Library log analysis and its implications for studying online information seeking behavior of cultural groups

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Abstract

Log analysis, as one of the less overtly intrusive ways to study information seeking behavior online, has been used to closely monitor patterns of user system usage looking at activities and actions since the 1980s (Villén-Rueda et al., 2007). However, to date there have been limited studies discussing its usage in respect of information seeking behaviors of cultural groups in the academic library context. With the growth in international student numbers, the increasing remote use of the library service and a globally connected digital environment, the particular needs and behaviors of different cultural groups, when studying in different settings, merits far greater attention.

This paper uses a library log analysis in order to explore international Chinese users' usage of an academic library in the UK and discusses the implication of it as a research method in library and information studies (LIS) research, reflecting on the potential for greater analysis of different cultural groups. The findings demonstrate that log analysis can be used as a method to better understand particular cultural groups information seeking behaviors; it also discusses the limitations of log analysis and gives suggestions for future research work.

Keywords: Library log analysis; Information seeking behavior; Digital library system; Cultural groups; Chinese information behavior

Introduction

The late 20th century saw an explosion of online information made available through an increasing range of digital services and resources. As such there has been a transformation over time in information processing, usage, storage, communicating and audience reach (Salganik, 2019; Thorson & Wells, 2016). Nevertheless, the quantity and diversity of information online delivers both opportunities and challenges when exploring information seeking behavior (Bawden & Robinson, 2009). Within the context of a library service, there is now a requirement to mediate and provide enhanced access to digital content. In addition, the digital library system must understand and serve users' evolving information needs and information seeking behaviors, ensuring that any library system design and any updates explore user needs in all aspects of digital delivery (Xie & Matusiak, 2016). Within this context, it is important to understand different user communities and their needs. One such student community in the UK are Chinese students, which in 2020 it was claimed made up the highest international student community within the UK accounting for £1.7 billion in tuition fees each year (Davies, 2020). This is reaffirmed by data from the Higher Education Statistical Agency (HESA), which recorded that in the academic year 2017-2018, 43% of students taking postgraduate degrees in the UK were from non-EU countries; and Chinese students constituted the largest single group (HESA, 2019). To date, digital library research has been largely focused on discovering what the users are doing in the digital library system as a mass community and how the system should be designed to accommodate their general behavior. However, there is a dearth of research studying different library cultural groups and as international student cohorts have grown, this represents an omission in serving all communities and working towards inclusion and nondiscrimination. Furthermore, it is possible that enhancements for one cultural group will benefit another. Finally, as more bespoke journeys become possible it is important to understand different potential needs.

Multiple techniques and instruments have been developed and applied to study information seeking behavior of library users, ranging from quantitative, qualitative to mixed methods. Among them, log analysis is considered to be an unobtrusive method which is able to show the activity and behavior of online users on a large scale (Covey, 2002). Log analysis has been a common research method since the 1980s (Villén-

Rueda et al., 2007). However, despite the usefulness of log analysis as a research method, there are very few studies discussing the application of it to learn about cultural groups in the library context. This paper strives to fill this gap and highlights its strengths and limitations through an analysis of international Chinese users in an academic library within the UK.

Literature review

In the Library and Information Science (LIS) field, information users or patrons are defined as any individual that interacts with the resources and services of, or in relation with, a library; they are not necessarily a registered borrower (Reitz, 2007, p. 491). There is a long history of user studies in the LIS field, especially with a focus on digital library system usability tests, where the aim is mainly to find out users' needs, behaviors and expectations (Chowdhury & Chowdhury, 2011b). Techniques from web analytics have been used to learn about library users' interaction with the resources and services provided by digital libraries and to evaluate the quality and usability of digital library systems (Agosti, 2008; Betty, 2009; Nouvellet & D'Alché-Buc, 2018). Library websites, or digital library systems, are conceived to be very different from normal web search engines. Web Search Engines (WSE), are defined as tools that "deal with the representation, storage, organization of and access to information items which are essentially web pages" (Agosti et al., 2012, p. 665), whereas digital libraries hold collections that are more structured, organized and described by expert librarians. They are built with an explicit goal of providing elaborately selected high-quality resources to serve the unique information needs of their users, ensuring they are targeted and relevant to their study and research work. Search engines such as Google use Natural Language Processing (NLP) which navigates information at scale across languages (Bohn, 2019); whilst most library systems rely on 'faceted' searching (Tunkelang, 2009). Library log analysis is seen by some as a comprehensive way of demonstrating all aspects of users' behavior and the operation of the system (Nouvellet & D'Alché-Buc, 2018).

The emergence of the Online Public Access Catalogues (OPAC) brought with it the introduction of library user log analysis research in the mid-1980s (Villén-Rueda et al.,

2007). Log analysis is frequently used in the context of academic libraries to learn about the varied search behaviors of university library users (Villén-Rueda et al., 2007), or in researching user behavior in more advanced digital library systems that contain multiple forms of resources (for example: multimedia resources, newspapers, archives etc.) (Agosti et al., 2012; Gooding, 2016). Since the 1980s, log analysis has been used as a common method of investigating user interactions, search patterns and information behavior in library systems (Jones et al., 2000; Millsap & Ferl, 1993). From logs, multidimensional data can be traced, including general data (demographics, pages, users, etc.), resources usage, sessions and actions, time log, searches and other descriptive statics, which provide clear indicators of how the system has been used (Cohen, 2003).

Over the decades, research utilizing log analysis in the digital library context has proved it to be a useful tool in exploring user activity and behavior in the digital library system and in helping with the system improvement (Arshad & Ameen, 2015; Kaur & Aggarwal, 2015; Wakeling & Clough, 2016). It is claimed that log analysis can generate "a detailed description of the behavior of a given group of users, on a single retrieval system, for a particular document collection" (Jones et al., 2000, p. 152), which is a vital consideration in monitoring targeted parts of an information system and the use of a particular group of people. However, despite the refined analysis that demonstrates some general user preferences, such as user activities during a day or their search patterns (e.g. landing page, browsers, operating systems, session length, etc.), the findings from the log analysis alone are hard to generalize as motivations and individual characteristics are hidden behind collective behavior. For example, a review work from Markey (2007a) summarized the statistics from 32 transaction log analysis studies conducted upon search engines, library OPACs and index service. Through her work, some common characteristics of users' search behavior were identified, such as the query length and the use of Boolean Operators, which indicated how the users were searching in the web. However, by reviewing the information retrieval models, she also pointed out that information behavior is a complex event that "involves changes in cognition, feeling, and/or events during the information seeking process" (Markey, 2007b, p. 1123). Log analysis alone was not able to demonstrate all the relevant factors that impact on the information seeking behavior of different user groups, such as culture, usage context, personality, although it can

highlight some user behaviors at scale. In addition, as it is unobtrusive it does not influence and subvert behaviors.

Another library transaction log analysis from Mischo (2012) which examined the usage on an academic digital library gateway, discovered the distribution of resources click-throughs did reveal certain user search habits. In this case, the adoption of log analysis is valuable in showing how the users were interacting with the digital library interface in order to improve the interface design. However, such studies are unable to measure the underlying needs and perceptions that indicate whether users were satisfied with the search process or results (Jansen, 2008). The history of research based on log analysis evidences its value in terms of what can be revealed at scale without influencing user behaviors. However, it is important to note that users' motivations, experiences and system satisfaction cannot be understood from the log analysis alone (Kurth, 1993).

The second issue about the analysis of logs is their limitation in depicting the users' context, without which their information seeking behavior cannot be analyzed and understood holistically (Järvelin & Ingwersen, 2004). The user context is a complex mixture which contains multiple facets that are constantly changing through time (Dervin, 1997); and culture, among all those facets, is a major one in influencing cognitive understanding and user behavior. It is claimed that culture and value play a significant role in influencing how people adopt and make use of information technology (Leidner & Kayworth, 2006). Learning about users' cultural needs is necessary in terms of understanding their information seeking behaviors, motivations and information needs. With the increasing amount of remote usage of library systems and a more globally connected digital environment, there are diverse user groups from different cultures that this research argues should be studied and understood to better serve international audiences. This paper aims to discuss the usage of log analysis in understanding part of that picture.

Methodology

This study focused on understanding international Chinese users' academic library experiences and needs within the case context of University College London (UCL). For the UCL Library, it is crucial to know who is using the library system and the cultural dimensions they bring to their system usage. The log analysis sought to illuminate this understanding. The critical questions of the study were to:

RQ1: Identify the international Chinese users and capture their information seeking behavior through their actions and activities.

RQ2: Evaluate the advantages and limitation of using log analysis to explore information seeking behavior of cultural groups and discuss its implication through the case context of UCL.

Having a long history of education, inclusion and equality of experience, UCL has a diverse student base and seeks to engage globally in terms of research and education (UCL, 2017). As a global university, UCL does have a large number of international students and students with a wide range in backgrounds focusing on very diverse areas of education and research. Facilitating and supporting such diversity is always a goal within UCL's development strategy (UCL, 2017). From UCL's official statistics on non-UK student numbers, the percentage of Chinese students who take post-graduate taught (PGT) courses has increased yearly from 2015 to 2020 (see Figure 1). This increasing scale of international Chinese students studying in the case context of UCL, ensured a strong body of data for Chinese students' library experiences and also enhanced the representativeness of this particular ethnic group.
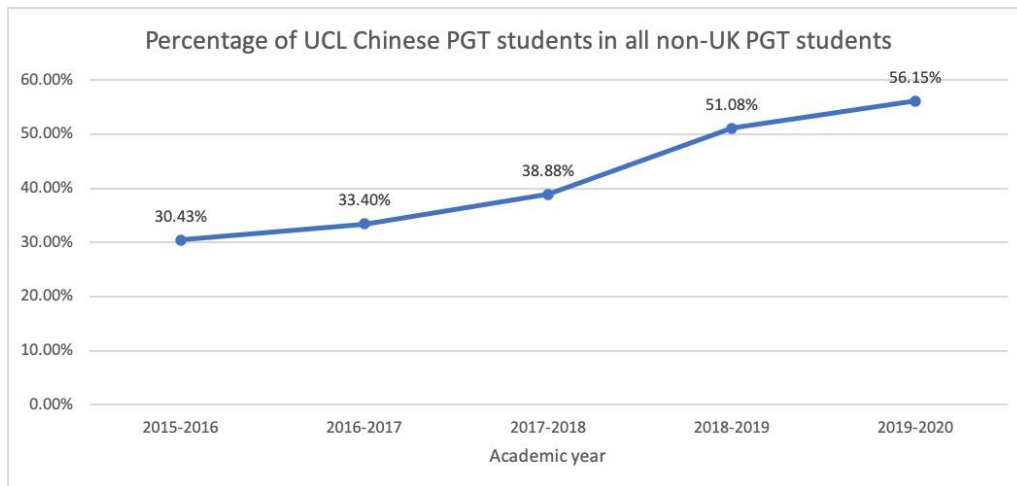
Figure 1 Percentage of international Chinese PGT students

With the support of the UCL Digital Libraries team, this research analyzed the transaction logs of the UCL library 'Explore' system (https://www.ucl.ac.uk/library/), which is a one-stop search tool for academic information discovery that integrates all the resources held or purchased by UCL for its libraries[1]. Two log data sets from the Primo Analytics data provided by the Ex Libris Primo platform and the Google Analytics data (both are anonymized log data) were accessed to conduct the log analysis. Both data sets covered the library system usage data throughout the academic year of 2017-2018 (September, 2017-August, 2018). Google Analytics log provides the macro level usage and summaries of online activities; while Primo Analytics reveal the detailed, in-depth statistics about each action within a single session. The statistics from Google Analytics and Primo Analytics were merged to better present and compare the results. It is important to note that the context of this log analysis was within the UK where the academic activities are regulated by the Data Protection Act 2018 (DPA) and the General Data Protection Regulation (GDPR); as such the log data from the UCL digital library were anonymized data that did not enable the identification of any individual person.

The two log data sets enabled a closer look into the UCL library user population and there was evidence that reflected most of the Chinese users' behavior in some but not all of the data. Due to the complete anonymity, the log data sets only presented the whole usage with the summaries of user actions monthly and yearly, and did not tell

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[1] This includes library catalogue, journals, databases, digital collections, UCL Discovery, UCL Exam papers, archives, UCL Reading Lists, Digital Education Resource Archive and UCL Research Data.

the age, gender, discipline, position or any other personal information that would suggest their identity. Nevertheless, there was log data which showed the location (country), devices they use and the system language of their devices when accessing the library system, which may reveal their nationality if they used the system from their home country or if they operated the system in their native language. Initially in order to understand distinctions between Chinese usage and other nationals more generally, the analysis started with a presentation of the 'the overall usage', which embarks on analyzing the log data from the UCL library population overall (50,000+ users), and then drills down to the 'Chinese users' usage', which uses multiple dimensions of the log data relevant to culture to explore information seeking behavior of the majority of Chinese users. The findings are organized in this way to show the research process in terms of how a specific cultural group's data can be captured and how their information seeking behavior can be inferred through comparing their data with the comparable data from all users.

In answering the critical questions of this study, it was necessary to investigate the overall usage and user interactions of the digital library system in order to map the general usage and for this data to then serve as a benchmark to later compare with the specific user population. This had some added benefits of revealing further findings about the bigger picture of UCL user information seeking behavior actions and activities and the benefits of log analysis. It was noted that some actions could only be observed at this holistic level.

Findings

1 The overall usage

1.1 User profile

Understanding users' characteristics, needs and context of usage is critical to understanding system needs and interactions (David, 2013, p. 138). Before analyzing specific aspects of usage, a general look into the library usage acts as a context and set of benchmarking data. The figure below shows the total number of sessions made in each month on the UCL's library system, which indicates the overall use

chronologically. The peaks and troughs are annotated (by session numbers in specific months) to infer the high and low traffic time periods in the library system.
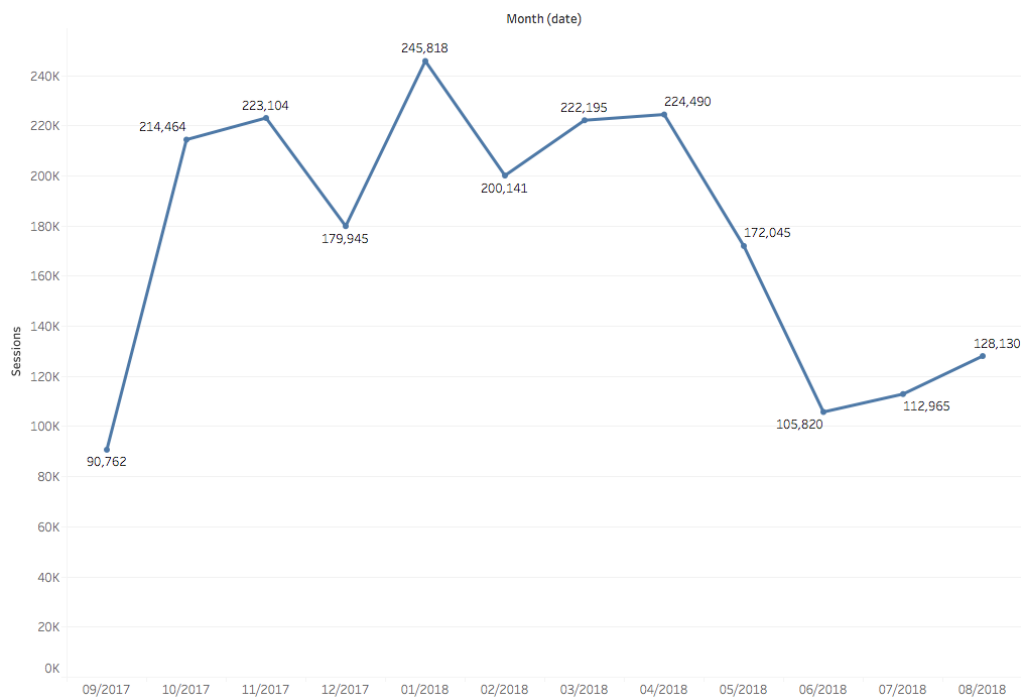

Figure 2 The monthly sum of individual sessions throughout the academic year

The graph demonstrates that in the UCL term time and exam weeks, the sessions reached particularly high peaks in terms of number of sessions, for example in November 2017 (end of term one), January 2018 (start of term two) and April 2018 (end of term two). This figure reflects the traffic brought about by information needs and tasks that are triggered by users' academic contexts; the contexts are defined by their role, position, time and space. It can be inferred that the research and learning goal is a primary motivation that influences users' activities in the UCL digital library system.

Another critical aspect of the user profile is geographic distribution: where the users were located when the sessions were conducted. The log analysis provided location information about the system usage which identifies where the requests came from and how users in different countries used the library system (Jones et al., 2000).

Table 1 Geographical distribution

Country	Acquisition

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		Users	New Users	Sessions
		407,033 100.00%	387,881 100.11%[2]	2,199,368 100.00%
1.	United Kingdom	373,366 (86.57%)	350,661 (90.40%)	2,004,957 (91.16%)
2.	United States	6,447 (1.49%)	4,509 (1.16%)	16,501 (0.75%)
3.	China	4,046 (0.94%)	2,525 (0.65%)	14,325 (0.65%)
4.	France	3,497 (0.81%)	1,863 (0.48%)	13,517 (0.61%)
5.	Germany	2,991 (0.69%)	1,814 (0.47%)	10,413 (0.47%)

From Table 1, UK is the primary country where the library system is being used, where 86.57% of library users are based and these constituted 91.16% sessions registered on the library system. Nevertheless, some users were accessing the system when they were outside of the UK, which provided further data to potentially identify Chinese users. It should be noted that it is possible that users were accessing the system using anonymization software, which would conceal their location, and it is also very likely that they were referring to cached pages and documents, which would under-register sessions (Groves, 2007) although the geographical distribution of the majority of users is accurately reflected from the log data.

1.2 Devices

Device analysis evidences how users make use of different devices to seek information on the digital library system via related log data, to explore their contexts of usage and to discover how they behave on different devices. From the Google Analytics statistics, a summary of device usage and three essential behavioral statics—bounce rate, pages viewed per session and average session duration—on different devices were captured to analyze the overall usage of the UCL library system on different devices. The table below is a summary table of users and their behavior on three major devices, desktops (including laptops), mobile phones and tablets.

Table 2 Summary table of device usage

	Acquisition	Behavior

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[2] This total percentage of 100.11% may be caused by the rounding error.

Device Category	Users	New Users	Sessions	Bounce Rate	Pages/Session	Avg. Session Duration
	407,033 % of Total: 100.00% (407,033)	387,881 % of Total: 100.11%[3] (387,447)	2,199,368 % of Total: 100.00% (2,199,368)	28.02% Avg for View	4.98 Avg for View	00:06:26 Avg for View
1. desktop	337,838 (83.02%)	322,119 (83.05%)	1,956,553 (88.96%)	25.37%	5.22	00:06:54
2. mobile	56,075 (13.78%)	53,525 (13.80%)	190,124 (8.64%)	53.04%	2.65	00:01:59
3. tablet	13,026 (3.20%)	12,237 (3.15%)	52,691 (2.40%)	36.13%	4.51	00:05:17

Bounce rate[4] is a key indicator in terms of showing the effectiveness and relevance of the web content in terms of the landing page. Web designers take bounce rate as an essential metric that evidences whether a user takes any actions (such as clicking a link, making a request or filling a form, etc.) upon arriving on the website landing page and to inform whether the landing page design is engaging and relevant to web users. Usually, a high bounce rate can indicate some problems with user engagement with the site if the goal of the website is to draw users further into the potential content, but it is not a definitive statistic that defines how the website is fully experienced and understood. Nevertheless, it does suggest some user characteristics and information seeking behavior particularly when compared with additional log data. As such it provides an initial comparison metric. The average bounce rate on the UCL library system was 28.02%. However, it needs to be understood that on the UCL Explore library system, unlike the Web, there are fewer layers of content; typically, a session starts with the search page (Explore home page/search box), followed by the result page (result list) and a specific resource detail page.

Compared to other studies on investigating bounce rate, the UCL library website has a lower bounce rate. According to Batra (2008)'s study on business websites, the average bounce rate was 40%; Betty (2009)'s study on library collections website had the average bounce rate of 34%. This indicates that the library users in UCL are much more engaged with the library system (with an average bounce rate of 28.02%). It is

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[3] This total percentage of 100.11% may be caused by the rounding error.
[4] Google Analytics Bounce Rate calculation is single-page sessions divided by all sessions, or the percentage of all sessions on your site in which users viewed only a single page and triggered only a single request to the Analytics server.

worth noting that different information intentions and goals of using the system leads to different levels of engagement; the users of the UCL library system are mainly students, staff, researchers and visitors who have explicit goals and tasks to carry on the website, which leads to a higher level of immersion and a lower bounce rate. Therefore, it is more valuable to compare the bounce rate of different user groups with the average bounce rate.

From the table 2, the primary devices used to access the UCL library system were desktops (including laptops), with 83.02% of the total number of users performing 88.96% of the sessions in the academic year 2017-2018 via a desktop device which has the potential benefit of a larger screen and greater functionality. The statistics of pages viewed per session and average session duration also suggests more complicated tasks and more time devoted when accessing the library system on desktops/laptops, with an average of 5.22 pages viewed and around 7 minutes spent in a single session. In comparison, the sessions on mobile phones, the second most popular device (13.78%) were fairly short (around 2 minutes with 2.65 pages viewed per session) and users jumped out of sessions more frequently than when using desktops or tablets. It should be noted that the pages viewed and session duration on tablets (3.2% of users) were similar to that on the desktops whilst the usage on mobile phones was distinctly different from the other two devices, which does suggest a significant behavioral disparity between using mobile phones and the other two devices. Their various choices of device may reflect different contexts and information needs and subsequent information seeking behaviors.

1.3 Actions

Actions are the detailed steps taken in the process of browsing, using and performing activities and conducting tasks on a website (David, 2013, p. 240). It is important to note that in this multiple clicks and actions constitute a session and each of them may be repeated several times in order to complete a task; the sequence of actions taken to complete a task is different depending on users' information seeking behavior and habits. Task analysis is often used as a way to design interactive systems and improve the website flow (David, 2013). In order to understand how UCL library users were using the digital library system and the tasks that might be implied from that, the library

log data that related to actions and searches was analyzed as a key aspect of understanding information seeking behavior. A summary of actions with the average clicks higher than 1000 times per month in the academic year 2017-2018 is shown in the Figure 3 below. These are the breakdowns of the actions taken in the sessions users made and each action represents a click on the library website.
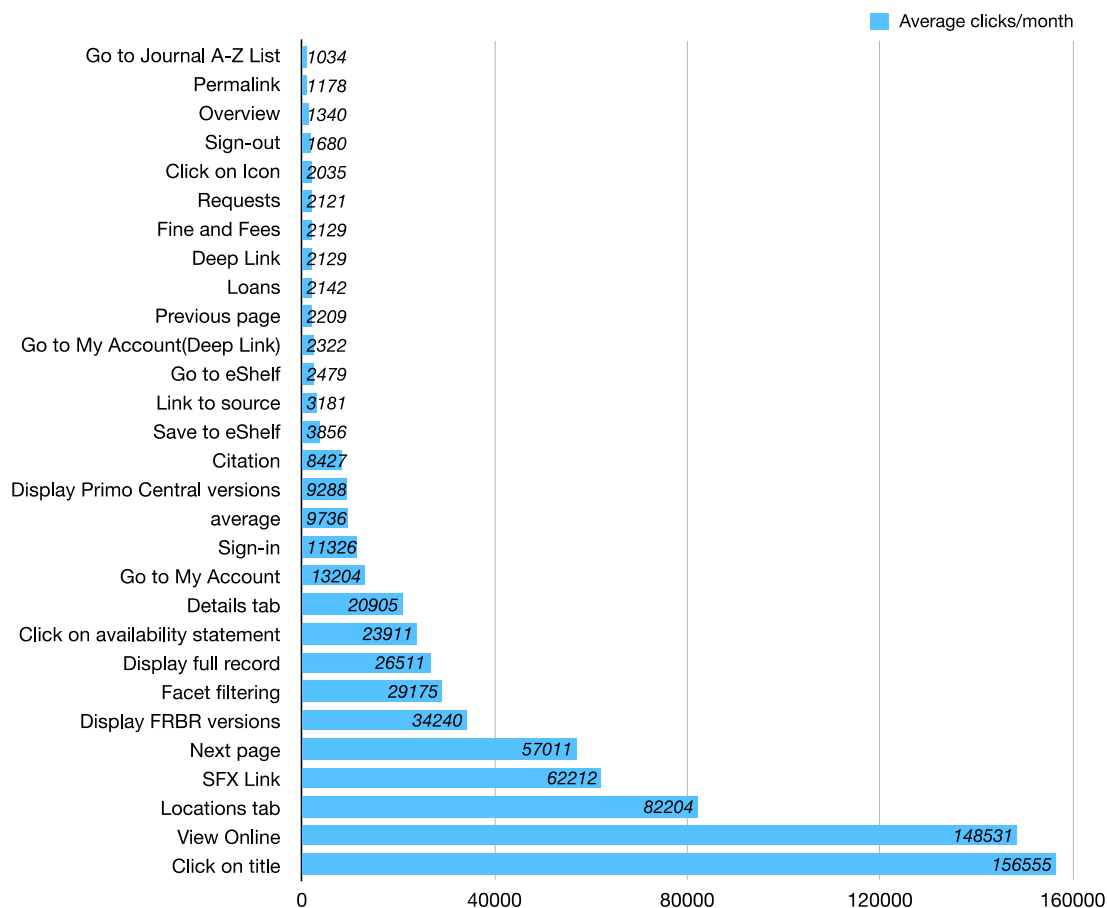

Figure 3 Summary of Actions per month (average clicks >1000 times/month)

The most frequently performed actions were 'click on title' and 'view online', with the average clicks of 156,555 times/month and 148,531 times/month. This is followed by the other eight actions that had clicks higher than 20,000 times per month. In this figure, there is a significant digital shift of library resources and user behavior from the statistics that showed a considerable jump from 'location tab' (checking the location of the print resources) to the number of clicks on 'view online'. It should be noted that a large number of library collections have been digitized, or online versions purchased, allowing for digital access without loan restrictions of time and space. It potentially evidences a digital behavioral change from users moving towards the use of digital

resources rather than borrowing printed books. With the digital transition, there are more people aware of the availability and usefulness of digital facilities without the constraints of the physical world, and the format of the information they prefer to use and their information seeking behavior seems to be shifting to what they assume to be convenient and more readily available. However, this statistic alone cannot gauge users' borrowing or reading preference with regard to formats due to the anonymity.

Another aspect of the analysis is the actions taken on 'next page' (57,011 clicks/month) and 'facet filtering' (29,175 clicks/month). It was found that a lot of users clicked 'next page' to see more results because academic work sometimes requires an in-depth reading on the same topic. As such it is normally necessary to consult more than one author on a single topic. However, the number of clicks on 'facet filtering' is shown to be almost less than half of the actions taken to move to the 'next page', which potentially shows that users would prefer to click on the next page to see more results rather than using the filter to limit the range of the results and improve the accuracy of a given search. This may be because the users had limited language skills which held them back from applying other approaches or keywords in searching or they were unfamiliar with the filtering tool and did not understand its value or that they knew clearly what to search for (e.g. having a title or an author name at hand) without applying filters to drill down into the results.

2 International Chinese users' usage

Having reviewed the holistic data, it was possible to analyze the data connected to international Chinese users enrolled on the UCL library system. Through using multiple dimensions of log data, especially through the ones that represent where the library system is being used (country) and the system language of the devices used when accessing the library system, the majority of Chinese students using the UCL's library system could be identified. It should be noted that this does not include Chinese students using a Cluster (university computer lab) machine, loan laptop or one running a non-Chinese OS setup, or a VPN.

2.1 Identify Chinese users by country

From the Google Analytics data, users' behavior (including the bounce rate, sessions, session duration and page per session) in the academic year 2017/18 was summarized and grouped by countries (see Table 3). Compared to users based in the UK, UCL library users in China viewed more pages in a session (5.50 pages/session) and had a longer session duration (around 9 minutes). These two statistical indicators were also higher than that of the average values.

Table 3 Summary of user sessions by country

Country		Acquisition			Behavior		
		Users	New Users	Sessions	Bounce Rate	Pages/Session	Avg. Session Duration
		407,033 100.00%	387,881 100.11%[5]	2,199,368 100.00%	Avg28.02%	Avg4.98	Avg00:06:26
1.	United Kingdom	373,366 (86.57%)	350,661 (90.40%)	2,004,957 (91.16%)	27.91%	4.98	00:06:24
2.	United States	6,447 (1.49%)	4,509 (1.16%)	16,501 (0.75%)	32.93%	4.71	00:05:45
3.	China	4,046 (0.94%)	2,525 (0.65%)	14,325 (0.65%)	28.80%	5.50	00:09:03
4.	France	3,497 (0.81%)	1,863 (0.48%)	13,517 (0.61%)	27.65%	5.02	00:06:42
5.	Germany	2,991 (0.69%)	1,814 (0.47%)	10,413 (0.47%)	27.27%	4.72	00:06:02

This is likely to reflect that the Chinese users interact with the digital library system in a different way. As the log data reflects library usage in the year 2017/18, which is before the COVID-19 pandemic (where distance learning is prevalent), the likely reasons for why there was access from non-UK countries but particularly from China at this time were: academics traveling (which may pick up statistics from staff or any affiliates), Chinese undergraduate students going home when they finish a term (normally in July) and using the library to prepare for the following year by downloading resources, Chinese PGT students going home for the summer (to avoid paying rent and to be with family) and completing their dissertations, or Chinese students going home for the Spring Festival in February 2018.

The average bounce rate at UCL was 28.02% and the UK UCL users rate was 27.91%. Users accessing from China had a bounce rate of 28.8%, which is around the average rate and is similar to users accessing resources in the UK, showing their tendency of

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[5] This total percentage of 100.11% may be caused by the rounding error.

exploring the UCL library system and viewing more content on that. If we take the statistics of pages/session and average session duration into consideration, users in China tend to stay, browse and conduct other activities in a longer duration on the library website.

2.2 Identify Chinese users by system language

Another facet of data that helps to identify international Chinese users is the system language used. It should be noted that the system language identified by the library log is from the user profile setting or device setting (system language on their device); thus, there may be Chinese users who were using English based devices. However, it is rarely the case that a non-Chinese user would be using Chinese as the system language on their devices, which should provide a guarantee that the Chinese users identified by the log data through the system language were the people that this analysis targeted. The Chinese region has a number of languages and the Google Analytics system distinguishes those varieties into different language codes (such as zh-cn, zh-tw, zh-hk and zh-sg). By capturing the system language of the majority of Chinese users (Chinese: zh-cn[6]) and the location (UK), the majority of Chinese users who were using the UCL library system were identified. It is noted that it is difficult to strictly align one of these languages to a precise land area in China. Future studies could perhaps analyze across these different groups. The table below illustrates the main information seeking behaviors of the Chinese users Chinese: zh-cn based on the system language and country.

Table 4 Summary of user session by system language and country

Country	System Language	Users	New Users	Sessions	Bounce Rate Avg:28.01%	Pages/Session Avg: 4.98	Avg. Session Duration 00:06:27
UK	en-gb[7]	219,125	206,227	989,278	28.33%	4.94	0:06:14
UK	en-us[8]	124,955	115,996	702,860	28.72%	4.8	0:06:08
UK	zh-cn	15,416	14,011	168,033	24.23%	5.83	0:08:12
US	en-us	4,636	3,672	11,266	33.54%	4.96	0:05:42

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[6] Zh-cn: Chinese (PRC), which is the simplified Chinese; this excludes the other variations, including Chinese (Hong Kong), Chinese (Taiwan) and Chinese (Singapore)
[7] En-gb: United Kingdom English
[8] En-us: United States English

| China | zh-cn | 3,104 | 2,061 | 11,454 | 27.26% | 5.62 | 0:09:27 |

As mentioned before, in order to precisely identify and evaluate Chinese users' behavior in the system, it is beneficial to compare their data with the average value. It can be seen from the table that compared with the average bounce rate (28.01%), the Chinese users (using a Chinese device) located in the UK have a lower bounce rate of 24.23%, even lower than the rate of Chinese users located in China (which is 27.26%). This means the Chinese users in UK usually visited more than one page of the library website in sessions to complete their goal. In addition, the results of the 'pages/session' and the 'average session duration' in the table indicate that Chinese users in the UK and in China viewed more pages in one session, around 5.83 pages/session and 5.62 pages/session respectively, and spent a longer time in one session, around 8 and 9 minutes, compared with other users. This two-dimensional analysis using the log data of system language and country is in line with the analysis that only used data of the country (see 2.1), which further illustrates the different information seeking behavior of Chinese users, no matter whether they are located in the UK or in China.

The analysis of country and system language demonstrates there is a clear difference between English language users and Chinese users on bounce rate, pages per session and session duration. This difference reveals some of the user characteristics and may demonstrate their unique information seeking behavior when using the library system: international Chinese users compared with other library users, spend more time using the library system, finding resources and completing information tasks. There may be a number of factors and reasons behind these figures that can be explored further. It is possible as the figures show, for example, that Chinese users may: put more effort into exploring the library resources; work harder and devote more time to study through the library system possibly in part due to reading in a non-native language, or due to encountering some difficulties during usage or factors around language problems applied to skills to support their search. In addition, they may have different habits in terms of interacting with the library system and different information seeking behaviors; be less familiar with the library systems in UK and take a longer time to navigate the systems. Thus the limitation of log analysis is evidenced in that it

demonstrates different but we cannot fully answer why there are differences without further investigation.

2.3 Chinese users' devices usage

By analyzing the log data of devices with system language (two-dimensional analysis), Table 5 was generated to identify Chinese users' behavior on different devices when using the UCL library system. Users who have devices with the system language of simplified Chinese (zh-cn) are labelled in grey which was deemed to capture the majority of Chinese users.

Table 5 Device usage by system language

Device Category	Language	Users	New Users	Sessions	Bounce Rate	Pages /Session	Avg. Session Duration (seconds)
desktop	en-gb	176,215	166,404	856,352	24.73%	5.33	419"02
desktop	en-us	130,661	122,110	764,836	27.75%	4.84	385"09
desktop	zh-cn	13,237	11,835	166,644	21.49%	6.27	546"29
mobile	en-gb	40,423	37,922	138,435	52.65%	2.59	112"36
mobile	en-us	7,760	7,159	24,062	53.57%	2.57	116"67
mobile	zh-cn	3,684	3,488	10,309	57.14%	2.77	146"62
tablet	en-gb	9,006	8,271	35,542	37.00%	4.29	312"56
tablet	zh-cn	1,451	1,370	6,265	35.43%	5.82	440"89
tablet	en-us	1,437	1,277	7,146	32.13%	8.48	445"66

From this table, the bounce rate of Chinese users on different types of devices is demonstrated: they had a very low bounce rate on desktops (which is 21.49%) compared to other users who were using desktops; however, they were also the users that had the highest bounce rate on mobile phones (which is 57.14%). Their engagement with the library system on desktops was deeper than that on mobile phones. This shows their different goals and information seeking behavior when using desktop and mobile to access the library system which may be caused by the environment or context of usage.

On both devices, Chinese users viewed more pages (6.27 pages on desktop and 2.77 on mobile) per session and spent a longer time in each session (around 9 minutes on

desktop and around 2.5 minutes on mobile) than other users. A quarter of them on desktops were using mobiles in the meantime, fulfilling their different information needs under varied contexts. There was a notable smaller number of Chinese users who used tablets to get access into the library system (1451 users) with a relatively low bounce rate (35.43%) and a high session duration (around 7 minutes) compared to other users. This finding is in line with the previous user analysis and may be caused by cultural factors, search habits, learning habits and digital information literacy skills.

With data from Table 2 and Table 5, three column charts are generated to show the critical statistics on different devices crossing the system language; with average values labelled on the charts, a more intuitive presentation of the two language groups' behavior on different devices is illustrated. The dark blue column represents Chinese users that used Chinese devices (zh-cn); and the dark green is users with UK English devices.
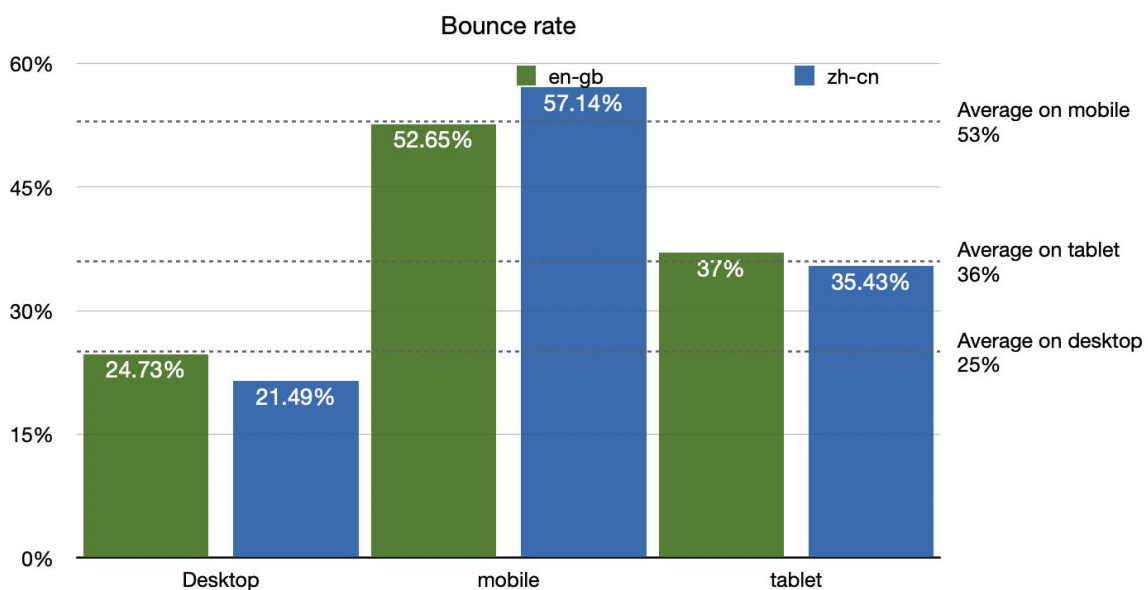

Figure 4 Average bounce rate on different devices by system language

Figure 4 is a demonstration of the average bounce rate which clearly shows a relatively frequent jumping behavior on mobile phones. Both language users tend to stay on the library website and explore the potential content when using a desktop/laptop, which shows their immersed information seeking behavior on a desktop and suggests the context of using a desktop may be conducive to study. However, with a mobile phone,

their jumping is revealed with behavior such as checking or confirming rather than browsing or exploring. Additionally, Chinese users tended to use the library website on a desktop rather than on a mobile phone or a tablet, and in these instances they stayed longer on the website and explored more content.
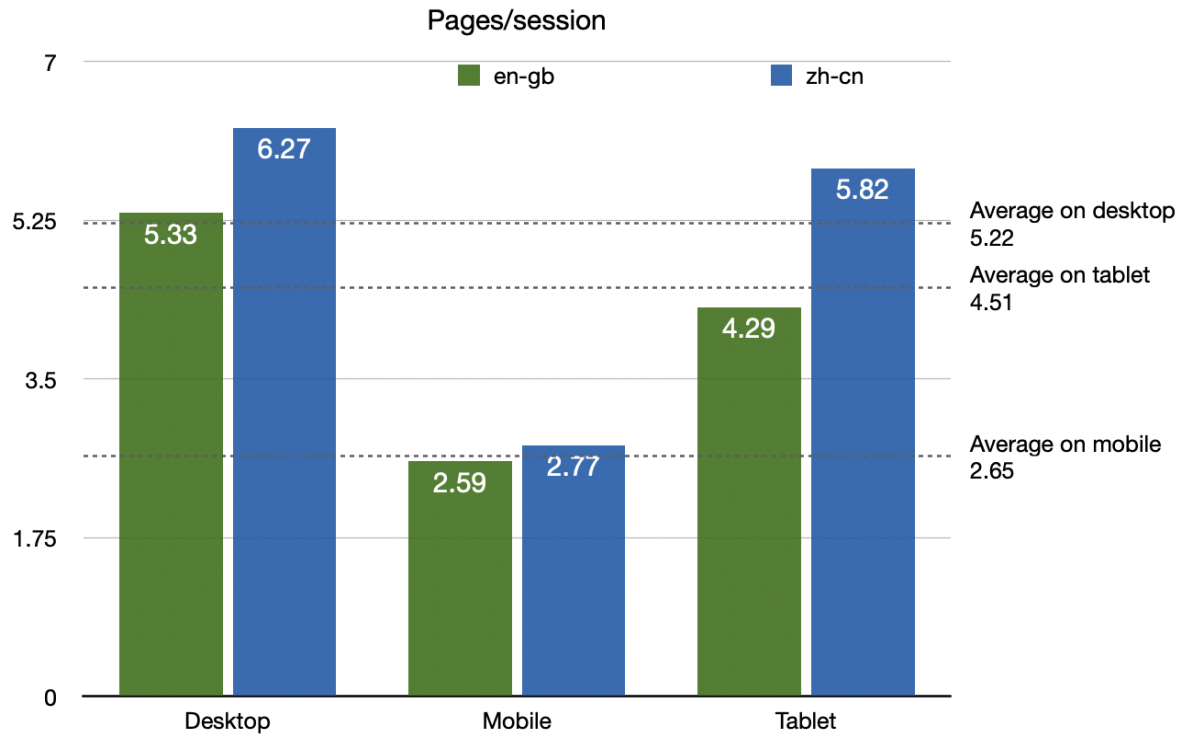
Pages/session

Figure 5 Average pages viewed per session on different devices by system language

As for the average pages viewed per session, for all users, the mobile phone is found to be the least preferred device in terms of accessing the library system and conducting a deep search was rarely performed on mobile phone. However, even on the least preferred device, Chinese users are found to view more pages than the UK users and the average users, and they presented the same behavior on all the three types of device. This behavior of Chinese users was evidently demonstrated on the desktop/laptop (6.27 pages/session) and the tablet (5.82 pages/session), which suggests that more immersed and complicated tasks are performed on those two devices than the mobile phone.
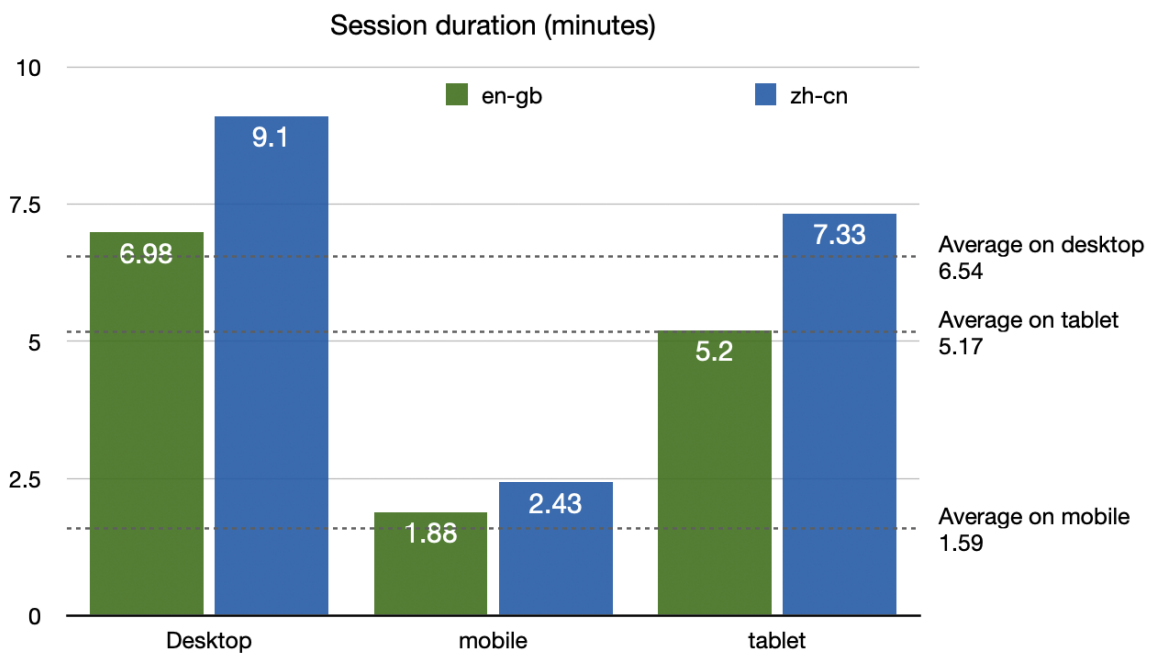
Figure 6 Average session duration (minutes) on different devices by system language

Figure 6 presents the average session duration by the two language groups on desktop, mobile and tablet. From this figure, users spent considerably more time on desktops and tablets compared to that on mobile phones. Chinese users spent a longer time in each session compared to English users and this is more obvious on desktops (9.1 minutes) and tablets (7.33 minutes).

The statistics from the logs are powerful in the way that they present the detailed usage and engagement conditions. With multiple statistics showing different dimensions, certain cultural groups can be located and identified and their unique information seeking behavior can be explored with clear evidence. However, it is hard to draw the conclusion that their behavior and the statistical difference is caused only by culture as the user context is complicated and flowing and culture only constitutes one part of it. This is in line with Gooding (2016)'s statement that log statistics do not give the motivations or reasons for user behavior; however, with the preliminary investigation through log analysis, a general picture of certain cultural group's information seeking behavior is evidenced and other supplementary methods can be built on it to fully understand users.

Discussion

Log analysis provides valuable insights into investigating information seeking behavior in the digital library system and it tells stories of the online activity of different user groups. As is stated by Nicholas, "the great thing about log analysis is that you are working with a huge population and thus can drill down to discover diversity" (Nicholas, 2010, p. 29). Besides, it is a direct and straightforward way to see what users did on the system, not what they recall they might do nor what they thought they did (Nicholas et al., 2006).

From the log file that generates the overall usage of all users it is possible to see the annual usage, geographical distributions, devices usage and user actions. The main users of the UCL library system are students, staff, researchers, and visitors to UCL, who can be novices or experts of library systems and their academic levels and abilities vary considerably. There is a lack of detail in the data imposed by the provider (Primo); it is somewhat unreliable due to the possibility of users disguising their location; and the impact of caching, not only on the users' devices but also by the university network and by the ISP, which means pages are being undercounted (Groves, 2007). Nevertheless, if we take the data at face value, we can see how the users are distributed in terms of locations and devices. This helps the library to identify the major user groups and more techniques could be used to find out more about their user experience, allowing improvements to be made to the system according to the main users' needs.

The usage statistics for the whole academic year illustrated how the UCL library website has been used throughout the year, along with the term and course arrangements; every access is triggered by certain information needs and goals which form the seeking process and the construction of knowledge (Kuhlthau, 2004). Difficult to measure, information need is seen as a complex result from personal knowledge demand, social and emotional factors and personal context (Chowdhury & Chowdhury, 2011a). The information needs for using the UCL library system is formed by a user's role in their academic activity and the tasks that emerged from the role; it is clear that their context of use is primarily academic.

A notable finding from the action analysis was the large number of clicks on viewing resources online rather than checking the location of physical copies. This implies a range of possibilities driving the overall usage of UCL library system. It may suggest the library users' adaptation to the digital library environment; there could be a digital transition of information type and information use; or more users may be aware of the constraints of the 'physical' and the convenience of the 'digital'. There is also the possibility that it is inconvenient (or not possible) to borrow books from the physical library when users are away from campus. The log data simply does not distinguish between these possible causes.

Digital technologies are created to serve people with various activities in different contexts (Gourlay & Oliver, 2018). It is not surprising to see that the longest session duration and most pages viewed in a session appeared on laptop/PCs, where the context of using laptops is mostly in the places designed for learning. While the shortest session duration and least page viewed/session was shown on mobile phones; such apparent distinction suggests the different context and goal of using the library system on mobile devices, where information seeking behavior and user experience would be different from the one on a laptop/PC. It has been pointed out that there is a dearth of research that looks into how students might engage with the technologies and digital environment in their studies (Gourlay & Oliver, 2018). Context is essential in defining the setting and drawing the boundary, without which the information seeking behavior or user experience theory cannot be accurately described (Jansen & Rieh, 2010). However, the broadness and variety of context makes it difficult to define and study only through log data. The log analysis implies possibilities of users' context with regard to technologies, time and space, task and activities and other possible contextual factors; however, it is not adequate enough to show the whole picture. In-depth investigations should be conducted to fully understand how students make use of technologies in their academic library experience in diverse contexts.

RQ1- Identify the international Chinese users and their information seeking behavior

To address RQ1, through analyzing multiple dimensions of log data, especially with geographic location and system language, the majority of international Chinese users were identified, which provides insights into their information seeking behavior on the UCL library system and manifests their cultural dimension and usage context. However, from the log data, it is not possible to confirm the role or discipline they were in and the data only revealed summative behaviors from the majority of them who may be undergraduates, postgraduates, researchers or staff.

The log analysis results show that Chinese users had a relatively low bounce rate, longer session duration and viewed more pages in each session compared to other users. It has been pointed out in previous studies that bouncing "sometimes represents a highly direct and pragmatic form of information seeking" when users are aware of where to go and how to search for the exact information (Nicholas, 2010, p. 28). Considering the pragmatic function of the library system, the high bounce rate of English users may suggest their awareness and familiarity with using the library system to find the resources they need or that they spend less time on the library system because of their learning habits. In contrast, the lower bounce rate and longer session duration of Chinese users may indicate their different way of information seeking, a specific strategy of using the library system, or the ineffective use of it. The reasons cannot be revealed merely from log analysis, and other approaches should be used to get narrative explanations from users. Previous work has indicated that language barriers, transition to a new academic environment, unfamiliarity of utilizing resources and other factors were the issues that have a negative impact on international students' overseas learning experiences (Wu et al., 2015; Yi et al., 2003). From the findings, we see that the bounce rate, session duration and pages viewed per session for all users changed over time; however, the lower average bounce rate of Chinese users compared with other users may suggest their different patterns of interaction and the difficulties that may be brought by the difference in culture and language.

Information seeking behavior research conducted in an everyday life context, namely the theory on everyday life information seeking (ELIS) (Savolainen, 2008), has assessed how cultural and social variables have influenced the way people find information for their daily needs. According to ELIS, gender, age, socioeconomic

status, cultural background, location, education level and other factors can affect people's information seeking in everyday life. While the context here is an academic library within the higher education system, the library log analysis does suggest specific ELIS characteristics of Chinese users that may be brought about by culture, past educational experience, the disciplines they are in, or other factors. How those factors influence their behavior and experience in the academic library could be explored further through other techniques.

RQ2-Advantages and limitations

Log analysis has three key limitations. First of all, no matter how long the log file covers, it is constrained by time and space and is not able to show the complex and changing user context (Kurth, 1993). In the UK context, due to ethics and privacy issues, the gathering of user data is obligated to respect individuals' privacy rights (Farrell, 2017). It is therefore hard to isolate individual users from the log data and thus not possible to describe their patterns of information seeking behavior in more detail. Summaries are important, but with no breakdowns, we cannot track the path they went through and the experience they had.

Secondly, even with statistics that show the differences amongst users from various cultural backgrounds, we cannot tell the reasons and motivations behind these differences; likewise there is an inability of showing the actual full information needs (Jansen, 2006). The macro view of the user interactions does reveal a lot of information but does not capture the detailed stories of their seeking behavior. Information needs and context of usage are essential components of the information seeking process, without which the information seeking behavior cannot be understood properly (Järvelin & Ingwersen, 2004).

Third, although the log is undoubtedly able to reveal what users are searching for and what functions they are using, it cannot show the intended search and use of those from the users' perspective (Kurth, 1993). It is hard to know whether users are satisfied with the seeking process and whether the results meet their needs. Therefore, it is incomplete in terms of fully understanding information seeking behavior.

Thus, while log analysis has provided the researcher with insights into the operation of a system and user interactions, it can be unreliable and inaccurate (hard to generalize, users providing false information, caching causing undercounting), incomplete (cannot demonstrate fluid and diverse contexts, culture, personality, need, satisfaction, motivation, experience, role, discipline, user perspectives) and lacking in detail (monthly / annually, age, gender, position, discipline, student number, borrowing date).

However, whilst log analysis does have these limitations, which have been identified in the literature as well as through this research, its value should not be overlooked. Log analysis can act as a benchmark for a larger scale study, where some aspects of usage status and different user groups can be identified. Log analysis is helpful in identifying statistical differences (e.g., session duration, bounce rate and pages viewed per session), which in turn evidence the potential engagement of users and in addition the systems problems they encounter. In this study, a high click on checking online resources and limited use of certain functions indicated aspects of the habits and seeking behavior of users. Their behavioral differences may suggest their cultural dimension and the underlying issues brought by culture and other contextual dimensions. Because of the large scale of data, it is easier to see trends that capture the typical interaction between user and system (Jansen & Pooch, 2001). A notable advantage of log analysis is its capability of showing the system operation status and what users are doing with the system content. Finally, as well as operating at scale, the research is conducted at a distance. This means users behaviors are not influenced. When used in conjunction with other methods, log analysis provides additional power to the evidence base and to the development of the overall picture.

Conclusion and future work

Information seeking behavior research in the LIS field has explored and discussed multiple research methods in learning about user behavior and user context. Previous work has found that demographic factors, especially cultural background, do have an impact on international undergraduate students' library usage, which is mostly due to the "different early training on how to find and use information resources" (Stone &

Collins, 2003, p. 31). The complex nature of people is formed in part by their social and cultural environment, thus culture's impact should never be ignored nor stereotyped (Berry et al., 1987; Kang & Chang, 2016). To understand library cultural groups' actual experience, their interaction with the information and services is not the only thing to examine, but also their needs, characteristics and cognitive process, which constitute the stimulus for such interaction are more important things to explore (Marchionini, 1996).

Within the context of exploring cultural dimensions, it is always a trade-off to decide on which methods to use and this depends on the research questions that need to be answered. In this paper, a study of international Chinese users in the UCL digital library was conducted to discuss the application of log analysis in learning about information seeking behavior of cultural groups. Within the study, the log analysis did provide a clear and explicit picture of Chinese students' information behaviors. It was able to show the diversity of user interactions and demonstrate differentiations among user groups in terms of their systems interactions. It provided a strong overview in terms of what users were doing. It was able to situate them in comparison to other users. However, it is to be noted that ideally investigating information seeking behavior in full does involve knowing not only 'what' users are doing, but in addition, 'how and why' they are doing it. As such, using log analysis as one of a set of methods can help build a more powerful evidence base of information behaviors. It provides clear metrics at a scale that have not been biased by any researcher interruptions. Moreover, it can then be developed in terms of building a picture by using other quantitative and qualitative methods which directly engage users, including but not limited to surveys, interviews, observations and focus group investigations, that can further focus on explanation, exploring the 'how' and 'why' of their information behavior in order to better understand their information needs and experiences.

In addition, log analysis can have potential power over time. This particular log analysis was based on data generated from the library system from 2017-2018, a 'normal' academic year outside of the COVID-19 pandemic. In the light of COVID-19 this provides an opportunity to compare some shifts and changes over time in behaviors given the move to greater digital delivery. Future work could consider logs after the pandemic to allow comparisons to be made. Certainly, the need for academic

libraries to better understand the complex needs of their global user communities is an area that will merit further research time and attention.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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