The use of human-computer interaction in libraries: a systematic literature review

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Abstract

Purpose – This study aims to analyze the status and application/use of human–computer interaction (HCI) in libraries by conducting a systematic literature review (SLR).

Design/methodology/approach – A Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) approach was used to search Scopus, Web of Science and Google Scholar databases. The search criteria included research studies published in English language between 2010 and 2021, which were 4,167 citations. Out of 4,167 citations, a total of 50 studies were selected for the final analysis.

Findings – The results showed a positive attitude of librarians toward HCI applications in libraries worldwide. The results depict that one-third (30%) of the studies were conducted in the USA, followed by four (8%) studies in China. Out of 50 studies, a portion of 15 (30%) studies were based on digital libraries, followed by seven (14%) studies on academic libraries and five (10%) studies on libraries and their websites. HCI was used for searching and retrieving information, users' interaction, authentication, online help/support, feedback, library web access, web OPAC, virtual access to resources, indigenous repository and virtual services. The most productive year was 2015, and journal of *The Electronic Library* had more articles on HCI than other journals.

Practical implications – The findings of this study could assist policymakers and library authorities in reconciling the HCI application in libraries for providing effective and efficient access and services to end-users.

Originality/value – This study is unique as no comprehensive study has been conducted on the use of HCI in librarianship using the SLR method.

Keywords Human–computer interaction, HCI-Libraries, Librarianship-HCIs, Systematic literature review, PRISMA

Paper type Literature review

Introduction

Human–computer interaction (HCI) is a multidisciplinary subject that focuses on the design of computer technology, particularly the interaction between humans (users) and computers (machines). HCI began with computers and has now grown to encompass all aspects of information technology and information architecture design. It is mostly used to assist humans by recognizing their needs and desires (Dhiran, 2021). The goals of HCI are to create systems that are useful and safe, as well as functional to meet the desired needs of end-users. HCI is a body of knowledge that has emerged in several fields and with a significant increase over time in how people interact with computer applications (Martínez-Toro *et al.*, 2019). Consequently, a vast range of computer programs and software have been created to improve the functioning of various systems and assist users in making decisions (Turk, 2014).

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In recent years, the connection between humans and technology has improved as it describes the interaction of graphic items. The interface used art effects such as a keyboard or a mouse on the screen in a library automated catalogue for local/regional languages (Seufert *et al.*, 2014). Furthermore, HCI improves the interaction between users and computers by making computers more user-friendly and receptive to users' needs (Xu, 2019). The essential elements of an HCI system are human factors, cognitive science and computer science, as shown in Figure 1. A library computer-based system focused on humans and developed the contents keeping in view the information needs of end-users.

Software developers must understand the users' experiences to promote the use of technology in libraries (Twidale *et al.*, 2021). These technologies support library services such as library bookmarking apps, big data, artificial intelligence, blockchain technology, the Internet of Things; augmented reality, digital interfaces for printed books, user-focused interface applications and so on (Hussain and Pervaiz, 2021). The technological application in libraries facilitates automatic patrons' identification systems, individual verification for transactions via biometric fingerprints, facial patterns, voice, hand geometry, face recognition or typing cadence (Gul and Bano, 2019). These technologies also facilitate searching through voice commands and self-checked-in/out. Geographic information system for resource location, drop-boxes, kiosks, radio frequency identification and closed circuit television camera systems to ensure smooth library operations with minimal staff involvement. It secured the assets of the libraries, organized collections, improved efficiency and saved time and resources for the users and staff (Nisha, 2018).

The use of the HCI base system in libraries saves time, energy and resources for improving various library services. It makes the library system more efficient, accurate and client-oriented by adopting the technological approach of HCI to interact with library users in a friendly and need-based environment. The use of HCI can improve the efficiency and effectiveness of library resources and services (Alazemi *et al.*, 2020; Lawrence and Ashleigh, 2019). The use of libraries has changed enormously with the development of computer-based interfaces, and nowadays library resources can be accessed remotely with the help of information and communication technology (ICT) (Chen *et al.*, 2019). A library is regarded as a complete system that is made up of a range of information resources, systems, policies, object recognition, human dynamics (Herath *et al.*, 2017) and users' experiences (Lallemand *et al.*, 2015). Thus, researchers are now focusing on creating different approaches to further improve HCI. Similarly, among other things, the premise to follow is intuitive communication (Martinez-Toro *et al.*, 2019). From the standpoint of HCI, there are chances to assess and contribute to the creation of librarianship projects that are based on sustainability

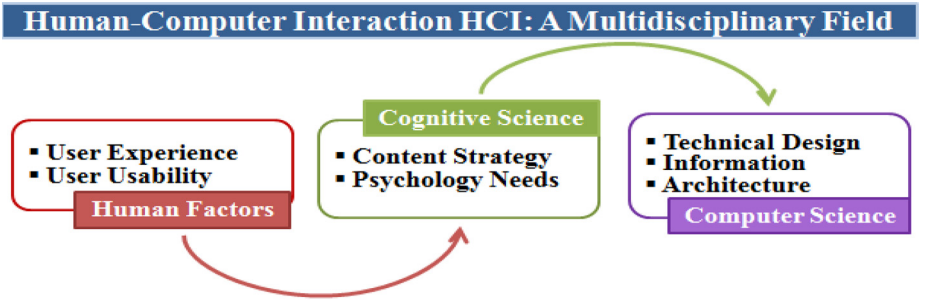

Figure 1.
Three essential components of HCI

Source: Figure by authors

as well as users' demands, thereby following global trends in resource utilization that are intelligent and efficient (Tajedini, 2020).

Less use of HCI in libraries of developing countries

There are a number of reasons for less use of HCI in libraries of developing nations. Following are the main factors:

- Limited resources: Libraries in developing countries find it tough to invest in HCI due to a lack of suitable financial and technological resources. Companies might not have the funds to purchase new technology or upgrade their existing equipment, or they might not have the staff available to develop and execute HCI solutions.
- Lack of knowledge: Libraries in developing countries might not understand the value of HCI or how it can benefit their patrons. Perhaps insufficient understanding of current HCI trends and best practices exists.
- Infrastructure issues: Due to inadequate internet access and frequent power outages, it might be difficult to implement HCI solutions in underdeveloped countries that require a constant connection or power supply.
- Cultural factors: Cultural factors might limit the adoption of HCI in libraries. For instance, there may be a preference for conventional information access techniques, such as the availability of print resources (Stephanidis *et al.*, 2019; Serholt *et al.*, 2018).

Since the past decade, researchers have been focusing on HCI and its use in various fields. However, to the best of researchers' knowledge and available literature, research studies are lacking to investigate the use of HCI in the context of libraries using an systematic literature review (SLR) approach (Shibuya *et al.*, 2022). Thus, to fill this gap in the literature, this research aims to examine the fields of HCI and librarianship using SLR techniques to understand the utility of HCI as well as how it is used in libraries to help their users. The researchers mapped the knowledge by using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) framework to find how well it suits them, which areas of study are most concentrated, and to identify gaps. The following sections explain the approach we used, the results we discovered and a discussion of the findings.

Purpose of the study

The main purpose of this study was to examine published literature on the application and use of HCI in libraries. A SLR method was used to determine the value of HCI and how it is applied in libraries around the globe. User experience, library security, library development, information modeling and other concerns may also be described, analyzed and improved by using HCI viewpoints. The study maps the information to see how HCI facilitates libraries to provide effective and efficient services to end-users and discusses the possible future scenarios and finally provides a future agenda. This study tries to outline the existing literature on HCI used in libraries, emphasizing the importance of recognizing the value of HCI in libraries. However, some specific objectives are:

- to determine the status of research on the said topic;
- to determine the HCI application in the libraries; and
- to find out the challenges faced by the information managers while using HCI in libraries.

The SLR will answer the following two questions:

RQ1. What is the status of research on the use of HCI in libraries?

RQ2. What are the uses of HCI in librarianship?

RQ3. What are the challenges faced by the information managers when using HCI in libraries?

To answer *RQ1*, the researchers collected articles related to the use of HCI in libraries from Scopus, Web of Science (WoS) and Google Scholar. For *RQ2*, the researchers interpreted various applications of HCI to categorize its uses in librarianship for the improvement of different library services and for *RQ3* the researchers find out various challenges faced by information managers while using HCI in libraries from the collected articles.

Material and method

The PRISMA guidelines were followed in this study, and these guidelines allow systematic literature reviewers to plan and conduct carefully and explicitly documented reviews with a plan to enable others to replicate the review and judge the validity of methods used (Mahmood, 2017). SLR is a means of identifying, evaluating and interpreting all available research relevant to a particular research question or topic area, or phenomenon of interest (Keele, 2007). The systematic assessment includes six steps that must be completed in the correct order, i.e. selection criteria for studies, search strategy, selection of articles, data extraction, data analysis methodologies and interpretation of results (Jünger *et al.*, 2017).

The systematic review of the literature is a review process of clearly formulated questions with systematic and reproducible methods to identify, select and critically evaluate all relevant available research and to analyze collected data from the research studies included in the review (Muka *et al.*, 2020). Similarly, Siddaway *et al.* (2019) reported that a SLR aims to identify, evaluate and summarize the findings of all relevant studies on a related issue, i.e. economic, social and health, by making the evidence accessible to authorities for policymaking and combining results in one place.

Data sources and search strategies: There searchers conducted a thorough search of two electronic databases and a search engine (Scopus, WoS and Google Scholar) for the years from 2010 to 2021. These are the most useful databases (for finding and evaluating information) in the English scientific literature. Accordingly, they were included in our study. The researchers looked for peer-reviewed research with English-language papers. The authors searched databases to find as many relevant studies as possible, and they expanded our search terms and techniques. As follows, search keywords were modified in combination with informatics and mixed with Boolean operators as per the standard requirements of each bibliographical database.

(human AND computer AND interaction) AND (use* AND librar*)
(human-computer AND interaction) AND (use* AND librar*)
(HCI AND use*) AND (librar*)

On the WoS, these keywords were used for the topic, and the title, keywords and abstract of the article (Scopus) are shown in Table 1. A manual search based on review articles was also performed. A backward and forward search technique on Google Scholar was also used to broaden the selection of literature. After the electronic search, the reference lists of the eligible papers were included.

Search by keywords	Scopus All fields	Web of science Topic (title-Abs-key, etc.)	Google scholar
Human AND computer AND interaction AND use* AND librar*	1,285	252	Nil
Human-computer AND interaction AND use* AND librar*	669	187	Nil
HCI AND use* AND librar*	101	79	Nil
Total	2,055	518	8
Total (without duplication in the same DB)	1,295	288	8
Total (without duplication in all DBs)	1,545	Nil	Nil
Total (after keywords, title and abstract assessment)	119	Nil	Nil
Total (after assessment of entire manuscript)	50	Nil	Nil

Source: Table by authors

Table 1. Searches by keywords for selection of research articles

Selection of studies: The researchers separately assessed titles and abstracts to find paper eligibility for inclusion in the study using the above-mentioned criteria. For final inclusion, the whole text of possibly relevant articles was reviewed.

Quality assessment of studies: To assess the quality of studies in a SLR, a quality assessment of all included studies needs to be conducted (Seo and Kim, 2012). Many studies recommend different quality-control tests and checklists while considering the nine and more than or equal to nine scores as good in a 13-point checklist (Kitchenham, 2004). The quality assessment process brings more clarity to selecting studies for systematic review. It also helps to finalize the list of studies on the basics of inclusion and exclusion parameters (Ross *et al.*, 2016).

Eligibility criteria: The reviewed articles were chosen after three rounds of selection. The title and abstract were screened in the first round of analysis. The articles were then analyzed in the second phase. The selection criteria were determined based on the research question, and the results were arranged in a table. The studies that were not available in the full text were not included in the final round of the section. In the third phase, we read all of the results and combined them into a single document. Before being considered for inclusion in our study, articles from this round were retrieved for a thorough review. All publications were excluded that did not express research exploring the use of HCI in libraries to satisfy our specific research goals.

An inclusion criterion was developed by following the methodology of Durach *et al.* (2017), which is shown in Table 2. To begin with, the search criteria only included peer-reviewed literature, as peer-reviewed articles are considered to have higher academic credentials (Denyer and Tranfield, 2009). Second, we limited our search to publications

Inclusion criteria	Exclusion criteria
Peer-reviewed articles	Non-peer review studies
Papers published during 2010–2021	Papers published before 2010 or after 2021
HCI used in libraries	HCI used by other than libraries
Accessible articles only	Non-accessible/restricted articles
Journal articles and conference papers	Books, thesis, chapters and unpublished studies

Source: Table by authors

Table 2. Inclusion and exclusion criteria

published in the years from 2010 to 2021 (as HCI in the library is the latest research trend), when the data was collected. Articles written in the English language were included. Furthermore, we exclusively looked for articles that described the use of HCI in libraries. As a result, peer-reviewed articles that did not meet the criteria were removed.

Data extraction: The PRISMA diagram in Figure 2 indicates the search of a total of 4,167 articles based on the inclusion criteria and the process of screening with reasons for exclusion. After two steps of screening (title, abstract and full text), 119 articles were selected for inclusion. After a full-text assessment for eligibility, only 50 studies were selected for final review. A data extraction table was created for each eligible study to collect information on the author(s), year of publication and other pertinent details, such as journal title, country, HCI used in libraries and so on.

Results

The results were divided into two parts. The first section focused on the primary research objective: to determine the status of research on this topic, as well as a description of the

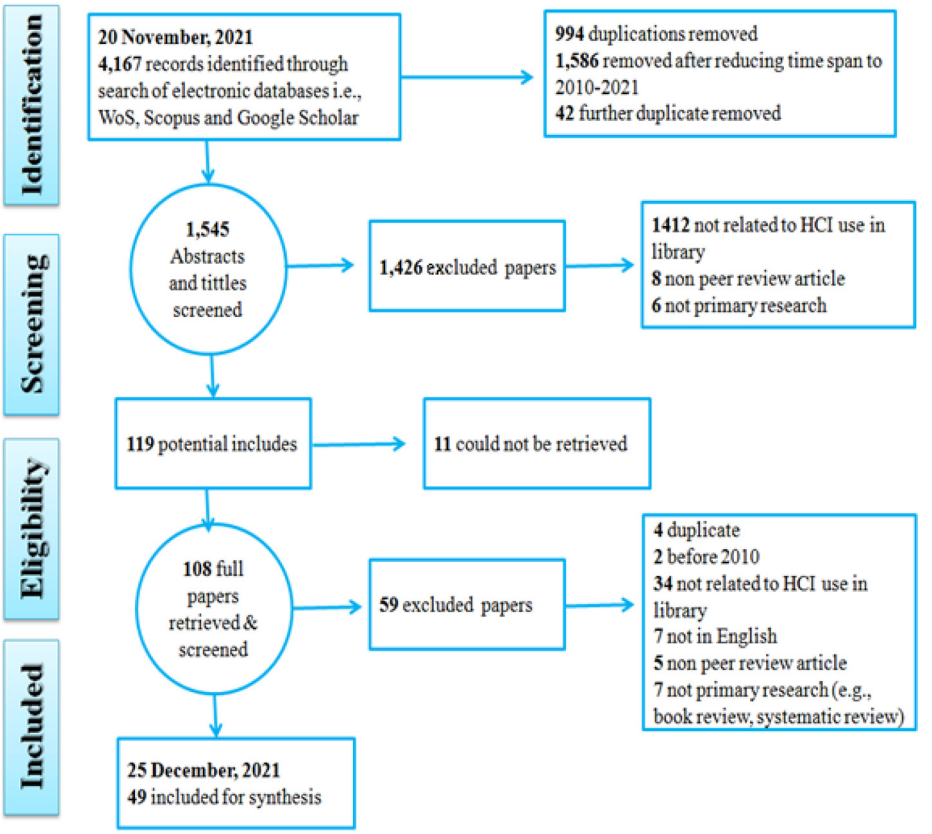

Figure 2.
The PRISMA flow diagram for article selection

Source: Article selection method adapted from Muka *et al.* (2020)

papers included. Part 2 delved deeper into a subsection of those studies' findings to investigate the second study objective: to determine the HCI applications/used in librarianship. The analysis focuses on the use of various HCI approaches in the library for the provision of better library services to users.

Description of included studies: The literature was searched through two databases and a search engine, i.e. WoS, Scopus and Google Scholar, respectively, resulting in 4,167 articles. In total, 119 studies were found after a cursory review of titles and abstracts. Finally, 50 studies met the criteria for inclusion and provided the HCI approaches for use in libraries. Table 3 describes the summary of data extracted from selected studies, and Table 4 depicts the HCI used in libraries. The year of publication of the research ranges from 2010 to 2021. The majority of the works were published in publications related to library and information science, although some were also published in publications related to other disciplines such as computer science and information technology.

Detailed characteristics of studies

Geographical distribution: Table 3 depicts that about one-third (30%) of the studies were conducted in the USA, followed by four (8%) studies in China. Only three (6%) studies were conducted in Norway and two (4%) each in Canada, Colombia, Germany, Malaysia, New Zealand and the UK. Similarly, only one (2%) study was done each in Australia, Bangladesh, Belgium, Cyprus, Denmark, France, India, Kuwait, Nigeria, Philippines, Russia, South Korea, Switzerland, Taiwan and Thailand. Results related to various countries and the numbers of studies included in the review are presented in Table 3 below.

Status of publication: The studies included in the review were from peer-reviewed journals and conference papers. About half (50%) of the studies were presented as conference papers. High numbers (8%) of papers were from *The Electronic Library* journal, followed by three (6%) studies were from the journal of the *Association for Information Science and Technology*. Two (4%) articles were from the journal *Library Hi Tech*. The rest of the articles were from famous and reputed journals. Nine (18%) and seven (14%) studies were included for the years 2015 and 2011, respectively, in this SLR.

Chronological distribution: Table 3 illustrates those five (10%) studies that were included for each year between 2016 and 2021. Four (8%) studies were included from the year 2012 and 2019. Three (6%) studies were included for the years 2013, 2014, 2017 and 2020. Only one (2%) study was included for the year 2010. Results of year-wise included numbers of studies in the review are obtained from the year of publication of each article.

Domain of the selected studies: Studies were selected after a rigorous process for the SLR and evaluated to determine the targeted domain of the studies. Out of 50 studies, a portion of 15 (30%) studies were based on digital libraries, followed by seven (14%) studies on academic libraries and five (10%) studies on libraries and their websites. Some other domains like national libraries, mobile technology used in libraries, library systems, human libraries, personal libraries, embodied libraries and institutional repositories were discussed in line with HCI use in libraries worldwide from 2010 to 2021 by the researchers.

The HCI applications and uses in librarianship

A total of 50 studies were analyzed to find various HCI applications in libraries based on the following review and meta-analysis. Table 4 depicts the HCI applications and uses in libraries, and the major themes are elaborated below:

- *Catalogue/web OPAC or searching, information retrieval*: In 23 (46%) of the 50 studies, the HCI approach was used in the development of library catalogues and web OPAC (Online Public Access Catalogue).

S. no.	Study	Journal/Conference	Country	Domain
1.	Rubin *et al.* (2010)	*Library Hi Tech*	Canada	Libraries
2.	Geng *et al.* (2011)	IMAGAPP and IVAPP	UK	Digital libraries
3.	Lopatovska and Arapakis (2011)	*Information Processing and Management*	USA	Libraries
4.	Chen *et al.* (2011)	*Portal: Libraries and the Academy*	USA	Libraries
5.	Godon *et al.* (2011)	International Conference on Human-Computer Interaction	Belgium	Library design
6.	Strebe (2011)	International Conference on the Theory and Practice of Digital Libraries	Germany	Library websites
7.	Liew (2011)	*The Electronic Library*	New Zealand	Library websites
8.	Kim (2011)	*Library and Information Science Research*	USA	Library websites
9.	Han and Jeong (2012)	*Proceedings of the American Society for Information Science and Technology*	USA	Academic libraries
10.	Damnjanovic and Hermon (2012)	International Conference on the Theory and Practice of Digital Libraries	Cyprus	Digital libraries
11.	Khoo and Hall (2012)	International Conference on the Theory and Practice of Digital Libraries	USA	Digital libraries
12.	Brangier *et al.* (2012)	*Le travail humain*	France	Design of digital libraries
13.	Albertson, (2013)	*Journal of Documentation*	USA	Digital libraries
14.	Zainal and Sa'don (2013)	2013 International Conference on Research and Innovation in Information Systems (ICRIIS)	Malaysia	Library websites
15.	Vongjaturapat and Chaveesuk (2013)	International Conference on Information Technology and Electrical Engineering	Thailand	Mobile technology in libraries
16.	Kadir *et al.* (2014)	24th IBIMA Conference	Malaysia	Academic digital libraries
17.	Culén and Gasparini (2014)	The Seventh International Conference on Advances in Computer-Human Interactions	Norway	Academic libraries
18.	Zhang and Soergel (2014)	Journal of the Association for *Information Science and Technology*	China/USA	Library uses
19.	Culén and Gasparini, (2015)	International conferences on interfaces and HCI	Norway	Academic libraries
20.	Gasparini (2015)	International Conference of Design, User Experience, and Usability	Norway	Academic libraries
21.	Chourasia *et al.* (2015)	International Conference on Human Aspects of IT for the Aged Population	USA	Access in libraries
22.	Liu and Hui (2015)	Proceedings of the 2014 International Conference on Future Mechatronics and Automation	China	Digital libraries
23.	Aljohani and Blustein (2015)	International Conference on Design, User Experience, and Usability	Canada	Institutional repositories
24.	Chiu (2015)	International Conference of Design, User Experience, and Usability	Taiwan	Library websites
25.	Zhang *et al.* (2015)	International Conference on Human Interface and the Management of Information	USA	Mobile library catalog
26.	Kam and Lee (2015)	The Eighth International Conference on Advances in Computer-Human Interactions	South Korea	National Digital Library
27.	Vanderschantz *et al.* (2015)	Proceedings of the 15th New Zealand Conference on Human-Computer Interaction	New Zealand	Personal digital libraries

Table 3. Detailed characteristics of included studies

(*continued*)

S. no.	Study	Journal/Conference	Country	Domain
28.	Chowdhury (2016)	*Journal of the Association for Information Science and Technology*	UK	Digital libraries
29.	Galindo and Morreale (2016)	International Conference on Human-Computer Interaction	USA	Design of digital libraries
30.	Mahadik *et al.* (2016)	International Conference on ICT in Business, Industry, and Government (ICTBIG)	India	Library system
31.	Jeong (2016)	1Digital Library Perspectives	USA	National library
32.	Yesmin and Ahmed (2016)	*The Electronic Library*	Bangladesh	Academic libraries
33.	Gaona-Garcia *et al.* (2017)	*The Electronic Library*	Colombia	Digital libraries and repositories
34.	Gračanin *et al.* (2017)	International Conference on Virtual, Augmented, and Mixed Reality	USA	Libraries
35.	Nachreiner (2017)	29th Australian Conference on Computer-Human Interaction	Australia	Academic libraries
36.	Baryshev *et al.* (2018)	*The Electronic Library*	Russia	Academic libraries
37.	Gaona-García *et al.* (2018)	2nd International Conference on Cloud and Big Data Computing	Colombia	Digital libraries
38.	Li (2018)	IOP Conference Series: Materials Science and Engineering	China	Digital libraries
39.	Goti *et al.* (2019)	ECAADE SIGRADI	Germany	Design of the library
40.	Garcia (2019)	IEEE 11th International Conference (HNICEM)	Philippines	Human libraries
41.	Stephanidis *et al.* (2019)	*International Journal of Human–Computer Interaction*	USA	Challenges to HCI
42.	Yoo *et al.* (2019)	Halfway to the Future Symposium	Denmark	Library service design
43.	Fox (2020)	ACM/IEEE Joint Conference on Digital Libraries in 2020	USA	Digital libraries
44.	Lueg (2020)	*Journal of the Association for Information Science and Technology*	Switzerland	Embodied libraries
45.	Alazemi *et al.* (2020)	Heliyon	Kuwait	Library interface
46.	Cao (2021)	*Scientific Programming*	China	Digital libraries
47.	Seberger (2021)	*Journal of Documentation*	USA	Digital libraries
48.	Benson-Goldberg and Erickson (2021)	*Research in Developmental Disabilities*	USA	Digital libraries
49.	Oyelude (2021)	*Library Hi-Tech News*	Nigeria	Libraries
50.	O'Hara (2021)	IEEE 45th Annual Computers, Software, and Applications Conference (COMPSAC)	USA	Public libraries

Source: Table by authors

Table 3.

- *Library website/web page*: HCI techniques were used in the development of library websites or web pages in 12 (24%) studies. The main use of HCI in the library context was for semantic and interactive library websites and pages for library users to facilitate their search for required information.
- *Virtual assistance/reference*: The analysis shows that seven out of 50, only (14%) studies used HCI techniques in virtual assistance/reference, virtual private networks

S. no.	HCI use in library	Description/ Approaches	Studies
1.	Catalog/web OPAC (searching, information retrieval)	Available resources and showing alternative relevant results from HEC DL, Google and database subscribed by the library	Lopatovska and Arapakis (2011), Alazemi *et al.* (2020); Strebe (2011), Chen *et al.* (2011); Lueg (2020), Zhang and Soergel (2014); Yoo *et al.* (2019), Garcia (2019); Gaona-García *et al.* (2018); Li (2018), Rubin *et al.* (2010); Baryshev *et al.* (2018), Albertson (2013); Liew (2011)
2.	Library website/ web-page	Semantic and interactive library website and pages for library users	Strebe (2011), Chen *et al.* (2011); Lueg (2020), Liew (2011); Brangier *et al.* (2012), Chaveesuk *et al.* (2013); Chiu (2015), Han and Jeong (2012); Khoo and Hall (2012), Kim (2011); Liu and Hui (2015), Zhang *et al.* (2015)
3.	Virtual assistance/ reference	Using virtual private networks (VPN), for helping user at remote area specially in the era of pandemics	Goti *et al.* (2019), Lueg (2020); Yoo *et al.* (2019), Gaona-Garcia *et al.* (2017); Mahadik *et al.* (2016), Benson-Goldberg and Erickson (2021); O'Hara (2021)
4.	Virtual access to resources of library	During COVID-19 era, the library around the globe and start serving the user via virtual access to resources and services	Goti *et al.* (2019), Seberger (2021); Geng *et al.* (2011), Garcia (2019); Baryshev *et al.* (2018), Gaona-Garcia *et al.* (2017); Gračanin *et al.* (2017); Benson-Goldberg and Erickson (2021), Chaveesuk *et al.* (2013); Chiu (2015), Chourasia *et al.* (2015); Damnjanovic and Hermon (2012), Liu and Hui (2015); O'Hara (2021); Zhang *et al.* (2015)
5.	Online help/ support and feedback	Using social media, instant messaging, interactive voice recording (IVR), text and voice/video calls	Lopatovska and Arapakis (2011), Garcia (2019); Baryshev *et al.* (2018), Chaveesuk *et al.* (2013); Culén and Gasparini (2014); Han and Jeong (2012)
6.	Authentication	To identify a unique user for a transaction like charging/ discharging of library items, getting clearance, reserving library material or using VPN/ virtual library services remotely	Strebe (2011); Culén and Gasparini, (2015); Yoo *et al.* (2019), Rubin *et al.* (2010); Baryshev *et al.* (2018); Mahadik, *et al.* (2016); Chourasia, *et al.* (2015); Gasparini (2015), Oyelude (2021); Vanderschantz *et al.* (2015)
7.	User alerts for SDI/CAS, fresh arrival and events	Automatic notification via postal and electronic mail, voice or instant message	Cao (2021), Garcia (2019); Baryshev *et al.* (2018), Nachreiner (2017); Chiu (2015), Galindo and Morreale (2016); Gasparini (2015), Oyelude (2021)
8.	Digital library/ collection/ indigenes repository	Theses, dissertations, articles conference proceedings and local experiments	Culén and Gasparini (2015); Cao (2021), Seberger (2021); Geng *et al.* (2011); Gaona-García *et al.* (2018); Li (2018), Albertson (2013); Liew (2011), Fox (2020); Nachreiner (2017), Kam and Lee (2015); Aljohani and Blustein (2015), Benson-Goldberg and Erickson (2021); Brangier *et al.* (2012), Chowdhury (2016); Damnjanovic and Hermon (2012), Galindo and Morreale (2016); Gasparini (2015), Jeong (2016); Kadir *et al.* (2014), Khoo and Hall (2012); Liu and Hui (2015), Vanderschantz *et al.* (2015)

Table 4.
HCI Application/ used in field of libraries and to librarianship

(*continued*)

S. no.	HCI use in library	Description/ Approaches	Studies
9.	Interfacing with library systems	Normal Touch screen Voice Wave Eye movements	Alazemi *et al.* (2020), Chen *et al.* (2011); Cao (2021), Geng *et al.* (2011); Zhang and Soergel (2014), Yoo *et al.* (2019); Garcia (2019), Li (2018); Rubin *et al.* (2010), Baryshev *et al.* (2018); Nachreiner (2017), Benson-Goldberg and Erickson (2021); Brangier *et al.* (2012), Chourasia *et al.* (2015); Damnjanovic and Hermon (2012), Galindo and Morreale (2016); Godon *et al.* (2011), Han and Jeong (2012); Khoo and Hall (2012), Kim (2011); Liu and Hui (2015); O'Hara, (2021); Oyelude, (2021), Vanderschantz *et al.* (2015); Zainal and Sa'don (2013)
10.	Virtual world	Using 3D virtual tours, shelving location and library map in libraries	Lueg (2020), Geng *et al.* (2011); Garcia (2019), Baryshev *et al.* (2018); Benson-Goldberg and Erickson (2021), Chourasia *et al.* (2015); Oyelude (2021), Vanderschantz *et al.* (2015)

Source: Table by authors

Table 4.

(VPN) from the perspectives of libraries to facilitate library users in a remote area, especially in the era of pandemics or distance learning students.

- *Virtual access to library resources*: Virtual access to library resources is an important component of all academic library services. Fifteen out of 50 (30%) studies show that during the COVID-19 era, libraries around the globe have started serving users via virtual access to resources and services by using HCI tools.
- *Online help/support and feedback*: The most important service in libraries is online help and support for library users. The findings show 50 research papers, six (12%) articles using social media, instant messaging, interactive voice recording, text and voice/video calls for online help, support and feedback.
- *Authentication*: Authentication plays an important role in the online environment of teaching and learning. Out of 50 studies, ten studies (20%) identified users' experiences with a transaction like charging or discharging of library items, getting clearance, reserving library material or using VPN/virtual library services remotely.
- *User alerts for SDI/CAS, fresh arrival and events*: Eight (16%) studies have found the use of the HCI tools in automatic notification via postal and electronic mail, voice or instant messages. The study details are presented in Table 4.
- *Digital library/collection/indigenes repository*: The findings in Table 4 show that the majority of 23 (46%) studies applied HCI tools in building digital library collections and indigenous repositories of theses, dissertations, articles, conference proceedings and local experiments (Table 4).
- *Interfacing with library systems*: This study found that about 25 (50%) research studies used HCI approaches in library interfaces, such as computer technology in normal, touch screen, voice, wave and eye movements.
- *Virtual world*: The virtual world feature is popular in today's modern library services. This study found that about eight (16%) studies applied HCI approaches, including 3D virtual tours, shelving locations and library maps in libraries to facilitate end-users.

Challenges to libraries when using HCI

Following Table 5 described the four major challenges faced by the libraries when using HCI. These challenges included accessibility, usability, integration and security. Only few studies highlighted the challenges regarding use of HCI in libraries and these studies are from developing countries. So, developing countries need more work on the use of HCI and its challenges faced by their libraries.

Discussion

HCI is primarily about solving problems and innovation. It focuses on people and technology to drive human-centered technological innovation. Libraries and information centers are growing well in the current global village and have adopted revelation technologies to cope with the flood of information. Recent studies claim that HCI is important because it is fundamental to making services or products successful, safe and functional. The results of these peer-reviewed studies revealed that HCI tools were mostly (47%) used in the discipline of librarianship from a diverse angle, such as searching and

Table 5.
Challenges to libraries in use of HCI

S. no.	Challenges to libraries in use of HCI	Description	Studies
1.	Accessibility	One of the main issues in HCI is making sure that technology is available to all users, regardless of their ability. Libraries must make sure that every aspect of their systems is created with accessibility in mind, including providing alternative language for images and utilizing assistive technology for visually impaired users	Garcia (2019); Gaona-García *et al.* (2018); Gaona-García *et al.* (2018); Stephanidis *et al.* (2019)
2.	Usability	Another difficulty is ensuring that library systems are straightforward and easy to use. Libraries must do usability testing to identify any systematic issues and apply the appropriate remedies	Gaona-García *et al.* (2018); Gaona-García *et al.* (2017); Yesmin and Ahmed (2016), Stephanidis *et al.* (2019)
3.	Integration	Integration can be challenging for libraries as they use so many different platforms and systems. Libraries must ensure that all of its systems are operational and able to communicate with one another	Garcia (2019); Gaona-García *et al.* (2018); Stephanidis *et al.* (2019)
4.	Security	Reading preferences and other private information are collected and stored by libraries about their patrons. Libraries must have strong security measures in place to prevent unauthorized access to sensitive data	Garcia (2019); Gaona-García *et al.* (2018); Gaona-García *et al.* (2017); Yesmin and Ahmed (2016), Stephanidis *et al.* (2019)

Source: Table by authors

retrieval of information and digital repository service (Cao, 2021; Fox, 2020). In addition, digital library services and virtual access to indigenous repositories were also provided by eight (16%), Web-based library services by 12 (25%) and virtual assistance by seven (14%). These findings are confirmed by Seberger (2021) and Goti *et al.* (2019), followed by online help/support and feedback services. It is revealed from the analysis of this study that library professionals must give proper attention to round-the-clock help system design with the help of HCI to keep the users updated and timely facilitated.

A study on HCI also depicts that literature published on HCI techniques in libraries was mostly for authentication and interaction with library systems (Oyelude, 2021). This study also revealed that a good number of studies were published from technologically advanced countries such as the USA, Canada, Norway, China and France (Benson-Goldberg and Erickson, 2021). On the other hand, only a few research studies on HCI tools in libraries from developing countries such as Bangladesh and India have been published. Thus, it is recommended that other countries from developing nations should contribute to HCI literature and its use in libraries.

The results revealed that *The Electronic Library* journal published four papers on HCI and the most productive year was 2015 with 18%, followed by 2011 with 14% publications. This current review has combined the results and approaches of HCI used in the different types of libraries worldwide (Siddaway *et al.*, 2019). Because it is evident that libraries are growing organisms and adopt changes very quickly (Hussain and Pervaiz, 2021). The current study found that no study has been published by the research journals from Asia, which shows less focus on HCI use in librarianship. Thus, collaborative research with computer science can easily fill this knowledge gap in the literature.

Researchers and libraries used different HCI approaches to satisfy users' needs and improve library resources and services by adopting emerging technology (Oyelude, 2021). HCI approaches are also adopted by libraries to make library resources and services more user-friendly and effective (Garcia, 2019). It has improved the interaction between library systems and users by saving resources, time and money. HCI also brings transparency, accuracy, standardization and access to library resources more effectively and efficiently. The findings of this study also reveal that HCI approaches were applied in library catalogue/web OPAC, searching, information retrieval (Alazemi, *et al.*, 2020), library website/web page, virtual assistance, reference, virtual access to the library, online help/support and feedback (Lueg, 2020). The current study suggests a strong relationship with the ICT department for the library professional to meet the challenges and design a workable system for all levels of library users.

HCI approaches are also used by library professionals for authentication, user alerts, SDI/CAS, new arrivals and library news/events. HCI comes under the umbrella of modern technologies and is suitable for the digital library collection and indigenous repository management. It enables users to interact with library automation and digitization systems in the virtual world (Hussain and Pervaiz, 2021). The 21st century is based on the digital technological era. The youth preferred all kinds of services at their fingertips. This study suggests developing digital repositories of indigenous and getting access to resources in e-format to satisfy the needs of library and information center users by using HCI in the libraries. This study also identified several challenges required to be overcome such as accessibility, usability, integration and security issues. Published literature on HCI application in libraries of developing countries are very scare and need immediate action to be explored from different perspectives (Stephanidis *et al.*, 2019).

Conclusion and recommendations

This study aimed to analyze the published literature on HCI and its use in libraries. To achieve the study objectives, data were collected using an automatic string on WoS, Scopus

and Google scholar. To update the search results, forward and backward citation methods were used on Google Scholar. This study was conducted using systematic review methods. The PRISMA principles were used for data extraction. The primary investigation recalled a total of 4,167 records, and only 50 studies were selected as per inclusion criteria. Studies included in this review aimed to provide a broad portrait of the status of research on various HCI approaches used in the context of libraries.

HCI approaches are used in libraries to improve the quality of the service and create an expert system that reduces human involvement and expedites the library process. Literature on HCI uses in libraries and its approaches towards librarianship were identified in this study but were limited to English language studies published as peer-reviewed from 2010 to 2021. HCI is used in most library operations, from selection to the circulation of resources. It is used in library services like cataloging/web OPAC, searching, retrieval, library web access, virtual assistance and references, virtual access to resources, online support and feedback, authentication, user alerts, SDI/CAS, fresh arrivals and so on. HCI enables interaction with library systems in the virtual world and provides real-time access to resources and services.

HCI perspectives strongly support approaches and use in libraries such as interface design, simulation, data analysis and information needs. This study suggests that HCI is suitable for all types of libraries to facilitate their users by improving their services and giving access to a wide range of resources. The findings of this study will be helpful for authorities and policymakers to reconcile research on HCI techniques and eradicate the barriers to the use of HCIs in libraries globally. Furthermore, the review contributes to a new emergent body of knowledge on the use of HCI in libraries worldwide through exploration and reflection.

The finding of the SLR from fifty selected studies recommends the use of HCI in libraries for better performances of the library operations and services. Libraries and information resource centers could also enhance the servicee quality of libraries as per users' expectations through the application of HCI in this virtual environment.

The use of HCI is essential for library professionals to streamline services and restructure policies regarding digital/virtual service model adoptions in libraries. Professionals need to learn advanced technologies such as HCI use and allied skills. Library professionals and practitioners can enhance the required skills by organizing workshops, webinars and training programs related to the use of HCI in the library. Learning the emerging technologies is the main factor for implementing HCI in libraries. Furthermore, in an environment of continuous environmental change and pandemics such as COVID-19 and other communicable diseases, the use of HCI is the most suitable solution to meet the information needs of library users.

The lack of HCI use in libraries of developing countries can be attributed to limited resources, lack of awareness, infrastructure challenges and cultural factors. However, libraries can overcome these challenges through building awareness (conferences, workshops and training sessions can assist libraries in exploring the significance importance of HCI), collaboration (the sharing of information and resources between libraries and other businesses or organizations is possible), identifying priorities (libraries can select what their users value most and focus on HCI solutions to meet those needs) and adopting flexible approaches to HCI implementation (libraries might select adaptable HCI implementation techniques that take into account the particular challenges of their setting).

This study was conducted with many limitations, including peer-reviewed studies published in the English language from 2010 to 2021. There are possibilities of studies on HCI approaches in libraries in other languages of the world that might not be covered in the

current study. Future research should consider other areas of research using HCI approaches, such as academic libraries, library websites, content management systems, automation and digitization of library resources and services. Further studies should be conducted to examine users' behaviors with information systems, information portals and users' interfaces, applying HCI techniques.

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