Diving in at the Deep End: The Value of Alternative In-Situ Approaches for Systematic Library Search

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ABSTRACT

OPAC interfaces, still the dominant access point to library catalogs, support systematic search but are problematic for open-ended exploration and generally unpopular with visitors. As a result, libraries start subscribing to simplified search paradigms as exemplified by web-search systems. This is a problem considering that systematic search is a crucial skill in the light of today's abundance of digital information. Inspired by novel approaches to facilitating search, we designed CollectionDiver, an installation for supporting systematic search in public libraries. The CollectionDiver combines tangible and large display direct-touch interaction with a visual representation of search criteria and filters. We conducted an in-situ qualitative study to compare participants' search approaches on the CollectionDiver with those on the OPAC interface. Our findings show that while both systems support a similar search process, the CollectionDiver (1) makes systematic search more accessible, (2) motivates proactive search approaches by (3) adding transparency to the search process, and (4) facilitates shared search experiences. We discuss the CollectionDiver's design concepts to stimulate new ideas toward supporting engaging approaches to systematic search in the library context and beyond.

Author Keywords

search, public library, tangible interfaces, multi-display environment, in-situ study.

ACM Classification Keywords

H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

INTRODUCTION

The role of public libraries has changed from a pure provider of information to an institution of lifelong learning which provides access to global information resources and a local learning setting for guidance and training in media literacy [6]. It is often libraries where critical (re)search skills are taught—crucial capabilities in today's world of ever-increasing information resources of varying quality.

Today's public libraries offer access to a vast range of media in physical and digital form. Interfaces to electronic library catalogs (known as OPACs: Online Public Access Catalogs) can be therefore considered as key mediators between visitors' information needs on one side and physical and digital library resources on the other. Much research has been done to understand search practices in physical and digital information spaces [1, 13, 25, 30, 36, 37, 38] and how to support these through interface design (e.g., [16, 46]). However, the question of how to impart media literacy through the support of *systematic* and *in-situ* search in public libraries is still underexplored. Our research aims to fill this gap by investigating alternative approaches to, still typically text- and list-centered, library catalog interfaces (e.g., see Fig. 2) in order to promote systematic in-situ media search at public libraries.

While OPAC interfaces provide convenient access to library resources and are commonly used outside and within public libraries, it is well-known that they are not without difficulties. Early studies found that while targeted, known-item searches are well-supported, open-ended *subject searches* are problematic [2, 26, 29, 45]. More recent studies confirm that this still holds true: people still often find OPAC interfaces difficult to use, in particular compared to canonical web search engines which support more free-form queries [18, 23]. Studying book search strategies in public libraries, Mikkonen and Vakkari found the catalog to be the least popular tactic [30]. This trend is problematic as libraries still host information resources that are not necessarily represented in common search engines [3]. Current trends in OPAC interface design go toward search paradigms as exemplified by canonical web-search engines. While this approach accommodates visitors' expectations who are typically experienced in using such search engines, it does not mediate systematic information seeking skills, such as the specification and adjustment of search criteria along different facets.

We describe the design and study of an alternative library search system—CollectionDiver—which supports systematic in-situ search comparable to traditional OPAC interfaces

Figure 1. Small family engaged in shared search on the CollectionDiver.

while applying a fundamentally different approach to information and interaction design (see Fig. 1). Inspired by previous research [21], the CollectionDiver combines large display technology with tangible and direct-touch interaction, and visual with textual elements to make systematic library search accessible and transparent. A qualitative study which compared library search activities on the CollectionDiver and on a common OPAC interface revealed that both systems similarly support systematic search processes. However, the CollectionDiver (1) makes systematic media searches easier to understand and, therefore, more accessible, (2) promotes active approaches to search by (3) catering for a transparent search process, and (4) facilitates shared search experiences, an important aspect in public libraries that are often visited, for example, by small families. Our discussion of the design concepts manifested in the CollectionDiver stimulates new ideas toward supporting more engaging approaches to systematic search in the library context and beyond.

DESIGNING (LIBRARY) SEARCH INTERFACES

A large body of work has investigated general search behaviors and processes [1, 13, 25], and, more specifically, search processes in library catalogs (e.g., [4, 10, 18, 23, 27, 42]), public libraries [30, 36, 37, 38], and book stores [7]. When designing our in-situ search system, we followed design-centered models of the search process [40], as well as contemporary guidelines toward designing search interfaces [16, 46]. Hearst and Wilson, for example, both highlight the need of supporting the fluid adjustment of search criteria, and establishing a close connection between search criteria and the result list [16, 46]. Hearst in particular stresses the importance of visual aesthetics in the design. Focusing on exploratory approaches to search, White and Roth highlight the importance of promoting an understanding of the search process to facilitate the active adjustment of search criteria [43].

To our knowledge, alternative approaches to systematic search of library catalogs *in-situ* are underexplored. The few exceptions to this are (book) search interfaces that have been designed with young audiences in mind [11, 12, 14, 19]. While our work is inspired by approaches which incorporate the use of novel technology such as direct-touch displays [15, 39], RFID sensing [8], tangible tokens [11], or interactive floor systems [14] to promote engagement, we focus on alternative search systems that support systematic, faceted search.

Previous work has discussed alternative solutions to general search interfaces. Advances in supporting collaborative search, for example, typically incorporate large displays to increase awareness of the search processes among group members and to facilitate shared interactions [21, 31, 32, 33]. Our work does not focus on collaborative search, but we seek to enable and promote *shared* search experiences through the use of large displays where visitors can casually browse the library catalog with their friends or family.

Interfaces have been built that provide a more visual approach to search which integrates search and result navigation. With InfoGallery, Grønbæk et al. present the idea of showing library-related information on large surface displays throughout the library [15]. Kleiner et al. introduced Blended Shelf, a digital book exploration system that borrows its design from typical physical bookshelves [24]. Thudt et al. introduced the Bohemian Bookshelf, a visualization-based system designed for exploratory book search that enables the navigation of a book collection along several qualitative perspectives [39]. Their findings from an in-situ study highlight the importance of providing multiple access points to the collection and enabling playful interactions to motivate more elaborate exploration [39]. Our approach to systematic search systems for libraries is inspired by this previous work and the design considerations that follow from it.

Other visual approaches have been applied to facilitate an understanding of the search process itself, for example, by visualizing Boolean queries [47, 28]. This has been taken a step further, making use of tangible tokens to facilitate the search process in a more hands-on way [21, 41]. However, none of these approaches have been studied in a library context. In our work we expand on the idea of Facet-Streams [21] making it suitable for use in a public library and studying how this design approach compares to a common OPAC interface in terms of visitors' search processes and experiences.

RESEARCH BACKGROUND

Our research was conducted at the main branch of the Public Library Cologne in Germany which, with over 937.000 visitors per year, is highly frequented. Across six floors, this main branch offers a large spectrum of topics (e.g., children's books, fiction and non-fiction), media types (e.g., books, eBooks, DVDs), and interactive systems (e.g., internet workstations, search terminals, and a 3D printer) to support (re)search, learning, and (creative) thinking. Our collaboration was driven by the library's motivation to explore digital technology as a means to promote search and exploration activities in a systematic yet engaging way.

Contextual Inquiry

The design of the CollectionDiver was informed by findings from previous work as outlined above, as well as a one-week contextual inquiry that we conducted at the library early on in this project. As part of this we observed visitor activities and gathered information via brief interviews and questionnaires from 75 visitors about their library use, the types of interactive systems they utilize to satisfy their information needs, and the types of problems they encounter as part of this. We also interviewed three librarians about their work with visitors and typical search habits, and talked to pupils who visited the library for a training course on (re)search methods.

Our inquiry largely confirms previous findings regarding the vast range of visitor backgrounds (i.e., age, professional and social background) and diverse library usage patterns. The majority of visitors come to the library alone, but some visit in small groups (e.g., families and student groups). The Online Catalog terminals from which the library catalog is accessible (see Fig. 2) are typically used for targeted searches. Most visitors are familiar with the interface and also use it within the library. However, most in-situ explorations focus on browsing the shelves, and many visitors still rely on in-person interaction with librarians to find media of interest.

As most web search interfaces the Online Catalog is designed for individual search activities as conducted by adults. It provides a "Quicksearch" and "Advanced Search" feature where
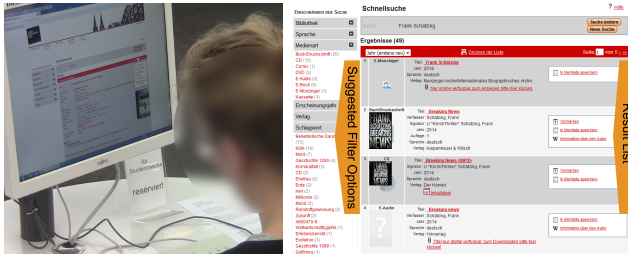
Figure 2. The Online Catalog library search interface.

one or several search terms have to be specified before any media or additional filters are shown. The Quicksearch features a single text field for specifying queries, while the Advanced Search supports the combination of several search terms through logical AND or OR connections. If a search term has been specified, a result list is shown with related keywords to the left-hand side of the interface which can be applied to further filter the result list (see Fig. 2, right).

Design Goals
From our contextual inquiry and previous findings we derived a list of goals that guided the design of the CollectionDiver.

Support Systematic Media Search through Novel Interaction
Prompted by visitors' limited engagement with the Online Catalog as a library exploration tool, and by the problems of OPAC interfaces previously discussed [2, 26, 29, 45], we envisioned an alternative search system that would make the library catalog more *accessible* and systematic search a more *engaging* endeavor. Inspired by previous work [21, 39], we aimed at exploring tangible interaction mechanisms to specify search requests in order to provide a distinct counterpart to the mouse-and-keyboard interaction paradigm offered by the Online Catalog and to, potentially, allow people to approach their search in more playful ways.

Promoting a Proactive Approach to Search
Our contextual inquiry revealed visitors' difficulties of coming up with adequate search terms and/or of understanding how the result list (which can be lengthy or empty) is influenced by individual search criteria or filters. Our goal was to address this lack of *transparency* in the search process, while, at the same time, making different types of filter mechanisms easily adjustable to enable a proactive search approach.

Bridging Physical and Digital Information Spaces
We can consider an OPAC interface as a mediator between physical and digital information spaces: It is the shelfmark listed in the OPAC interface which connects the digital to the physical information space. Inspired by the idea of *blended interaction* [22], we aimed at exploring interaction mechanisms to bridge digital media search and shelf browsing.

Facilitating Shared Search Experiences
Search in public libraries is defined by individual and shared explorations (e.g., among family members or as part of consultations with library staff). Yet, the canonical OPAC interface is mostly designed for single users. Inspired by previous work on collaborative search [21, 31, 32, 33], we aimed at supporting casual shared search experiences in-situ.

COLLECTIONDIVER: DESIGN & FUNCTIONALITY
Guided by these design goals the CollectionDiver expands the idea of "Facet-Streams" [21]. With a public library context in

mind, we simplified some interaction techniques and modified the visualization of the Boolean logic to ensure intuitive use. Physical setup and interactive features were designed for shared rather than collaborative search experiences.

The CollectionDiver (see Fig. 7) is permanently installed at the Public Library Cologne, running on the same back-end as the Online Catalog, that is, it represents the library catalog in its entirety. It consists of two direct-touch displays (1920 × 1080), controlled by a single PC (I7-4770K, 8GB Ram, GTX 760, Win 7). The tabletop display (MultiTaction MT420S; 42") uses an optical camera system built into a LCD backlit display to enable limitless multi-touch tracking and marker sensing. This enables the formulation of search queries through tangible tokens. The vertical display (Citron dreaMTouch; 55") uses an infra-red frame to detect up to 32 simultaneous touches. It allows for browsing and assessing search results. Both displays are conceptually and visually linked, as described below.

Horizontal Search Display
The horizontal display offers five types of physical tokens to assemble a search query. Similarly as in Facet-Streams, each token can be considered as a filter to the library catalog [21]. However, each token type represents particular query parameters: three tokens are available to specify *search terms* and one token each to specify an *author*, *publication year* range, *media type(s)*, or *language*. The design of physical tokens (custom-built acryl blocks equipped with optical markers) directly reflects on the query parameters they represent and makes them distinguishable from each other (see Fig. 3).

To initiate a search, a visitor places a token on the display which brings up additional options to be adjusted via direct-touch. For example, the media token enables filtering the catalog for particular media types (e.g., books, DVDs, magazines, or eBooks). Several options can be selected simultaneously (see Fig. 4, left). The year range token can be used to find media published in a particular time span: start and end year can be specified using the arrow buttons (see Fig. 4, right). Placing the search term or author token on the display, evokes a text field and direct-touch keyboard that allows visitors to specify terms or names of interest (see Fig. 5).

As soon as a token is placed on the display, a search query is executed and results (if there are any) appear on the vertical display (see Fig. 7). A tool tip is always visible below the token to show the number of media that match the token's criteria (see Fig. 4, left). If there are no matching media found,
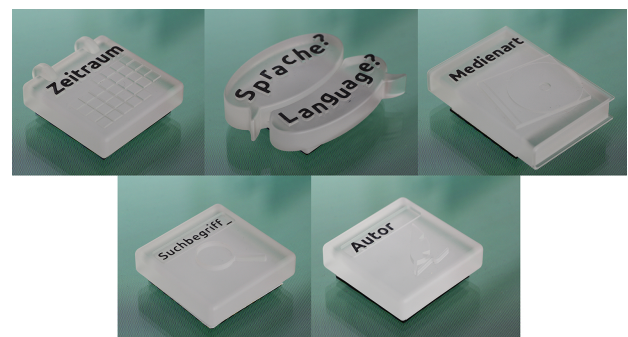

Figure 3. Filter tokens. Top row (left to right): year range, language, and media type token. Bottom row: search term and author token.
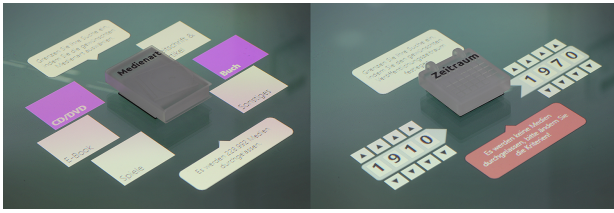
Figure 4. Media type token (left), the year range token (right).

Figure 5. The search term token allows the visitor to specify a search term of interest via touch-typing.

this tool tip turns red and a text indicates that the criteria have to be adjusted (see Fig. 4, right). In this way, the influence of each token on the result list is always visible. To highlight the conceptual link between the search and the result display, a stream of digital bubbles floats from the token that was last placed on the table up onto the vertical display.

Placing multiple tokens on the table enables complex media searches (see Fig. 6). The order of placement determines the order in which the different filters are applied to the library catalog. Moving tokens on the table does not change this order. However, lifting a token up and placing it somewhere else, will cause this particular token filter to be executed last. A stream of bubbles indicates the order of filter execution.

Placing tokens onto the tabletop surface automatically links them into a logical conjunction; their relative position to each other does not matter. One exception are the search term tokens, which can be linked by a logical conjunction or disjunction, depending on their physical proximity to each other. When far apart, the search term tokens form a logical disjunction, visible by their individual bubbles which indicate that each search term is treated as a separate filter in the search query (see Fig. 6, left). Moving the two tokens together changes the shape of the bubble, indicating that a potential connection can be established (see Fig. 6, left). The bubbles will eventually merge as the tokens come close to each other (see Fig. 6, right). With this merge, the corresponding search terms are connected with an ampersand "&" to indicate their logical conjunction. Only a single stream of bubbles emerges from this combination of search terms to further highlight the conjunction (see Fig. 6, right). Spatially separating conjoined search term tokens will break up their conjunction, and they will be linked as a disjunction instead. Any desired number of search terms can be joined or disjoined in this way, given that enough search term tokens are provided.

Vertical Result Display
Query results as specified by the tokens are presented on a vertical display in list form, similarly as in the Online Catalog (see Fig. 2). Media items are listed by their title, author, and shelfmark, with a cover image (if available) displayed to the left. Visitors can browse the list by sliding their finger
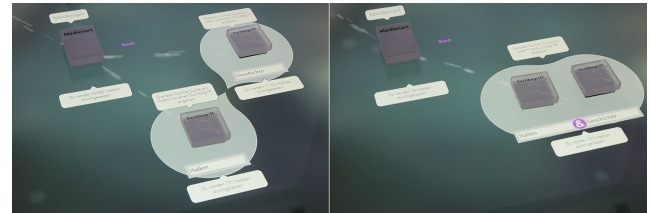

Figure 6. Three filter tokens forming a conjunction of three search terms. The resulting number of items is shown below each token.

up or down the display. A touch-tap on a media item fluidly expands it into a detailed view which includes the items' indexed keywords, an enlarged cover image and a floorplan showing its location at the library (see Fig. 7, middle). In contrast to the Online Catalog, these details are revealed within the context of the result list; no additional information layer opens up (cf. [16, 20]). Visitors can print a slip with all information necessary to find the item at the library using the item's print button (see Fig. 7, middle & right). Five buttons below the list allow the sorting of results by relevance (selected by default), title, author, year, or media type.

The CollectionDiver provides an alternative way of searching the library catalog in-situ. With our approach we aim to (1) support different search approaches, (2) provide a bridge between the digital and physical information spaces inherent in a public library, (3) promote transparency of the search process, and (4) facilitate shared search experiences by making the system accessible to multiple visitors at the same time. The differences between the design concepts manifested in the Online Catalog and the CollectionDiver are summarized in Table 1. We conducted a semi-controlled study at the public library to investigate how these differences effect visitors' search approach, process, and experience.

PUBLIC LIBRARY STUDY
Our study follows a within subject design where recruited participants conducted searches based on given open-ended search tasks using the CollectionDiver and the Online Catalog, which runs on terminals throughout the library (see Fig. 2) . Favoring this semi-controlled setup over an in-the-wild study ensured that participants worked on comparable search tasks and provided similar attention to both systems.

Participants
We recruited 33 study participants (11 male, 22 female; 12 individuals, 9 dyad, 1 triplet). Our study was widely advertised through the library's website and bulletin boards across the city. The recruitment of participant groups (group members knew each other prior to the study) in addition to individuals allowed us to gain insights into *shared* search approaches with the two systems. The triplet was formed by one dyad who spontaneously brought their four year old daughter. She participated in the search tasks but not in the interviews.

We deliberately recruited participants from different age groups and professional backgrounds. Our adult participants span five age bands: 18–21 (three people); 22–34 (13 people); 35–44 (three people); 45–54 (eight people); and 55–64 (three people). In addition, the four-year-old and two 13 year old girls participated each with a parent. Participants' professional backgrounds (excluding the 4-year-old) ranged from

Figure 7. Participant browsing the result list (left), bringing up details of a media item (middle), and printing an information splip (right).

	Online Catalog	CollectionDiver
Information Structure	Layered/Nested	Flat
Search & Results	Integrated in one view	Visually and physically separated
Interaction Design	Mouse & keyboard	Combination of tangible + direct-touch
Display Hardware	Small display	Large vertical + horizontal display
Presentation of Search Criteria	Textual approach	Combination of tangible, textual, and visual elements

Table 1. Design concepts of the Online Catalog and the CollectionDiver in comparison.

high-school (4) and university students (4), artists, photographers, social workers, academics, technicians, managers, retired, and currently unemployed people. This diversity in age and background is typical for the audience of large public libraries. Four participants were first-time library visitors and two visit the library everyday. The majority come to the library at least once a week (14 participants) or once a month (four participants). Eight participants visit *"occasionally"*. Six participants stated to not use the Online Catalog; three of those were first-time users. 12 participants stated to use the Online Catalog both at home and at the library, while eight/six use it from home/at the library exclusively. Only three participants had noticed the CollectionDiver prior to the study and only one had very briefly tried it once in passing.

Study Setup & Procedure

To mimic a realistic library search scenario as closely as possible, our study took place during the library's opening hours on the floor where the CollectionDiver is permanently installed. This floor hosts mostly non-fiction text books, study spaces, and terminals featuring the Online Catalog. Participants therefore interacted in a realistic setting alongside other library visitors who looked for books themselves.

Participants filled out a questionnaire about their age, background, frequency of their library visits and use of the Online Catalog. Participants were then given six search scenarios from which they chose two. The scenarios described open-ended search tasks focusing on a different topic each (Art & Culture, Health & Sport, Travel, Literature, Children's books, and Technology). For example, the Health & Sport scenario puts participants into the role of someone who has recently acquired an interest in running and is now looking for media about training methods and nutrition advice. Participants were encouraged to interpret the task based on their own interests and to find suitable media given the scenario, rather than going for quantity. In order to avoid learning effects, each participant/group worked on two different tasks, one using the Online Catalog and another using the CollectionDiver. Participants picked the first scenario themselves, before knowing which system they would start with. The or-

der in which participants used the two systems was counterbalanced. Participants received a 2 min. introduction to the search system in focus, regardless of their prior experience with it. They were then given a maximum of 15 min. for their search tasks, but could finish earlier. Group participants worked together on the tasks, sharing each search system.

We conducted an interview with participants after each search task, asking them about their general approach, any problems they had encountered using the search system, and their satisfaction regarding the supported search process and the found media. At the end of the study we conducted a final interview, asking participants to characterize the two systems in comparison, for example, regarding supported search features, interface design and interaction mechanisms, and personal experience. Dyads were also asked to reflect on their shared approaches using both systems. Each participant was compensated with 15 Euros for their time.

Data Collection & Analysis

Two researchers were present throughout the study to observe and take written notes of participants' interactions with the two search systems. All interactions were video recorded using a single camera for the Online Catalog and two cameras for the CollectionDiver, to capture interactions with both the tabletop and the vertical display.

All interviews were fully transcribed and qualitatively coded following a thematic analysis approach [5]. We iteratively coded for statements describing search processes, utilized system features, and experienced advantages and disadvantages of the two search systems. A qualitative video analysis was conducted following [17], which focused on the sequential use of search features in the two systems and included counting the use of features and criteria adjustments. Group search processes were analyzed for shared interactions.

Our findings, as described below, are based on this qualitative analysis of participants' interviews and interactions with the two search systems. We illustrate our results with direct participant quotes which are tagged with their individual ids ("i" for individual and "g" for group participant). All participant quotes were directly translated from German into English.

GENERAL APPROACHES TO MEDIA SEARCH

Previous research has characterized search strategies in digital systems as a combination of querying, assessment, and selection activities [1, 13, 40]. We found our participants' search workflow on both search systems to be consistent to these previous findings. Although they follow quite different design concepts (see Table 1), our video and interview analysis revealed that both systems support a similar search approach. Participants spent the same time with their search tasks on either system (both 11:30 min. in avg.; CollectionDiver SD 3:25 min.; Online Catalog SD 3:35 min.), discovered comparable amounts of suitable media items within this time (Tiefenrausch: 5 items in avg., SD 2; Online Catalog: 4 items in avg., SD 1.7), and were generally satisfied with the found items. However, participants were less confident with media items found using the CollectionDiver because it does not provide enough details about items' content.

Search on the Online Catalog

The Online Catalog requires the specification of search terms to initiate a query, so all participants started their media search by entering terms that they identified from the task description into either the "Quicksearch" (in 14 of the 22 study sessions) or "Advanced Search" feature (eight sessions). Participants then typically scanned the result list, assessing media items first based on their title, author, or cover and then, as part of a more low-level assessment, based on the item's content summary or table of contents. The latter involved selecting individual items from the result list which opened a new detail view. If an item was deemed as suitable to the task description, participants wrote down its shelf signature.

The search filters offered on the left-hand side of the interface, which allow narrowing the result list based subject headings, publication year, or media type, were used in all but two study sessions. This type of filtering was applied in particular in combination with the Quicksearch feature. Four participants explicitly expressed a preference for *gradually narrowing* their results, first using the Quicksearch to get an idea about the character of available items, and then applying the suggested filters. In contrast, eight participants/groups chose the Advanced Search directly to get less but more specific results right away: *"I like to directly narrow my search. I don't want to get 600 books that I have to scroll through."* [g22.A].

Each search task featured a number of different aspects, and participants adjusted their search criteria frequently throughout the task: they experimented with the filters mentioned above and changed their search terms (8.8 term adjustments on avg.; SD 5.24). Six of the 22 participants/groups switched between the Quick- and the Advanced Search feature at least once. These switches were typically triggered by an unsatisfyingly long- (switch to Advanced Search) or short result list (switch to Quicksearch). In particular the latter occurred frequently—50% of Advanced Searches did not return results (18% of Quicksearches for comparison), leading to frustration: *"Via the Advanced Search, nothing came up at all."* [i12]. Participants were often not aware of the difference between indexed keywords (as expected by the Advanced Search) and free-form search terms. Half of them expressed confusion why even common search terms would not

retrieve any results. This may be one of the reasons why 34% of our participants found the Online Catalog *"cumbersome"* to use, even though all but three had prior experience with it.

Search on the CollectionDiver

Participants initiated their search on the CollectionDiver typically via the search term token. In two study sessions, however, participants started with the media type and one with the language token before specifying a search term. In contrast to the Online Catalog, the CollectionDiver supports these different entry points into searching the library catalog. The media type was used in combination with the search token(s) in 19 of the 22 study sessions; the year was used in nine sessions and the language token in in five. The author token was not used, probably because of the search tasks' character. In 19 study sessions at least two search term tokens were combined in conjunction/disjunction depending on the result list; four participants/groups combined three term tokens. In fact, 46% of participants explicitly stated that Boolean AND/OR operations were easier to understand in the CollectionDiver than on the Online Catalog: *"I think it is easier to get the AND/OR search. Because [...] you see immediately: you put them together and now I search for both terms. [...] I think it is faster to understand."* [g22.A].

Participants' frequent manipulation of search criteria on the table (13.9 term adjustments in avg., SD 10.5) was intertwined with an assessment of the results on the vertical display. Here, participants' strategies compare to those on the Online Catalog: they scrolled through the result list, visually assessing media based on their title or covers, either directly or via the detail view. One major complaint about this assessment process was the lack of additional information about media items (content summary and availability information) which are currently not shown due to structural problems of the library catalog. This information was considered as crucial and its absence a reason to not use the system. Furthermore, several participants bemoaned the absence of keyword suggestions that the Online Catalog provides in form of filters alongside the result list. All participants found the feature of printing a slip with an item's details very useful.

Only one of our participants had previously (very briefly) used the CollectionDiver, and most participants agreed that they needed the brief introduction we provided as well as some time to become familiar with the system. However, after just a few moments of interaction time, none of them had difficulties understanding how to use it for searching the library catalog. That being said, all participants had visible problems specifying search terms using the touch keyboard, caused partially by the sensitivity of the touch display and partially by our keyboard design. All participants expressed frustration about this usability issue, and for some this clearly added to a negative impression of the installation altogether.

Despite of these usability issues and the novelty of the CollectionDiver's interaction mechanisms, our observations show that participants' search processes on both systems were similar, and their statements confirm this: *"I proceeded more or less in the same way."* [i18]; *"I like the physical tokens, but they are basically just a replacement of the query fields. [...] If I add a physical token to narrow my results, or if I en-*

ter a term into a search field does not make much of a difference." [i17]. Even a participant who felt less enthusiastic about the CollectionDiver stated: *"Using the CollectionDiver did not feel worse than the normal search system."* [g6.A].

The fact that the CollectionDiver supports a similar search process than the Online Catalog is remarkable considering its differing and, to participants, initially unfamiliar design concept. Going one step further, our findings suggest that these design concepts, in combination, positively influenced participants' search experience. 18 participants indicated a clear preference for the CollectionDiver as a search system and stated that they would *"definitely"* use it as part of future library visits for reasons that we will discuss in detail in the next section: *"It is a huge advantage that it does the same thing, but in a quite different way and with a more positive appearance."* [g15.B]. Eight participants generally preferred the search process through the CollectionDiver and would use it at the library, if the usability issues with the touch keyboard get fixed and additional information about media items and their availability are shown. Of the six participants who expressed a clear preference for the Online Catalog some generally prefered using a physical keyboard. Others (frequent users of the Online Catalog) did not see enough benefits in the CollectionDiver search or were thrown off by the fact that it is currently only installed on the third floor of the library.

EXPERIENCED DIFFERENCES BETWEEN THE SYSTEMS
Below we discuss how the different design concepts of the two systems influenced participants' experience of the search process and their overall preferences.

Design & Aesthetics
Independent of their general preferences, all participants commented on the CollectionDiver's *"visually pleasing"*, *"modern looking"*, and *"inviting"* appearance. Three participants even described the design as visually *"calming"*, commenting on the constant movement of bubbles from the horizontal to the vertical display: *"It is not grey and boring [compared to the Online Catalog]. I find the bubble effect very calming."* [i13]. In contrast, the Online Catalog was described as *"old fashioned"* or even *"boring"*, and participants complained about its visual layout which, as they stated, features a lot of information but in a slightly overwhelming, uninviting way. However, while the CollectionDiver's visual appearance positively impacted participants' overall impression of the system, our interviews show that visual aesthetics are not the deciding element in visitors' preferences; effective input mechanism play an important role—a weakness of the current version of the CollectionDiver: *"It looks pretty. It is prettier [than the Online Catalog], but if you have to constantly retype, and it doesn't work, it becomes unnerving."* [i2].

Tangible Interaction & Playfulness
Participants generally enjoyed interacting with the physical tokens and the direct-touch displays which, as they stated, promotes an approach to search which combines physical activity, tangibility, and direct manipulation: *"You are in it with your whole body. Your are somewhat more physically involved."* [i8]. One participant pointed out how much he appreciated *"this direct handling and touching, directly communi-*

nicating with the system." [g22.B], another commented on the physical movement involved when manipulating the tokens: *"Personally, I find it positive, because I think that movement stimulates the brain."* [i21].

The tangible tokens and the interface design of the CollectionDiver were experienced as playful, illustrated in the following two statements: *"It was fun using the CollectionDiver because of the physical tokens. Because it is a little bit playful."* [g1.B] and *"This haptic aspect is very appealing. That you can move these cubes around. In that way this is somehow fun."* [g7.A]. This playful aspect was a deciding element for many participants' preference of the CollectionDiver over the Online Catalog: *"It is just more fun with these tokens. If you have a little bit practice, and this goes very fast, it is simply more fun. Much nicer."* [i18]. Some participants even pointed out that there is a motivating element in the playful interaction to further explore the library catalog: *"It is in particular the playfulness of the CollectionDiver that motivates me to really search for more."* [g15.B].

Interestingly, however, the playful aspect put off other participants who described the CollectionDiver as *"gimmicky"*: *"I just want to find a book. I don't want to play some games."* [g11.B] and *"I find it too gimmicky. I am thinking of the adult visitors. This one is suitable and very good for the children's section. But I think adults would expect a perfectly normal direct-touch display."* [g4.A].

Overview & Transparency of the Search Process
While Online Catalog and CollectionDiver provide similar search and filter mechanisms, their presentation of these features differs. Our findings suggest that the CollectionDiver's large display and its tangible/visual approach to specifying search criteria provides a better overview of the search process and makes the influence of applied filters on search results transparent. This, in turn, not only promotes a better understanding of how results are generated but also an active approach to adjusting criteria throughout the search process.

Visibility of Filter Options and Specified Criteria
The Online Catalog and CollectionDiver apply different design concepts to support the filter and search process (see Table 1). The Online Catalog follows a *layered approach* where particular criteria and filters have to be specified step-by-step. For example, the visitor first has to specify a search term before other filter options appear—these are not visible in advance. In contrast, the CollectionDiver shows options and specified criteria in a single *flat* view. Participants' comments indicate that the latter approach has advantages when it comes to 1) promoting an overview of available filter options and 2) keeping track of specified search criteria: *"I can imagine that many will find this easy to use, because you have these tokens and you can place them, and you don't have to search in this nested way."* [g7.A]. Her partner added: *"Yes, and you see directly: 'What did I specified already?'. It is more comprehensive with the CollectionDiver. [...] I can imagine, that you rather get ideas yourself, how to connect things, because you have the different tokens, and you can see: 'Oh, yeah, I can add this one, too'."* [g7.B]. Another participant explained why the Online Catalog's nested approach is problematic: *"If you enter another search term [...] you have to open some-*

thing new, and you have to specify the term. And in this way, you do not have everything in one view." [i21].

The visibility of specified search criteria in the Collection-Diver paired with tangible interaction helped participants to fluidly adjust their search criteria without much effort: *"Yeah, it is easier to search. Simply the question if you want an OR or AND-connection. It's much easier, you can just do it and look what comes around."* [g6.A]. In contrast, adjusting search criteria in the Online Catalog was experienced as *"cumbersome. I do get all the information, but I cannot search for so many aspects at the same time, as here [the CollectionDiver]."* [i3]. That being said, the keyword filter options that are targeted toward the specified search term(s) are a strong advantage of the Online Catalog. The CollectionDiver lacks this feature, as stated earlier: *"We did not have any suggestions for keywords. That was a little bit disadvantageous."* [g4.B].

Transparency

The CollectionDiver's tangible and visual representation of filters in one view added transparency to the search process: *"You better understand what the program currently 'thinks' that it should do. You can better restructure your search request.[...] In the Online Catalog you enter something and the thing spits out something. You have no indication of how the algorithm actually works."* [g6.A]. *"You can understand 'How does it narrow down things?' For me, that was interesting to see."* [i12]. Participants mentioned that even more complex search processes, such as conjunctions and disjunctions of search terms, became easy to understand using the CollectionDiver. The bubbles that connect the tangible tokens also added to this transparency which promotes a flexible adjustment of search criteria, if necessary: *"The course of the bubbles shows you as well how the program connects things; the way of filtering."* [g6.A]. *"I like that you get things visualized, with these bubbles, how the search is executed, and what you have available. And that you can see this in one view, how to narrow things, and how to type in things and how to remove things [search criteria]."* [i13].

Display of Search Results: Large vs. Small Display

While the CollectionDiver's tabletop display helps to provide an overview of the search process, there were mixed opinions about the presentation of search results on a large vertical display. 22 participants indicated a preference for the large display approach because visual information (e.g., book covers) can be shown on a larger scale, and items in the result list are more readable. *"You don't need glasses."* [g7.B], as a more senior participant pointed out. Another participant explained: *"You can see more details at once."* [g9.A]. However, some participants had quite the opposite opinion: *"The problem is, that this display does not provide a good overview. It is much too large and much too close. [...] If I stand half a meter in front of a 1.5 meter display, I can see nothing if I have 200 results there."* [g11.B]. Three participants also criticized the presentation of search options and results on two separate screens: *"This looking back and forth between top and bottom is a bit troublesome."* [g6.A].

With its small display and layered information design, five participants thought that the Online Catalog provides a better overview of search results: *"You can see things bet-*

ter on a smaller, more constraint area, and you are not distracted, because you can focus on just that particular area." [i21]. That being said, navigating media items and adjusting search criteria was found to be more problematic: *"It was difficult with the back and forth navigation. This was better here [in the CollectionDiver] because it all stays visible."* [g7.A].

Another concern about the CollectionDiver's large result display is that of privacy. 30% of our participants mentioned that they were well aware of their search results being visible to other people and stated that they would be cautious of using the CollectionDiver for more sensitive search topics.

Shared Experiences during Search

Analyzing the search strategies of our 10 groups (e.g., choice of search features and sequences) did not reveal major differences to those of our individual participants, although additional discussions of search criteria and media selections naturally took place. With the Online Catalog, one group member typically controlled the keyboard and mouse while the other supported the search process verbally. On the CollectionDiver we observed more turn taking and equal activity of both group members. This is also reflected in participants' statements. When asked if they noticed differences in their search process, all but one group felt that, in contrast to the Online Catalog, the CollectionDiver facilitated shared interactions more. The large displays provide an awareness of the partner's interactions and space for more collaborative search processes where both group members can be actively involved in specifying and modifying search criteria: *"You can better see what the partner is doing. [...] I think, you can work together in a better way. [...] Because it is bigger, you can stand next to each other and everyone can also type a little bit."* [g7.A]. *"On the computer, one has control of the mouse. On this system [CollectionDiver], you can walk up with two or three people and everyone can do something. The other one is more like 'I do, and you watch'."* [g20.A].

The shared specification of search criteria can be particularly important if both group members have different ideas about the topic or the search strategy. One group stated that their search approaches at the library differ: one partner likes to specify their search criteria, the other applies a more open-ended approach, narrowing results more gradually. Using the Online Catalog, one partner took control of mouse and keyboard and therefore decided how they would approach the search. She explained: *"I took over the keyboard and that was it. You don't tend to say: 'Now I will type in a word, and then you can type a word again'. There [with the Collection-Diver], you do this really together."* [g22.A]. Another advantage of the shared access to search tokens is that visitors can help each other if interaction problems arise: *"I mistyped a word a couple of times. I would have deleted the whole word, and re-typed it, because I found it to finicky. But she just touched it [the text field] and deleted the letter that was wrong and corrected it. And that went relatively well."* [g22.B].

These findings indicate that the CollectionDiver facilitates shared media searches among small groups. However, one participant mentioned that even on the CollectionDiver, shared interactions were not without problems: again, the

separation of search criteria on one display and results on the other can cause interfering interactions between group members: *"It can be easier on the PC [Online Catalog], because there is only one display that you are focusing on. While with the other system [CollectionDiver], if one is looking at the upper display, and the other does something on the lower display [the table], you are not really aware of it."* [g19.B].

For public libraries that are often frequented by families promoting shared search experiences is particularly important. Our observations and participants' statements suggests that the CollectionDiver is child-friendly and supports shared searches among small families. When the group with the 4-year-old searched for media items on the CollectionDiver [the parents deliberately chose the children's book scenario], the young girl was actively involved in the assessment and selection process, pointing out media items that she liked and she wanted her parents to print out (see Fig. 1). While her parents were reading out the titles for her, she was able to see the cover images and therefore could participate in the assessment process. In contrast, when her parents searched for child-oriented travel books on the Online Catalog, she showed no interest in participating. While this disinterest may be topic-dependent, the computer terminal, which was difficult for her to see or reach, did not raise her curiosity. She clearly showed more interest in the CollectionDiver's touch displays and the tangible tokens. Her parents stated that they would definitely continue to use the CollectionDiver when searching for books together with their daughter in the library. While these observations are promising, future studies need to further investigate the suitability of the CollectionDiver for children, including different age groups.

Learning How to Search Systematically

As discussed, participants found the representation of the search process on the CollectionDiver to be more transparent and *"accessible"* [i17], compared to the Online Catalog. Nine participants explicitly explained that they thought the system would be, potentially, more suitable for children who are just learning to systematically search for books or other media: *"I deem it for more suitable for children. It is simply fascinating to see: I put the token here and it goes from 100 down to 20. And then I take it away, and I have all options again. [...] I think if you make that clear on the Collection-Diver, you can also say: 'And the same happens here in the catalog, you just have to do it like this and like that.' "* [i17].

Three of our participants (2 adults and one 13-year-old) had no experience with either search system. All three of them thought that both systems require some instructions and practice, but all stated their preference of the CollectionDiver and that they would use it in the future. The girl explained: *"I knew what I had to do, but I like this one better. [...] It is more fun the way I can take this [a token] into my hand and place it [on the display]."* [g9.B]. We need to further investigate this potential of the CollectionDiver to teach novices the principles of systematic search in the future.

Table 2 summarizes the strengths (+) and weaknesses (–) of the Online Catalog and the CollectionDiver. The strengths of one system implicitly point to weaknesses of the other. Additional information about media items, more efficient text in-

Online Catalog
+ Additional information about media items
+ Efficient input mechanisms
+ Rich filter suggestions

CollectionDiver
+ Appealing design & visual aesthetics
* Tangible tokens promote playful interactions
+ Overview of search criterial & process
+ Flexible adjustment of search
+ Transparency of search process
* Overview of search results through (split) large displays
+ Support of shared search experiences
* Suitable for children
+ Ability to print item info
– Privacy concerns

Table 2. Listed strengths (+) of the Online Catalog can be considered as weaknesses of the CollectionDiver and vice versa. The (∗) marks controversial aspects.

put mechanisms, and additional filter suggestions would further improve the current design of the CollectionDiver. The use of large display technology supports shared search experiences well but also evokes privacy concerns. Tangbile interaction techniques to promote playful interaction were deemed as advantageous by all but three participants, which is why we marked it as a controversial aspect (∗). Similarly, future research has to investigate the impact of (split) large displays to present search results as well as the suitability of the CollectionDiver for younger children and families.

DISCUSSION

We set out to explore how an alternative in-situ library search system could be designed to support systematic media search in an accessible and transparent way to promote a proactive approach to search and to facilitate shared search experiences among small visitor groups. In the following we discuss the CollectionDiver's design concepts (see Table 1) in the light of these goals and the questions this case study raises for the integration of alternative search systems in public libraries.

Making Systematic Media Search Accessible

Our findings indicate that the CollectionDiver is successful in making systematic media search accessible, even to visitors with little experience in common search systems (e.g., the Online Catalog). The flat information structure facilitates *multiple access points* to the library catalog. Visitors are not forced to start their search by specifying a search term; all filter options are available from the beginning. This allows for initiating the search in more versatile and open-ended ways . The visual and tangible representation of filter options facilitates informed decisions about adjusting search criteria. In fact, the visual design of the CollectionDiver promotes versatile searches, where participants felt compelled to adjust their criteria for further explorations. Previous work on promoting *generous approaches* to collection interfaces [44] and serendipitous discoveries [39] support this argument. However, our concept needs to be expanded to integrating recommendation mechanisms, for example, in the form of keyword suggestions to fuel associative thinking and creativity—important factors when it comes to open-ended search [40]. While our playful approach to interaction design

increased some participants' motivation to explore the library collection, others clearly prefered a more pragmatic approach which is more in line with the design of the Online Catalog.

Promoting Proactive Approaches to Search
Previous work and our contextual inquiry revealed that library visitors, in-situ, do not use traditional OPAC interfaces for extensive searches but quickly branch off to the shelves which promote more pleasurable exploration experiences [30]. In contrast, our findings suggest that the CollectionDiver promotes an enthusiastic and proactive approach to systematic in-library search. Again, the flat information structure which facilitates navigating the information space spanned by the library catalog plays a key role here: *"The interface is directly manipulable. You don't have to click around, everything is on one surface."* [g22.B]. Similarly the presentation of search criteria as discussed above helps people to understand how search results are generated which, paired with the playful interaction design, can motivate people to adjust or expand their search: *"I definitely found it motivating. [...] 'Ok, I will look further here, and here, too'. On the Online Catalog, I was rather glad that I could get away to the shelves where I can look at the books."* [g15.B]. However, detail information about selected media is crucial—a feature that the Collection-Diver currently lacks, though it could be easily integrated.

Promoting Transparency of the Search Process
Transparency of the search process is not only important to promote more proactive and in-depth searches; it is also crucial when it comes to teaching people how to search systematically—a key skill to critically engage with today's vast information sources. Despite of participants' familiarity with the Online Catalog, our findings show that the CollectionDiver, through combined visual and textual presentation of filters, better provides an understanding of media filtering. This transparency is further supported by a the flat information structure which keeps currently active search criteria and filters visible at all times and allows to open details of media items *within* the wider context of the result list, enabling a lightweight assessment process. We found that it is the visual representation of the search process, rather than the tangible interaction design, that is key when promoting transparency. Therefore, other types of interface design, that are, e.g., based on visual, non-tangible representations of search filters and/or using smaller direct-touch displays (see, e.g., [34]) may present alternative solutions. Participants' experience of the two large displays to present search criteria and results separately were diverse. Some thought this layout led to an improved overview, while some preferred the integrated view provided by the Online Catalog. Furthermore, the large displays raised privacy concerns among 34% of participants. Future design iterations should investigate the combination of different display sizes and technology (e.g., capacitive displays to improve the text input mechanisms [9]).

Facilitating Shared Experiences
We have shown that the CollectionDiver's large displays and decentralized interaction design facilitate shared search experiences among small groups and, potentially, even among parents and their young children. As suggested by previous work on co-located, collaborative work [35] and search [21, 31, 33], presenting search criteria and filters as well as search results on a large display helps group members to equally participate and to maintain a general awareness of the search process. Furthermore, providing interaction techniques that enable the individual and independent control of search criteria and filters facilitates a shared approach to specifying and modifying these, which can, in turn, promote active participation and discussions. The visual presentation of connections between search criteria and filters and how these effect the result list leads to transparency which further facilitates shared experiences. However, the impact of using multiple displays for presenting the search process and results remains an area for further research as it can also lead to a lack of awareness and, in turn, interfering interactions among group members.

Another question that our case study raises is if the design concepts manifested in the CollectionDiver can facilitate media search among younger audiences. Our observations of one family with a young child indicate the potential of the CollectionDiver to support the active participation of young children in the search process. This is supported by previous studies which suggest a flat information design for child-friendly book search systems [19]. Future studies need to investigate in more detail how small families experience the CollectionDiver, and if/how the system can help teaching children and other novices the concepts of systematic search.

CONCLUSION
With the CollectionDiver we have presented a new approach to supporting systematic, in-situ library search by combining tangible and large display direct-touch interaction with visual representations of filter connections. Our qualitative, comparative study shows that, while the CollectionDiver enables a similar search process as a typical OPAC interface, it positively influences participants' experience and engagement. The design concepts, namely a flat information design, playful tangible interaction, the visual, and textual representation of search criteria, and the large display technology (1) makes systematic search more accessible, (2) motivates proactive approaches by (3) adding transparency to the search process, and (4) facilitates shared experiences. Weaknesses of our current design approach include the lack of detail information about media items, the inefficient direct-touch text entry mechanisms, the lack of filter suggestions, and potential privacy concerns that search on a large display system raises. The playful interaction design and the display layout that separates search criteria and result space came out as controversial aspects. Our discussion of the CollectionDiver's design concepts stimulate new ideas toward supporting engaging approaches to systematic search in the library context and beyond. Future studies could explore how these concepts apply to other public information spaces such as museums.

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