

Search in One's Hand: How Users Search a Mobile Library Catalog

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Abstract. With the rapid growth of mobile devices, mobile websites become an important channel of library resources and services. The mobile catalog is often significantly different from its desktop version in interface and features, but few studies of library catalog search behavior have been focused on mobile catalog searches. We present a study on user search behavior with a mobile library catalog based on transaction log analysis. We compared mobile and desktop catalog search behaviors and highlighted the similarities and differences, which could provide important evidence for improving mobile library catalogs' search performance and usability.

Keywords: Mobile search behavior · Library search · Search log analysis · Mobile application development

1 Introduction

With the rapid development of mobile technology, the amount of searches conducted on mobile devices has dramatically increased. A recent report by the Pew Internet and American Life Project showed that over one third of cell phone activities are looking for information online [1]. Particularly for libraries, recent surveys showed that a majority of users expect to use mobile devices to access library resources including the catalog, databases, and reference services [2, 3]. The number of libraries offering mobile sites and mobile catalogs is rapidly growing [4]. Thus mobile websites have become an important channel of library resources and services. The mobile catalog is the core of a library's mobile website, and it is often significantly different from its desktop counterpart in terms of interface and features. While previous researchers examined users' search behavior with desktop library catalogs, few studies were focused on mobile catalog searches. To fill this gap, we conducted a transaction log analysis of user search behavior with a mobile library catalog. In the study we compared mobile and desktop catalog search behaviors and identified the differences, which could be used as a basis for improving mobile catalog's search performance and usability.

2 Related Work

2.1 Mobile Websites and Libraries

Library websites provide users with access to the catalog, databases, online journals, as well as different types of information such as locations, hours, services, and events. Libraries have been attempting to implement these elements on their mobile websites along with the advancement of mobile web. As an early example, West et al. reported the development of a mobile website on small-screen devices (e.g., PDA) for Ball State University Libraries [5], which encompassed the library catalog, journal search, videos about the libraries, collection information, inter-library loan and course reserves. The UC San Diego Libraries developed a mobile website using rapid development and testing cycles and the mobile website included hours, catalog, ask a librarian, research tools and databases, maps and directions, contacts, and a link to the full desktop site [6]. Regarding the elements of mobile websites, Bridges et al. suggested that libraries should first focus on time-sensitive and location-based services [7]. It is also important to understand library users' likely goals and tasks in mobile use scenarios [8].

For library catalogs on the mobile websites, there have been several vendor-supplied solutions, such as the AirPAC by Innovative Interfaces and WorldCat Mobile by OCLC, although there was a lack of customization and feature enhancement among those solutions [7]. Libraries have also developed their own mobile catalogs, an example of which is the mobile catalog at Oregon State University Libraries [8]. The mobile catalog could be searched by keyword, title, subject, ISBN, and course reserves by instructor or subject. The search results include call numbers, availability, and physical locations; and each result (item record) includes title, author, description or table of contents, and a link to the item's shelf view. Users can email or text the item's call number from the mobile catalog. An emerging trend of mobile website and mobile catalog is the responsive design of interfaces to support a wide range of mobile devices with various screen sizes and resolutions [9, 10].

2.2 Mobile Search Behavior

With the increasing use of mobile devices as an essential platform for information access, it is important to understand the information access behaviors of mobile users, particularly on their use of mobile devices for query-based search and information browsing. A significant part of studies on mobile search behaviors are based on the analysis of transaction logs. Transaction logs are electronic records of user interactions (e.g., clicking on a link, entering search queries, selecting a search field, etc.) with information retrieval systems. Although the format of transaction logs may vary depending on specific server settings, most logs contain information elements such as the particular page (URL) requested by the user, the identity of the requesting user (IP address), the date and time of the request, and whether the request was successful [11]. Transaction logs capture users' behavior in natural settings and can accumulate to a large amount of data over time. Analysis of

transaction logs can thus generate details of user behavior and interaction with the system at a large scale.

In general, previous studies have found that the diversity of mobile search queries was far lower than desktop searches, the length of mobile search queries was shorter, and users spend significantly more effort (time and key presses) to enter query terms [12, 13], possibly due to the physical constraints of mobile devices.

A seminal study by Church et al. analyzed the search behavior of more than 600,000 European mobile users in late 2005 [13]. They found that browsing dominated mobile information access in terms of traffic, but sessions involving search activities tended to be significantly longer and with more data usage than sessions without search. They compared a range of metrics of search and browsing behavior (e.g., query length, query reformulation, topic and interests) between mobile and desktop users. The results suggested that mobile search was in an early stage of development comparable to the desktop search in the mid 1990's. The majority of mobile users (76 %) used Google as their search engine, but the remaining 24 % of users used approximately 30 other search engines. Both mobile and desktop searches rarely used advanced search features. The average query length of mobile searches was shorter than desktop searches (2.06 vs. 2.3 query terms). Mobile searches had a high rate of query reformulation (23 %). The query substitution rate (i.e., replacing query terms without changing the query length) of mobile searches was 47 %, which was higher than the rate found in desktop search. Mobile searches contained a more limited set of query terms than desktop searches, probably because the content on the mobile Internet was relatively limited.

Users' search behavior with mobile devices is changing over time as users gain more experience. Kamvar and Baluja found that from 2005 to 2007 users typed faster (56.3 vs. 39.8 s) and increased their search query length (average 2.3 vs. 2.6 words). The queries were less homogeneous, as the top query in 2005 accounted for 1.2 % of all queries but that percentage decreased to 0.8 % in 2007.

There is an important distinction regarding the study of search behavior based on transaction logs between web search engines and digital library catalogs [14]. The goal of web search engine log analysis is to characterize users' information needs, such as how users make request by submitting queries; how users access and select search results; and how the search engine organizes and presents search results. Digital library catalogs usually have well-organized and explicitly described library collections (i.e., objects with much higher quality metadata than common web pages); and the goal of transaction log analysis is to study how users interact with the search interface in order to improve the effectiveness and efficiency of the search process.

Although a great deal of the literature was focused on users' search behavior with desktop library catalogs (more recently, discovery tools) [e.g., 15–17], little research has investigated how users search the mobile library catalogs. Extending previous studies that reported users' expectations and needs of libraries' mobile websites and catalogs, research on mobile catalog search behavior could reveal how the mobile interface supports information retrieval and how it should be better designed for the mobile context. Therefore, the goal of this study was to understand users' search

behavior with a mobile library catalog. Particularly, we expected the study could help answer the following research questions: (1) who were the mobile users and what technologies mobile users used to access the mobile catalog; and (2) how users searched the mobile catalog and whether there was any difference between mobile and desktop catalog searches.

3 Research Method

3.1 Study Site

The mobile library catalog we studied was part of the University of North Carolina at Chapel Hill (UNC) Libraries’ mobile website. The mobile website was launched in 2009 to support mobile users finding books and basic information such as library hours and branch locations. Users are automatically directed to the mobile website if they are using a mobile device. The mobile catalog interface was developed internally at UNC Libraries by accessing and reformatting the XML data into mobile-friendly representation from the desktop catalog (Endeca). The interface was implemented in PHP and iui web UI framework for mobile devices.

The mobile catalog was designed to support a primary use case: searching for a specific or known item by title or author. Thus it does not include most of the advanced search options in the desktop catalog. The item level display in the mobile catalog was designed to show essential item information, with clearly laid out physical location information and link for further actions. Figure 1 shows the homepage of the UNC Libraries mobile website and main interface of the mobile catalog. On the Catalog page, users enter search queries in the standard search box and the search fields include *Keyword*, *Title*, *ISBN*, *Journal Title*, *Author*, and

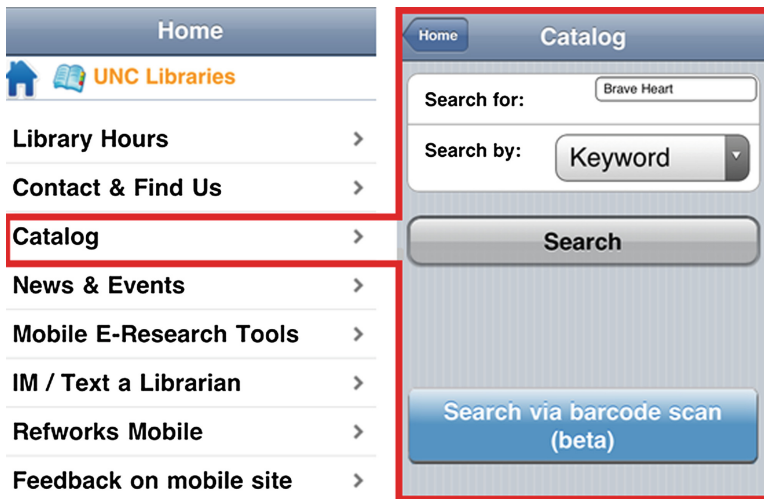


Fig. 1. The UNC Libraries’ mobile website and mobile catalog

The image shows a mobile library catalog interface. At the top, there is a navigation bar with a 'Catalog' button and 'Catalog results' text. Below this is a header for 'UNC Libraries' with a home icon and a book icon. The main content area is divided into two columns. The left column displays a list of search results, each with a title, author, and a right-pointing arrow. The right column shows a detailed view of the selected item, 'Brave heart of Jesus : Mel Gibson's postmodern way of the cross'. This view includes the author 'Egan, Joe, 1954-', a book cover image, the publisher 'Columba Press, 2004.', a note about bibliographical references, and a 'Locations' section for 'Davis Library' with a call number 'PN1997.2.F39 E43 2004' and a green 'Available' status. At the bottom of the item page, there are several blue links: 'Email this item's info', 'Text this item's info', 'Bookmarkable link to this item', 'See full (non-mobile) page for this item', and 'Back to main mobile page'.

Catalog Catalog results

UNC Libraries

Brave heart of Jesus : Mel Gibson's postmodern way of the cross, by Egan, Joe, 1954- >

William Wallace : brave heart, by Mackay, James A. (James Alexander), 1936- >

Pray for a brave heart, by MacInnes, Helen, 1907-1985. >

Dilwale dulhania le jayenge [videorecording] = Dilavāle dūlhaniyā le jāyēnge >

Polly of the pines : a patriot girl of the Carolinas /c by Adele E. Thompson ; illustrated by Henry Roth., by Thompson, Adele E. (Adele Eugenia), b. 1849. >

Polly of the pines [electronic resource] ; a patriot girl of the Carolinas., by Thompson, Adele E. (Adele Eugenia), b. 1849. >

A mighty heart : the brave

Brave heart of Jesus : Mel Gibson's postmodern way of the cross

Author: Egan, Joe, 1954-

Publisher: Columba Press, 2004.

Notes: Includes bibliographical references.

Locations:

Davis Library
 Call #: PN1997.2.F39 E43 2004
 Available

[Email this item's info](#)

[Text this item's info](#)

[Bookmarkable link to this item](#)

[See full \(non-mobile\) page for this item](#)

[Back to main mobile page](#)

Fig. 2. The search results page and item page of the mobile catalog

Subject. Figure 2 shows the results list page and item page when users select a result from the list. Options on the item page include email, text, bookmark, and link to the full item page on the desktop catalog.

3.2 Data Collection

We used Google Analytics to understand basic user information and conducted deeper transaction logs of the mobile catalog for search behavior analysis. The time window for the analysis was one month, from March 1 to March 31, 2012, for which we collected 759 useful log records for 216 sessions from the mobile catalog server. In addition, we also analyzed the log data (21,685 records) from desktop search during the same time window. Information in each log record included IP address, date, time, URL requested, referrer URL, and user agent. The logs were parsed and imported into SAS 9.2 for statistical analysis. We also used a previously developed visualization application, VUTL [18], to visualize the log information and explore potential behavioral patterns.

Table 1. The top ten mobile devices used to access the mobile website

| | Mobile device | Number of visits |
|----|--------------------------------|------------------|
| 1 | Apple iPhone | 357 |
| 2 | Apple iPod Touch | 63 |
| 3 | Apple iPad | 38 |
| 4 | Not set | 25 |
| 5 | HTC ADR6300 Incredible | 15 |
| 6 | HTC EVO 4G | 12 |
| 7 | Samsung SC-02B Galaxy S | 10 |
| 8 | Sony Ericsson LT15i Xperia Arc | 10 |
| 9 | HTC Glacier | 7 |
| 10 | HTC ADR6350 Droid Incredible 2 | 5 |

4 Results

4.1 User Overview

Google Analytics data showed that visits to the mobile website were steadily increasing since its launch in 2009, from 1.14 % of overall traffic to the libraries' websites in spring 2011 to 3.45 % in spring 2012. During March 2012, the mobile website received 755 visits from 455 unique visitors. Among the 755 visits, 329 (43.6 %) were new visits and the rest 426 (56.4 %) were returning visits. The majority of the visits (692, 91.7 %) were from the U.S. Most of visitors were from North Carolina, especially the Research Triangle Area, where UNC is located. This suggests that the mobile website was primarily used by local users. Table 1 shows the top ten mobile devices used to access the mobile website (the No. 4 "Not set" means Google Analytics was not able to identify the mobile device for the visits). Most of the mobile devices were smartphones except for Apple iPod Touch and iPad.

4.2 Search Behavior

Action Distribution. The simple functionalities of the mobile catalog limited the types of user actions it could support. We identified three possible actions: *TypeQuery*, where the user typed search terms in the search box; *SwitchSearchField*, where the user switched between search fields for the inputted search query; and *ViewRecord*, where the user clicked an item on the search results page and opened the item page. The distribution of the three actions and its comparison with desktop searches are shown in Fig. 3. Note that the *TypeQuery* and *ViewRecord* actions were fairly evenly distributed for mobile searches and the *TypeQuery* action has a lower percentage than *ViewRecord*. On the contrary, the *TypeQuery* action in desktop searches had a higher percentage than *ViewRecord*. Switching search fields was uncommon for both mobile and desktop catalog searches.

The average time spent on each type of action was also calculated and shown in Table 2. The average time for typing a query was comparable between mobile and

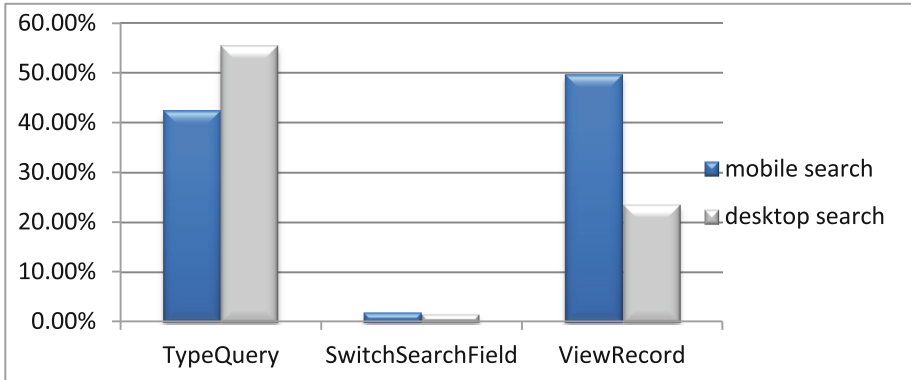


Fig. 3. Action distribution between mobile and desktop search

Table 2. Average time spent on actions

| Action | Average time and standard deviation in mobile searches (seconds) | Average time and standard deviation in desktop searches (seconds) |
|---------------------|--|---|
| Type query | 44.8 (7.6) | 43.7 (12.6) |
| Switch search field | 95.8 (46.2) | 81.7 (49.1) |
| View record | 125.9 (100.4) | 31.7 (20.8) |

desktop searches. The relatively large standard deviation for typing queries in mobile searches suggests that mobile users had higher variations in formulating their queries than desktop users.

We defined session length as the number of actions within a particular session, and set boundaries between sessions if more than 30 min of inactivity occurred. Figure 4 shows the distribution of session lengths for mobile and desktop searches. Sessions longer than 30 actions were not displayed due to their low percentage (<the mobile website 0.1 %). The session length distribution between mobile and desktop searches was roughly consistent with some differences at the lower end. Most search sessions were brief and the average number of actions per session was 3.5. The two-action session was the most common for mobile searches while the single-action session was the most frequent for desktop searches. Further visualization of sessions showed that the two-action pattern “*TypeQuery - ViewRecord*” was the most common action sequence among mobile searches.

Search Sessions. The average query length of mobile searches was 2.3 terms, comparable with the average of desktop search (2.7 terms). This similarity is in line with the comparable average time for typing queries in mobile and desktop searches. Two-term queries were the most frequent (32.5 %) among all queries and queries longer than six terms were very rare.

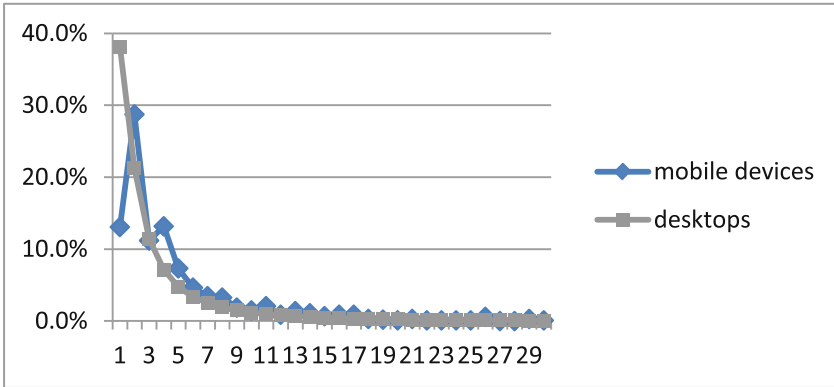


Fig. 4. The session length (number of actions) distribution for mobile and desktop searches

The most common search field among mobile searches was the default option *Keyword* (Fig. 5), similar to desktop searches and previous findings [13]. The *ISBN* search, usually a very specific and close-ended search, was much more common in mobile searches; while the exploratory and open-ended *Subject* search was less frequent in mobile searches than in desktop searches. These results suggest that users of the mobile catalog had a clearer goal of their searches and were looking for very specific information (e.g., a particular book).

Query Formulation and Reformulation. Approximate 48 % of mobile search sessions involved query reformulation, which is close to the percentage of desktop search sessions (50 %). The average number of clicks after each query formulation was 1.2, higher than the average number of 0.8 in desktop searches. This is possibly due to the fact that search results in the mobile catalog had limited information due to the screen display constraint and users had to view the item page to get more detailed information.

From the visualization of search logs of the mobile catalog, the most frequent queries were book title or author names, such as *From Darkness into Light, Principles*

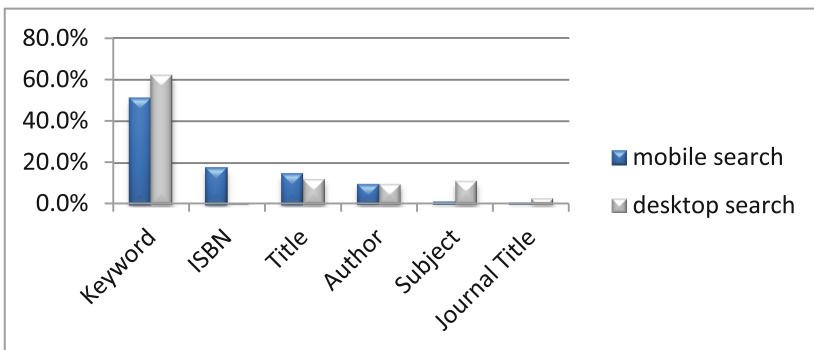


Fig. 5. Search field distribution in mobile and desktop searches

of *Biochemistry*, *Hunger games*, *Nancy Bercau*, and *Lehringer*. Most of these book title and author name queries pointed to specific items in the catalog. Topic searches or open-ended searches were rarely seen. This is different from the desktop searches, where a considerable portion of searches were topical or open-ended.

Mobile searches had similar query reformulation patterns with desktop searches, as many reformulations involved subtle changes to or simple deviations from the original queries. This observation is consistent with White and Marchionini's finding that in desktop searches many further queries were simply "syntactic variants" of the initial queries [19].

Three reformulation strategies were identified from the log data: narrowing by adding query terms, broadening by removing query terms, and paralleling by changing query terms. Broadening was much less common than narrowing in mobile searches. There were no consecutive uses of broadening or narrowing in search sessions. Instead, the combination of adding, removing, and changing query terms was common. One example is: *botanical data* → *mods* → *mods metadata* → *darwincore* → *darwin core* → *Darwin core metadata*. A few users switched the search fields in order to change the search scope. Two examples are: *An American rhetoric* (keyword) → *Watt, w.w.* (author); and *Beyond post process* (keyword) → *Dobrin, Sidney* (Author). A possible reason for this switch is the original queries led to too many search results from the catalog, so that the user was trying to narrow down the search scope.

5 Discussion

In this study, we analyzed information from Google Analytics of the UNC Libraries mobile website and transaction logs from the mobile and desktop catalogs. The results showed that the mobile website was used mostly by local users with Apple mobile devices. Possible interactions with the mobile catalog were limited, due to the limited functionalities of the mobile catalog. Typing query and viewing item record were the dominant actions in mobile searches, while users rarely switched the search field. The query length and session length of mobile searches were comparable to desktop searches. Most mobile searches were about specific items; and exploratory searches were rare with the mobile catalog, different from the combined exploratory and known item searches with the desktop catalog.

There were differences of action distribution between mobile and desktop searches. Different from previous studies [12, 13], users spent less time on typing queries than viewing item records, possibly due to the mature input techniques on most current mobile devices. Users clicked more on the search results and spent more time viewing records than desktop searches, which is different from Church et al.'s finding [13]. This difference could be caused by the fact that the mobile catalog interface puts more emphasis on item level information than the search results list.

The percentage of queries reformulated in mobile searches was close to the percentage of desktop searches. While previous studies on general web searches [20] indicated that desktop searches had higher percentage of query reformulations than mobile searches, the recent development of smartphone interfaces has enabled users to overcome the usual input constraint and conduct more searches as they would with

desktop catalogs. Similarly, the average query length of mobile searches was close to desktop searches and the longest mobile query we found was 14 terms. This suggests the traditional gap of query input between mobile and desktop searches is shrinking.

Our analysis of the query terms and search field distribution suggested that specific item (or known item) searches were common with mobile catalogs and the ability to locate the most relevant result is important. Thus the design of mobile catalogs need to well support this unique use scenario. For example, the relevance ranking could be adjusted to emphasize more on known items and the interface should allow easy change of the query and search field.

6 Conclusion

This study was an initial effort on investigating how users conduct searches in mobile library catalogs. The results revealed the similarities and differences of search behavior between mobile and desktop library catalog searches. The differences are partly due to the different motivations of mobile and desktop users, and partly caused by the simple mobile catalog interface with limited features for mobile users. Our findings could be used as a basis for further examination of mobile search behaviors with library catalogs and the improvement of mobile library catalogs.

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