about such activities surrounding the collections has become increasingly important (Serholt et al., 2018). A number of public display systems have been designed to aggregate and make multiple sources of information visible (events, news and social media, locally relevant information, new acquisitions, etc.) that are otherwise ignored (Kanis et al., 2011; Kukka et al., 2018) (see Figure 1 for examples). More recently, Yoo et al. (2020b) proposed a system to document library activities and make them visible through public displays in the library. There is currently no convention or standards on how to communicate about events in libraries. In this context, public and interactive displays are used in a widely different fashion, and librarians are imagining even more opportunities for design. In this paper we seek to identify the different aspects of event-centric public displays can have in libraries through the eyes of experts, the librarians, and crystallize that into a design space for displays in public libraries.

3.3 Design spaces

Efforts to structure a design space for public displays were made by Bendinelli and Paternò (2014), who propose four criteria to guide the design of public displays (content, dynamicity, purpose, position) and Müller et al. (2010) who have made a classification of public displays according to mental models applying to them (poster, window, mirror, and overlay). These proposals are based on the authors' expertise, and not grounded directly in empirical data or concrete design considerations. We take inspiration from this corpus of research but propose a more systematic approach, focusing on the creation of a design space for event-centric displays in public libraries. Moreover, by anchoring our design space in a specific use context, our approach goes beyond technical or interface considerations, to also consider the types of interactions and activities that the displays enable. We also developed the design space with the goal of making it meaningful to library staff, since they play a key role in integrating these displays in the library and their practices of mediation.

FIGURE 1
Two examples of event-centric public displays in a library.

To create the design space, we build upon Dorst and Cross (2001) study of the co-evolution of problem and solution spaces, as well as Heape (2007) thesis on the notion of design space. Biskjaer et al. (2014) and Dalsgaard et al. (2008b) add that the design space can be seen as a conceptual space, which the designer(s) co- construct, navigate, and transform through the design process. It is a co-constructed conceptual space in the sense that it is composed not only of concrete constraints, e.g., physical conditions and fixed budget and time constraints, but also of parameters that designers identify, articulate, and explore. Our understanding of design space is in line with Biskjaer et al. (2014) definition of the design space as "a conceptual space, which in addition to being co-constituted, explored and developed by the designer encompasses the creativity constraints governing the design process." This definition underscores that the design space is not given a priori, but that a central part of design is concerned with examining and building an understanding of constraints and possibilities. This echoes Schön (1992)'s understanding of design as reflective inquiry, in which the task of the designer is not just to provide optimal solutions within a pre- defined space of possibilities, but also to explore and establish this very space of possibilities. Moreover, this space is often shaped by further project and social constraints that have to be accounted for in any design project (van Amstel et al., 2016). Although there is no settled method for mapping a design space [as argued by Eriksson et al. (2021)], Biskjaer et al. (2014) propose a simple format for mapping the main features of the design space in a parametric matrix, i.e., one in which the main parameters that designers can address form the main categories, and the different conditions that designers can somehow manipulate or select amongst are listed for each parameter. We will use a similar but somewhat expanded parametric mapping of the design space for public displays in libraries in this paper.

4 Method: creating a design space from concepts

The study that forms the foundation for the design space is part of a European research project on the design of digital services in public libraries. The project consortium involved academic institutions and libraries from three European countries. The main criteria for selecting the libraries to participate in the project were that they should represent (1) different scales, ranging from the largest urban municipal library in a major European country to a smaller branch library, (2) different local contexts, being situated in three different countries and supporting communities with large socio-cultural variety, and (3) different stages in the move from "traditional" library services toward libraries as spaces for events, ranging from a library that is renowned for being a pioneer in this field to libraries that are in the early phases of exploring it. The co-design workshops reported in this paper did not directly involve library patrons, but they were informed by extensive insights into patrons' perceptions, needs, and expectations of library services, in part from the librarians ongoing engagement with patrons, in part from extensive ethnographic field studies, interviews, and focus groups in the research project in which the workshops were orchestrated. Throughout the project, we (the authors in collaboration with the project consortium) conducted a series of co- design workshops to explore the relationship between events organized in libraries and the library collections.

The workshops investigated how to document events and how public displays could be leveraged to communicate about events in the library space and support knowledge co-creation. In this paper, we focus on the concepts developed with, and by, library staff in these workshops.

4.1 Co-design workshops

In total, we conducted eight co-design workshops in three countries, involving a total of 88 librarians, from 2017 to 2020 (Figure 2). The workshops (presented below) all focused on how to incorporate event-centric displays within the physical space of the library and its collections. As such we included any form of public display located in the library space, as opposed to public websites or mobile apps that can be accessed from anywhere.

Workshop 1: involved 25 librarians (most of them being early career professionals) split in six groups during a 1h30 session

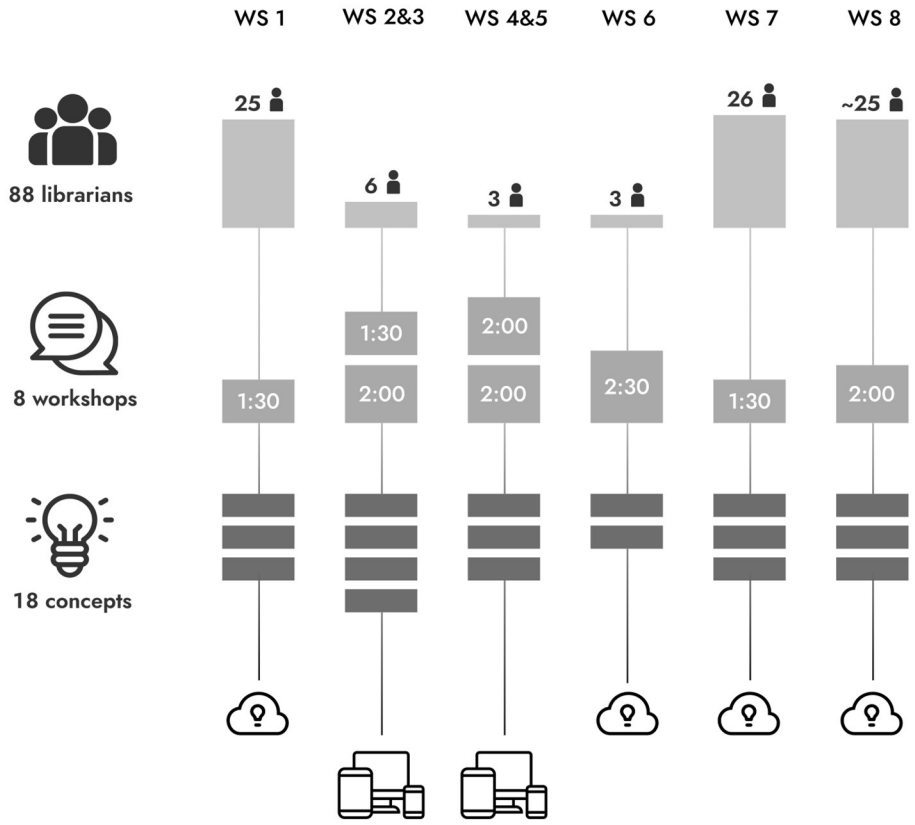

FIGURE 2
Overview of workshops including from top to bottom, for each group: participating librarians, occasions, and concepts.

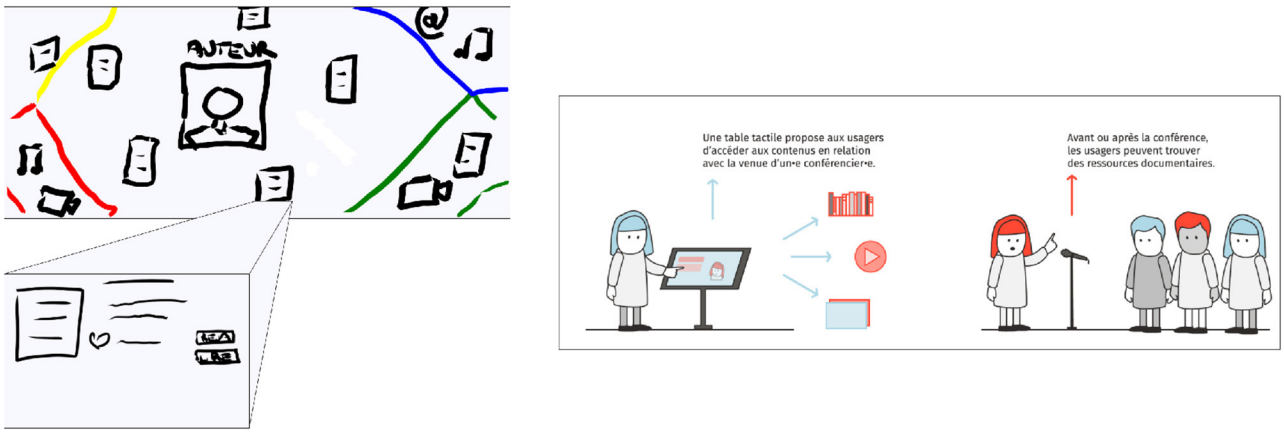

FIGURE 3
"Guest"—a concept developed by librarians, here presented both as original sketch and as later illustrated by us.

in a university library. Through a situated sketching activity, participants were invited to reflect on collections related to events, and creating space for events in the library. Three concepts came out of this workshop (C2, C3, and C4).

Workshop 2 and 3: involved six librarians and four HCI and Information Science researchers during 1h30 to 2 h sessions. These two workshops were part of a series of six participatory design workshops taking place in a public library. Participants took part in situated sketching and enactment activities, giving events a physical form in the library, by leveraging paper artifacts or by situating them in the collections. These two workshops led to the creation of four design concepts in the form of sketches, storyboards and video prototypes (C5, C6, C7, and C8).

Workshop 4 and 5: involved three music librarians and two researchers (in HCI and Information Science) for 2 h in a library. Participants were invited to reflect on events, content, and places of the library where digital information about events is relevant. The workshops led to the design of three design concepts with sketches and textual descriptions (C1, C9, and C10).

Workshop 6: involved five HCI researchers, two library researchers, and three librarians, split in two groups. The workshop took place in a public library, where participants performed situated sketching and enactment activities for 2h30. Participants were asked to create concepts that make past, current and upcoming events visible in the library. Each group created a video prototype of their concept (C17 and C18).

Workshop 7: involved 26 librarians split in four groups during a conference for music librarians. We invited participants for 1h30 to reflect on how to create links between events and the music collection of the library. Three groups proposed concepts around public displays, with sketches and scenarios (C11, C12, and C13).

Workshop 8: involved 25 librarians and students in library science split in four groups, during a librarian Summer School in North America. We invited participants for 2h to propose a concept that would help link events and collections in the library, considering four types of publics (collection users, events attendees, participative activity attendees, non-users of the library). Three groups proposed concepts with sketches and scenarios (C14, C15, and C16).

All workshops shared similar goals and instructions. Workshops 1, 2, 3, and 6 had an emphasis on enacting the concepts and leveraged situated sketching exercises (Bressa et al., 2019) and digital prototyping tools for public displays (Ducros et al., 2019). The workshops took place in public libraries to facilitate the consideration of contextual elements.

Workshops 2, 3, 4, and 5 involved librarians, the authors, and other researchers. The researchers participating in these workshops were partners in the EU project presented in the background section. The librarians were also engaged to various degree in the project, participating in other workshops, attending meetings and presentations related to the project. The scope was slightly more focused than the other workshop as librarians had the expectation that the design activities would ultimately lead to development and test of prototypes in their own libraries. The HCI researchers helped frame the workshop design and contributed alongside others to the concept creation. In workshops 1, 6, 7, and 8, it was clear to the participants that the design activity was exploratory and would not be followed up with developments.

Participation in the workshops was voluntarily and in compliance with The General Data Protection Regulation (GDPR) and ethical principles for conducting research in the European Union. We collected the outcomes of the workshops, mostly scenarios and sketches (see Figure 3), with the consent of the participants. Workshop 4 and 5 were video recorded and we collected field-notes for each design concept. We filtered the concepts that involved public displays in one form or another. This resulted in 18 design concepts, (see Table 1). We collected the concepts in a single document for coding and analysis, together with the field-notes from observations.

4.2 Data analysis—Mapping the design space

We conducted a thematic analysis of the concepts, as this method is well suited for identifying, analyzing and reporting patterns within qualitative data (Braun and Clarke, 2006), by developing a coding scheme through associating data to codes and identifying repeated patterns that describe the relationship between codes. We used an inductive approach in developing the codes (Mayring, 2000), and challenged our initial assumptions through several coding iterations with a triangulation approach (Golafshani, 2003), to improve the validity and reliability of the coding scheme.

The primary author started by collecting and transcribing the sketches and scenarios in a shared document of 18 design concepts (see Table 1 for a summary). He then developed a first iteration of the coding schema while attempting a first classification of the concepts. This first version of the coding scheme together with the entire data set was then discussed with one of the co-authors from library science with extensive knowledge of librarian practices. This led to a second version of the coding scheme. Then, the primary author and two other co-authors independently coded the same subset of cases and compared their coding to ensure agreement over the coding scheme. Once a definitive coding scheme was agreed upon, the first author analyzed the 18 concepts as exemplified in Table 1. See Figure 4 for examples of four concepts.

To develop the design space, we drew from the literature on work-books (Gaver, 2011), i.e., considering the design concepts as manifestations of ideas that emerge slowly over time rather than definitive concepts. We framed our work with the definition of constraint-based design spaces, i.e., the design space takes the form of a table. Each column of the table corresponding to an aspect of the design space, and for each aspect a number of options that are available. As an example in the design space, the aspect "Display Medium" has the options "Paper," "Object," "Screen," or "Interactive Screen."

5 Event-centric displays in public libraries—A design space

The design space focuses on event-centric displays in public libraries. These are displays of various sizes located in the library and relate to events either through their content or their location in the library space. These displays are mainly interactive but can be static. Their content is often created either by library staff or by patrons and consists of physical or digital materials. It can include announcements about various kinds of events taking place in the library, but also documentation and experiences of past events, and other public information. The design space is structured in four overarching themes with

TABLE 1 Overview of the 18 concepts developed by and with librarians.

Concept	Description
1. Explore Music Dept	A portrait large screen showing content that the music department provides related to events. An associated tablet allow patrons to consult showcased content.
2. Tell your story	In the context of writing workshops, a touch-screen is installed in the reading area of the library. Patrons can watch videos of the reading of the text and leave comments.
3. Live Stream	During an event on video games, a live stream of the tournament is projected in the library. Tablets are also placed near exposition desks to propose additional content.
4. Guest	After a conference, an interactive desk is setup and give access to multiple content about the speaker: biography, bibliography, recordings, websites, etc. See Figure 1
5. Chitchat Wall	In the hall of the library, a screen displays posts from patrons and librarians. Patrons can scan a QRcode to post content. Patrons without smartphones can use a tablet that is placed next to it.
6. Events Summary	Tablets show upcoming events in different departments of the library. A large display is placed in the hall to give an overview of all tablets installed in the library. Patrons are invited to read more on tablets in the library.
7. Screen in the Shelf	A screen embedded in the shelf, where patrons interested in the collections can consult content about an upcoming event. They can also print a ticket with a link, to access content from home.
8. Live from the Library	During an event, attendees can share tweets from their phone or from a shared tablet. Tweets are then shown live on a large screen in the hall.
9. Musical Chair	By the entrance hall, a chair has an integrated tablet. It give access to past and upcoming events and to listen to recordings.
10. Interactive Poster	A big interactive screen displays digital content available around a specific theme, in a graphical way. When a patron interact with the screen, she can get links to consult this content.
11. Step by Step	Signs on the ground leads patrons to curated documents and finally to the event place.
12. Ghosts	Once an event has happened, share information and content usingpaper flyers on documents relevant to the event.
13. Wanderings	Tablets and smartphones are used for an AR visit in the collections of the library in relation to an event.
14. Print your Event	Each time you borrow a resource, a printed ticket recommends you with upcoming events in relation to the resource.
15. Book and Recommend	Patrons can use their smartphone to get event recommendations based on their loan history and their metadata.
16. Food Literacy	During the food literacy event period, patrons can access new recipes every day through an app.
17. Find your Way	Signs placed on the ground lead patrons to events. If it is before the event, they there have access to an interface that allows them to book the event in their calendar and access related content.
18. The Fox Experience	Patrons entering the library may take bippers. Those will vibrate when an event is about to start and invite patrons to get more information on nearby public displays.

corresponding aspects: event-, content-, interaction-, and display-centric theme. The aspects of the design space derived from our coding scheme.

5.1 Interaction-centric theme

The Interaction-centric theme (see Table 2) centers on users, their roles and the actions they can perform with the displays. The Action aspect focuses on how people can interact with the displays. This ranges from very lightweight interactions such as "Watch from afar" that are a shared by most public displays to the more elaborate actions such as "Writing content" or "Create Media" that require devices with interactive capabilities and even suggest a connection to some collection database. In this theme we also focused on two broad classes of public display users, Patrons, and Librarians. Reflecting the traditional role of patrons in the library as "Content consumer" (or book borrower), public displays primary focus is often on giving access to information: bibliography, videos, etc. However, if devices allow participation, patrons can gain the role of "Editor" or "Curator" when they are invited to share their thoughts, suggest books or other documents they appreciate, or even their own writings and productions (e.g., photos or artifacts).

The concepts also reflected the traditional roles of librarians: "Curating content" to make them available in the library. However, librarians are also expected to fill new roles such as "Moderators" of the content proposed by patrons this was a concern frequently raised, as librarians did not want to content

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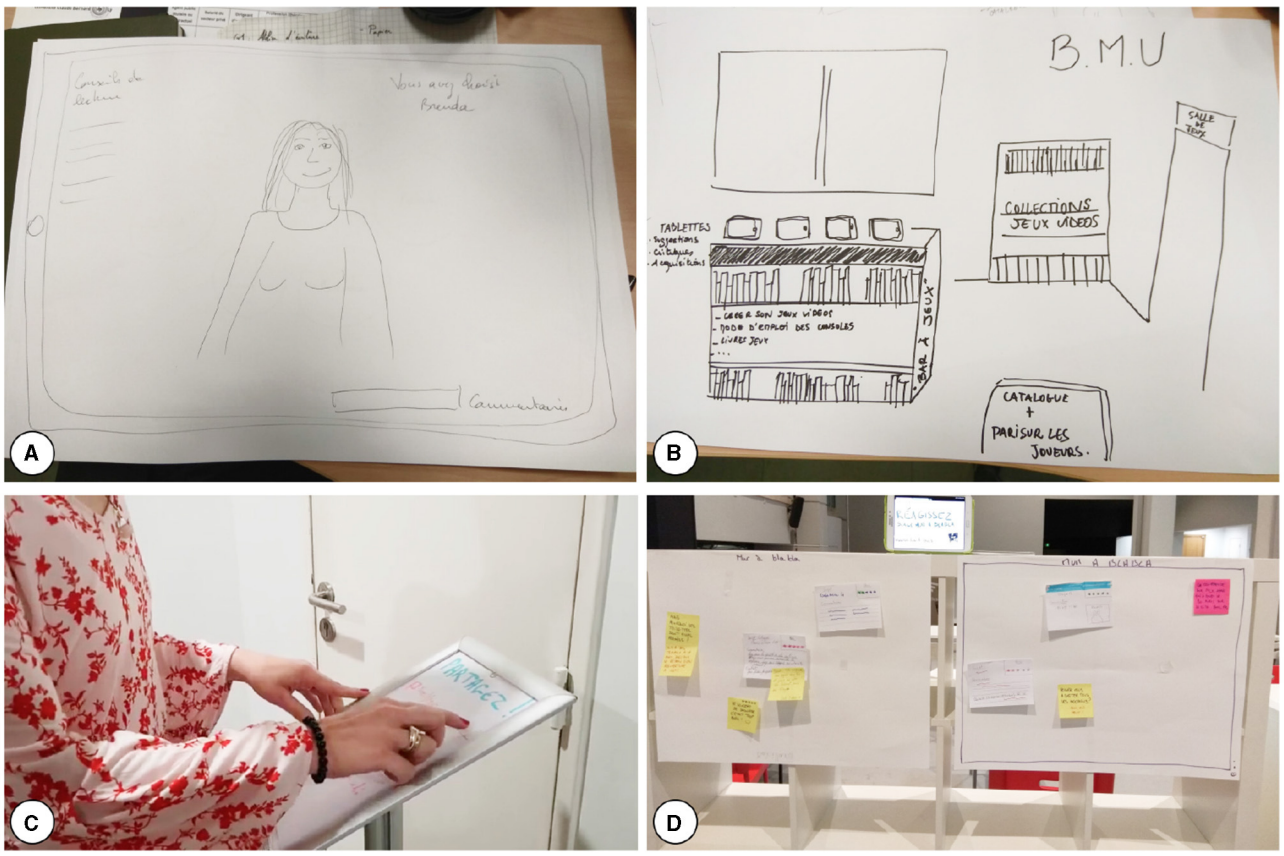

FIGURE 4
Four of the 18 design concepts. **(A)** (C2) Tell your Story, **(B)** (C3) Live Stream, **(C)** (C8) Live from the Library, **(D)** (C5) ChitChat Wall.

TABLE 2 The Design Space theme Interaction-centred with corresponding aspects and modalities.

Interaction-centered		
Aspect	**Modalities**	**Questions**
Action	Watch from afar Navigate content Consult an item Personal access Write content Create Media	How can users interact with the device?
Patron Role	Data consumer Curator Editor	What kind of roles do the end users of the device endorse? Do they only consume content? Do they have the ability to curate existing content? Do they have the ability to edit new content they created ?
Librarian Role	Editor Curator of external content Curator of internal content Moderator Mediator	Do they have the ability to curate existing content? Can they curate content from external sources? Do they have the ability to edit new content? Do they or should they moderate content edited by end-users? Can they or should they use the device as a mediation tool?

shared within libraries or with libraries credentials that went against their rigor criteria or broad library values. In between, these two roles, the role of "Mediators" (between patrons and content/devices) emerged as way to facilitate interaction, foster participation, or use devices to convey a message by leveraging its content.

5.2 Content-centric theme

Our second theme centers on the display content, and its relationship with the surrounding space (see Table 3). Content source refers to where the information comes from: it can either be from the library itself (e.g., a bibliography, or information about

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TABLE 3 The Design Space theme Content-centred with corresponding aspects and modalities.

Content-centric		
Aspect	**Modalities**	**Questions**
Content source	Librarian Patron Partner Library collections Web	Where does the content come from or who created the content available on the device?
Content type	Event information Bibliography Picture (local) Picture (external) Video (local) Video (external) Other external media Post Textual content Reaction Other event production	What kind of content is available on the device?
Content spatial proximity	Embedded Situated Non-situated	What is the proximity of the device relative to the content it displays? Are the devices displaying content in direct relation to their surrounding (embedded)? Or is it situated nearby? Or elsewhere (non-situated)?

TABLE 4 The Design Space theme Event-centric with corresponding aspects and modalities.

Event-centric		
Aspect	**Modalities**	**Questions**
Event spatial proximity	Embedded Situated Non-situated	What is the proximity of the device relative to the event it relates to? Is the device "embedded" in the place where the event takes place? Or is it "situated" near the event? Or is it "non-situated" (installed far from the event)?
Usage temporality	Before the event During the event After the event	When are end-users expected to interact with the display ? (Relative to the event time)

an upcoming event). The information can be sourced from event partner's websites, or curated by a librarian, or even created by patrons. Type of content refers to the diversity of content that can be displayed. Content type is associated to device capabilities: some can only display simple static information about upcoming events whereas others offer access to videos, bibliographies, articles, and more.

The content displayed by the device relates in one way or the other to the broader library information ecosystem. We refer to this aspect as the spatial proximity of the device content in relation to the library space. A tablet installed in the shelves of the library displaying content associated to the surrounding collections is considered "Embedded" in terms of spatial proximity, whereas the same tablet installed in the hall, far away from the anything related would be considered "Non-situated." We would consider it "Situated" if it was within the relevant library department.

5.3 Event-centric theme

Our third theme, Event-centric, focuses on temporal aspects of public displays (see Table 4). As libraries organize an increasing number of events, this question was present in all the workshops we ran. The aspect that kept re-occurring throughout the concept is Usage time, i.e., when the device is supposed to be used relative to the event. Its values are before/during/after, with some concepts covering many temporalities. Most concepts enabled advertising an event before it happened. On the other hand, eight concepts enabled the access to past events, as events could be relevant after they happened, for instance by giving access to recordings or resources that were shared during the event. Only four concepts were designed to be used during the event unfolding. For instance, one concept proposed to live stream videos or social network activity. We also identified spatial proximity in relation to the event. An "Embedded" device here means it is used where the event

TABLE 5 The Design Space theme Display-centred with corresponding aspects and modalities.

Display-centered		
Aspect	**Modalities**	**Questions**
Input	Mouse and keyboard Touch Tangible Remote control Gesture (hand or full)	What types of input are used to interact with the display?
Display medium	Paper Object Screen Interactive screen	What kind of medium is used by the display?
Display size	Small (smartphone/ticket) Medium (tablet/A4) Large (large display/poster)	What is the size of the display?
Multiplicity	Single device Multiple devices Swarm of devices Combination of devices	Is the display a single device? Or does it involve a given number of similar devices? Does it involve a potentially large number of devices? Is it a combination of different devices?(eg. a tablet and a poster)

is taking place. "Situated" means that the device is close to the event, whereas "Non-situated" meaning that the device is not used anywhere close to the event.

5.4 Display-centric theme

The final theme, display-centric, focuses on material considerations regarding the devices involved in the concepts (see Table 5). The first aspect we consider here is the medium used to display content. With little surprise, interactive display was a very popular medium across the design space, along with non-interactive screen. Three concepts chose only paper as their medium, in the form of posters or fliers. Size is the second aspect we consider. Here we consider three options: small that is the size of a smartphone or a flier, medium that correspond to a tablet, and large that describes large displays or posters.

The third aspect, multiplicity, comes from the observation that most concepts involved more than one display. Where options such as "Single" or "Multiple" easily make sense when thinking about public displays, we considered that some concepts involved a "Combination of devices" that is the combined use of displays of different size or type. The last option, "Swarm of devices," differentiates itself from "Multiple" devices by the scale it represents. Depending on the concept: dozens of fliers disseminated in the collections or leveraging the smartphones of all the patrons for example.

5.5 Applying the design space to analyse and categorize design concepts

For illustrative purposes, Table 6 shows how the design space is applied to three concepts developed in the workshops: "Explore Music Dept," "Chitchat Wall," and "Screen in the Shelf." The design concepts have been structured according to the four themes and corresponding aspects as outlined in the design space description in Tables 2– 5.

6 Discussion

The access to information anywhere, anytime, on any device, has dramatically challenged libraries to rethink their role, the services they offer, and their public perception. One of the dominant trends is for libraries to serve as hubs for knowledge exchange and community building through event hosting (Reich and Weiser, 1994; Berndtson, 2013; Yoo et al., 2020a). However, digital systems for libraries mostly focus on digital archive services and providing access to resources rather than events (Serholt et al., 2018). As public libraries grow their repertoire of public events such as book readings, creativity workshops, film clubs, etc., event-centric displays become increasingly important to communicate within the library space (Serholt et al., 2018; Yoo et al., 2020a). As a few place- and activity-centered digital services for public libraries have started to emerge as commercial products and in the HCI literature (Gröschel et al., 2018; Yoo et al., 2020a,b), we sought to identify design commonalities and specificities through a design space. When dealing with event-centric information, the role of librarians is even more central, since they play a key role in organizing and hosting events, and in mediating access and co-creation of knowledge. The design space emphasizes librarians' perspectives and practices in respect to event-centric information, as they play a crucial role in facilitating and curating community-based knowledge, and sustaining this as a collective resource over time.

6.1 Challenges and opportunities of designing event-centric systems for public libraries

While there are now guides and handbooks on service design for libraries, these mostly center on collections, with little attention to events. Designing event-centric information displays in a public space comes with a number of challenges, for instance how to link digital and physical documents to the events and how to

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TABLE 6 Example of the design space applied to three concepts: Explore Music Dept, Chitchat Wall, andScreen in the Shelf.

	Aspect	1. Explore Music Dept	5. Chichat Wall	7. Screen in the Shelf
Interaction-centric	**Action**	Watch from afar, Navigate content	Watch from afar, Navigate content, Write content	Navigate content, Consult an Item, Get personal access
	Patron Role	Data consumer	Data consumer, Editor, Curator	Data consumer
	Librarian Role	Curator of external content, Curator of Internal content	Editor, Moderator, Mediator	Editor, Curator of external content, Curator of internal content
Content-centric	**Content Source**	Librarian, Library collections, Web, Partner	Patron, Librarian	Librarian, Library collections, Web, Partner
	Content Type	Event information, Other external media, Video (local source)	Post, Event information, Pictures	Event information, Bibliography, Other external media, Video (ext. source), Pictures
	Content Spatial Proximity	Situated	Non-situated	Embedded
Event-centric	**Event Spatial Proximity**	Non-situated	Non-situated	Non-situated
	Usage Temporality	Before the event, After the event	Before the event, During the event, After the event	Before the event
Device-centric	**Input**	Touch	Touch, Remote control	Touch
	Display Medium	Interactive screen	Interactive screen, screen	Interactive screen
	Display Size	Large, Medium	Large, Medium	Medium
	Multiplicity	Combination of devices	Combination of devices	Multiple devices

design the temporal flow of content before, during, and after events. Prior research contributions have provided valuable knowledge on designing for public displays, particularly regarding interaction techniques and the relations between perception, movement, and interaction of end-users (e.g., Ballagas et al., 2004; Boring et al., 2009; Müller et al., 2009; Alt et al., 2012), but they offer little insights on how such displays can relate to their environment, people creating or consuming the content, the relationship of the displays to their environment, etc. In other words, these design spaces are not situated. Librarians lack practical tools and approaches to support the design of these new type of digital services on event-centric public displays. Our design space seeks to balance the situated insights we gathered through longitudinal participatory design work, and more general insights from the broader workshops organized with librarians. We drew on our deep engagement in three sites to curate and sort the wide variety of design ideas from librarians.

1. Links between collections and events: a number of the concepts we analyzed seek to connect events and collections via space. Concepts such as "Musical Chair," "Screen in the Shelf," or "Guest" display content ranging from videos to pictures and/or websites related to events physically in the library, in thematically related space. This content not only serves to advertise events, it is in line with libraries role as places of knowledge: they serve as sources of information that complement the collections, often with content created by librarians themselves (bibliographies, short articles, book tips) or Internet sources (Youtube videos, Wikipedia articles, blog posts, etc.) (Serholt et al., 2018). Event-related content usually has a short lifespan, compared to library collections. This means that it disappears from the physical library or the library websites, and becomes difficult to discover once the event has passed. With concepts such as "Guest," or the "Musical Chair," public displays become access points to archives of the library activity by giving access to the content of past events.

2. Situating displays in the library space to support a sense of place: place is a multifaceted concept touching upon space, time, and social dimensions. Public displays are not only located in space, but also display content that has a temporality of its own, and the way people engage with them depends on social context. The 18 concepts upon which we built our design space allowed us to analyze numerous combinations of those facets. In practice, placedness relates to the physical location of the displays in respect to collections and events, but also temporal aspects related to use. In our design space, it relates to the spatial proximity dimensions, of both content and events, but also to usage time.

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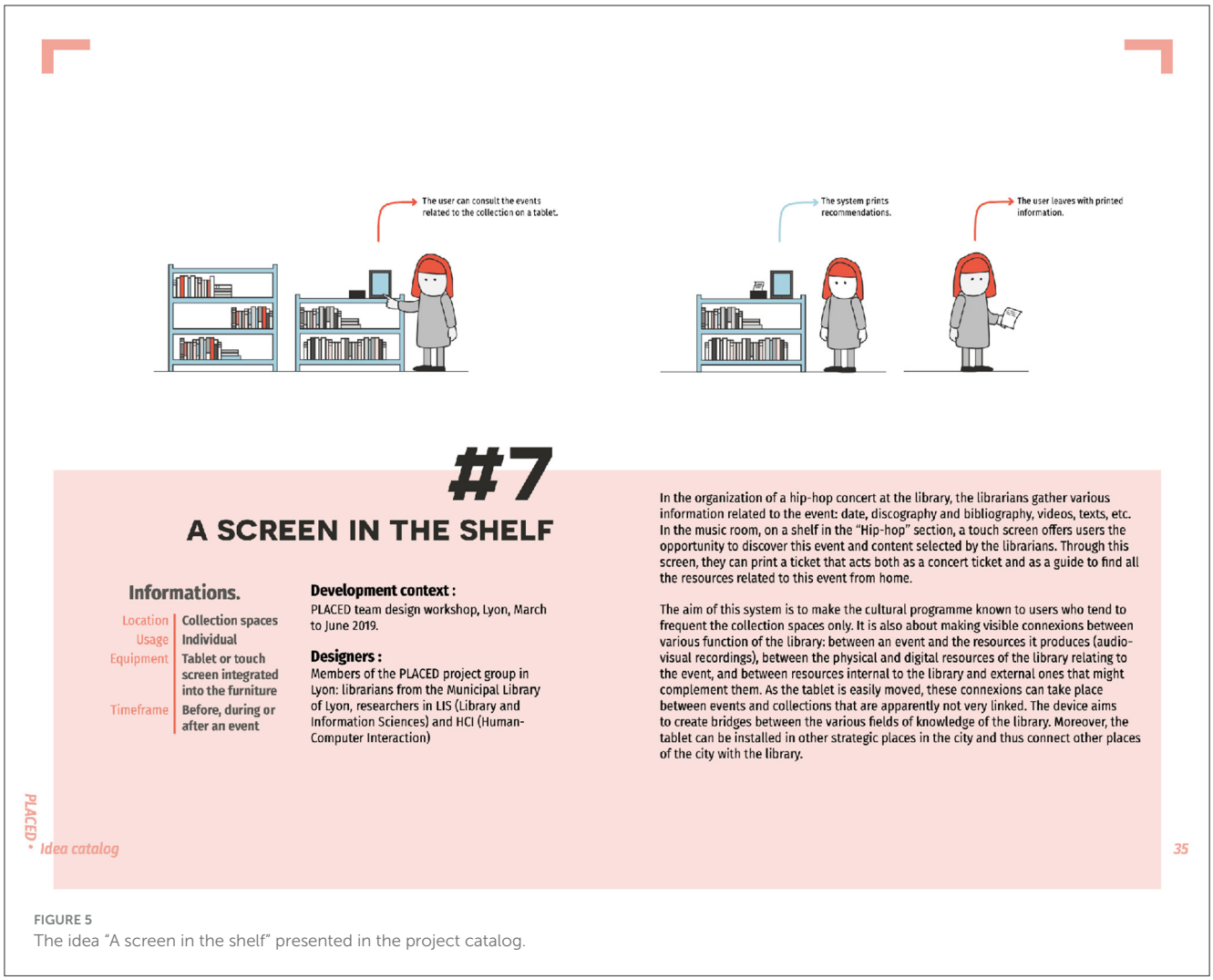

FIGURE 5
The idea "A screen in the shelf" presented in the project catalog.

In many concepts we find a tension between anchoring displays in the collections or in the events. Concepts such as "Screen in the shelf," or "Interactive Poster" are closely tied to the collections but are also thematically close to events: both are designed to be installed in the department responsible for the events they showcase. The first one goes even further as to embed the display in the collections themselves. Devices can also be physically close to the place where events will happen. It is the case with "Musical Chair" or "Live Stream," where the first is installed in the hall of the library, where music shows usually happen, the second leverages the wall outside the room of the event to display a live stream. In order to foster engagement or relate to more people, it may be more relevant to be situated in a space that fosters exchange and participation, rather than a space that it thematically relevant. For instance "Tell your Story" is placed in the reading area to encourage consultation of the content, "Event Summary" is placed in a popular pathway of the library to be more visible, and "Print your event" leverages devices already placed in the library. These prototypes support the sense of place of the library, i.e., where things happen, that patrons are familiar with, and to which patrons belong through experience.

3. Participation, co-creation of content, curation, and moderation: in libraries, the information offered to the public is normally curated by librarians. Displays with public access change this dynamic, by enabling patrons to be the originators of content that will be displayed publicly in the library. Concepts such as "Live from the library" or "Tell your story," proposed to create or share content through the displays. Other forms of contributions are also possible, with "Stream event" participation happens through the live streaming of attendees playing a game, and with "Chitchat Wall" patrons can participate by suggesting music or books.

However, by opening up participation to public displays in a library context, the question of moderation became central to librarians. This was treated in the interaction theme of our design space, by emphasizing the various roles librarians can (or will have to take) such as curators of internal content and moderators. This covers both the type of content that is acceptable (or legal) to publish, but also raises questions of coherence or tone. This concern was notably present in the "Chitchat Wall" concept, and during many discussions that happened around the workshops.

6.2 Potentials and limitations of the design space

We leveraged the design space along with other resources from our project to create a catalog of ideas that could be shared with librarians. The concepts are presented as illustration/comic strip with a description as a short illustrative story and some explanations of the motivation behind the idea (see Figure 5). Our design space is used to classify the idea, and provide extra information on where the displays should be located (content-centric theme), which type of use is expected (Interaction-centric theme), the devices involved (display-centric theme) and how it relates to events time-wise (event-centric theme).

As outlined in the Related Work section, competing conceptions of design spaces have been discussed in HCI. Some design space creators seek to create an objective framework for exhaustively mapping out design dimensions of interactive artifacts. Others favor more performative purposes, i.e., they are meant to help the creators accomplish specific outcomes. Another tension is between approaches that seek to provide generic design spaces that can be applied and reused across contexts, vs. efforts that build upon situated knowledge and anchor design spaces into specific contexts.

The scope and potential uses of a design space varies depending on these conceptions. For instance, the design space for media architecture presented by Biskjaer et al. (2014) is general in scope, since it is intended to capture systems that vary greatly in size, domains of use, content forms, interaction modalities, and users, but still seeks to provide designers with useful parameters. Compared to this, the design space for event-centric displays in public libraries is situated, both in terms of the domain of design, the content, potential users, and the technologies in use. Narrowing the scope of a design space constrains the space of opportunities for designers. This may at first glance seem to hinder design creativity when a design space is used for generative purposes. However, as Onarheim and Biskjaer (2015) have demonstrated, a certain level of constraints can be beneficial for design creativity and our results suggest that it may be the case for our design space with people already engaged in this domain. We ground our design space in a systematic analysis of design concepts for public displays in libraries. This distinguishes our work from other design spaces in the area (Müller et al., 2010; Bendinelli and Paternò, 2014).

Our data-set is—although based on 18 concepts developed by 88 librarians in three different countries—inherently limited. The components of the design space are limited to what was present in the concepts that librarians produced. It may be that the inclusion of additional concepts and products could extend the design space. We see this as an invitation for further development of the design space as a tool for analysis and design. Another limitation is the reliability of the analysis by which we arrived at the design space. The themes have been decided on by the authors themselves, who have been involved in technology development in the library context for many years. As such, the design space may be influenced by the background knowledge that we bring to this field. We have, however, strived for a method by which data drives the analysis. Nonetheless, this long-term and participatory engagement also means that our analysis is deeply anchored in ongoing discussions on the role of information technology in libraries. Another limitation concerns the assessment of the design space. So far, it has been tested with two colleagues and four external HCI researchers with some experience from designing for displays in public libraries. This assessment has provided us with some preliminary results, which indicate that it could be useful to extend the testing.

7 Conclusion

Building on extensive collaboration with staff from public libraries in cities across Europe, we have developed a design space for event-centric displays in public libraries, connecting four aspects of concern: interaction, content, events, and displays. The design space complements previous research on public displays in two ways. Firstly, it is inductively developed via the perspectives of librarians, since they are a keystone species in the information ecology of libraries (Nardi and O'Day, 1999). Secondly, it is strongly situated in the concerns, challenges, and potentials of public libraries, responding not only task-oriented scenarios, but as much so to socially situated and context dependent concerns.

The design space can firstly serve as an analytical tool for understanding and categorizing information displays and identifying overarching design considerations, and secondly be a generative framework to inspire design. In particular, the design space indicates three ways in which interactive displays can be designed and employed to support the changing role of libraries as hubs for events and activities in cities: firstly by connecting events to the libraries' collections of media; secondly by establishing or strengthening the sense of place in libraries as a shared, communal institution; and thirdly by supporting co-creation and curation of content from events via the participation of library patrons.

Our ambition is that the design space can inspire, and support designers and library staff realize some of these potentials in the design of future event-centric displays in public libraries. As part of this, we are continuing our collaboration with public libraries to examine how to best communicate the design space and the insights we have gained from the process of developing in such a way that local libraries can adopt and appropriate them to best fit their local circumstances, and we expect to report on these efforts in future work.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

AD led the work, organized some of workshops, collected and analyzed data, and contributed to writing. RB led some of the workshops, collected the data, and contributed to the analysis. AT contributed to the analysis and the writing. EE and PD contributed

and participated to the writing. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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