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A Conceptual Framework for an Information Behavior Model Based on the Collaboration Perspective between User and System for Information Retrieval

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ABSTRACT

This research aimed (1) to study and analyze the ability of current information retrieval (IR) systems based on views of information behavior (IB), and (2) to propose a conceptual framework for an IB model based on the collaboration between the system and user, with the intent of developing an IR system that can apply intelligent techniques to enhance system efficiency. The methods in this study consisted of (1) document analysis which included studying the characteristics and efficiencies of the current IR systems and studying the IB models in the digital environment, and (2) implementation of the Delphi technique through an in-depth interview method with experts. The research results were presented in three main parts. First, the IB model was categorized into eight stages, different from traditional IB, in the digital environment, which can correspond to all behaviors and be applied to with an IR system. Second, insufficient functions and log file storage hinder the system from effectively understanding and accommodating user behavior in the digital environment. Last, the proposed conceptual framework illustrated that there are stages that can add intelligent techniques to the IR system based on the collaboration perspective between the user and system to boost the users' cognitive ability and make the IR system more user-friendly. Importantly, the conceptual framework for the IB model based on the collaboration perspective between the user and system for IR assisted the ability of information systems to learn, recognize, and comprehend human IB according to individual characteristics, leading to enhancement of interaction between the system and users.

Keywords: information behavior, information behavior model, collaborative information behavior model, information retrieval

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1. INTRODUCTION

The digital environment allows humans easy, prompt, and instant access to information. However, this circumstance inevitably introduces a drastic change to a number of aspects in our lives as well. Among these aspects is an information search process for working, studying, and making quick but effective decisions. The increasing demand by humans for information is what necessitates this phenomenon. Hence, system design and development aims to produce an information system with a more refined capacity for learning, memorizing, and understanding human behavior.

Information behavior (IB) researchers normally define human IB as an expression of information needs combined with interaction with information sources and other channels (Wilson, 2000). Studies in human IB show that people often have more than one stage when interacting with an information retrieval (IR) system. Particularly, each stage of IB encompasses factors that might be changed depending on their individual characteristics. The studies also indicate that the relationship between IB and IR systems might be reconsidered in various issues. First, a user's search behavior varies distinctly by task and has significant changes over time (Jiang, He, & Allan, 2014). The principles, patterns, and development of IR need to be reconsidered with these factors. Second, in the context of developing an IR system, especially with library automation systems, online databases, and information repositories, these systems have dramatically changed from large-scale search engines to specialized software, which has transformed the way in which we access information and are for many an integral part of their daily lives (Hofmann, Li, & Radlinski, 2016). They need to be reconsidered in order to improve their compatibility for supporting holistic human IB, and they also need the appropriate model for developing an IR system as holistically and effectively as possible, in order to cover all aspects of IB in the digital environment (Yangyuen, Nuntapichai, & Phetkaew, 2016).

Under these circumstances, the interesting question would be how the IR system would relatively evolve to effectively comply with the changing technology and human IB, in which there are many aspects that were summarized from relevant research findings. For example, Petrovskiy (2006) identified that modern software with the storing of log files allows the system to predict user behavior. Gooding (2016) analyzed the IB of online newspaper readers to gain insight into the interaction between information systems and users. The study of Gooding revealed that some factors associate effective information systems with their ability to learn their users' behavior. Hence, the system needs to analyze user search behavior because the users themselves may not succeed in comprehending the system's entire functionalities.

Eventually, there are still some issues that are involved with sophisticated methods and techniques for analyzing user behavior related to system design and development of intelligent functions for enhancing an IR system. For example, Maleki-Dizaji, Siddiqi, Soltan-Zadeh, & Rahman (2014) proposed that it was imperative for the IR system to be attuned to user needs through modern techniques, which is in accordance with the principle of data mining. Buettner (2017) determined user preferences as a condition for effectively operating automatic recommendation systems by using the personality information for analysis with data mining, and then having the ability to sell products that meet the needs of customers. These findings revealed that the specific issues related to intelligent techniques and data storage were essential applications to meet effective IB. It is necessary to properly analyze and design log file storage in terms of operation, data storage, data structure, and analysis techniques which comply with IB. For example, (1) sophisticated methods of data mining should be applied to support IB; and (2) IR systems must be able to store log files in various formats, which allow the systems to address user needs more effectively. However, these issues are still confined to certain limitations and needs to have a conceptual framework for the system design and development of an IR system to enhance IB in the digital environment.

In general, a conceptual framework essentially represents an integrated concept of looking at how to explain and give a broader understanding of the phenomenon or research problem (Imenda, 2014). The conceptual framework should be defined as an integrated concept that also brings a number of related concepts together. Thus, in this phenomenon, the way to design an IR system to support user behavior in the digital environment is a problem that cannot meaningfully be researched based on only one concept or theory. Hence, based on these issues as mentioned above, the conceptual framework may be defined as the final result of bringing together the different aspects of the IB model and the different concepts of the IR system.

Therefore, the purpose of this research is (1) to analyze the capacity of the current IR system from the perspective of IB by analyzing the concordance, capacity to comprehend and interact, user interface design, data display, problems, and limitations; and (2) to propose a conceptual framework for an IB model based on the collaboration perspective between the user and system for IR, which can apply intelligent approaches enabling the system to learn, recognize, and understand individual human IB better. All concepts in this research

were drawn from theoretical perspectives, and the conceptual framework was derived by synthesizing existing views of IB models with IR system characteristics. The proposed conceptual framework of this study can provide not only user need-relevant information but also address the cognitive process in order to ensure that user requirements are being met when they participate with an IR system in the digital environment.

2. LITERATURE REVIEW

2.1. Information Behavior Model

The IB model is one of the indispensable components for study on the implementation of IB since the model profoundly reflects a core principle, logic behind functionalities, work processes, and workflow. It also explains the relationship with users for each step clearly. Due to the constant change of both user behavior and digital context, the IB model inevitably needs to evolve accordingly in order to effectively sustain its compatibility with user behavior in the digital environment. A summary of five well-known IB models under the digital context is described in Table 1. All of these five models required certain changes and modifications to comply with not only the present user behavior but also the digital environment.

The evolution of digital technologies determines the growth in transparency of the IB of a person as a subject of the digital environment and as a user of electronic resources. The digital development of society has required the technological development of the monitoring of the IB of a person in various spheres of activity. Astakhova (2018) proposed that the cognitive determinants of the IB of subjects of different activities in the digital environment are as follows: (1) the epistemological status of information; (2) the cognitive transformation of social and information needs, interests, and motives of subjects; (3) the cognitive managerial paradigm of the development of modern society; and (4) the imperative of the development of an individual's cybersecurity culture.

2.2. Information Behavior Models and Information Retrieval Systems in the Digital Environment

Developing an IR system to be able to support, store, track, and analyze user IB in the context of the digital environment by applying an IB model as a blueprint still needs to be investigated. Further research into approaches for the IR system design revealed a number of new approaches proposed by previous researchers under the goal of covering as much of user IB as possible, whether it is a contextual design involving the system or information seeking context (Spink & Wilson, 1999), or a participatory design allowing those involved to take part in designing, etc. The reason behind this necessity of new approach

Table 1. Summary of information behavior (IB) models in the digital context

Information search process by Kuhlthau (1991)
• The model needs to operate under a series of fixed sequential stages. This means lack of flexibility required in practice. The user IB under the present digital environment has already changed, and more importantly it is not defined by a sequential nature. The high tendency for success depends on the user's cognitive capacity and ability. • The model is devoid of a monitoring process.
Ellis's information-seeking behavioral model by Ellis, Cox, & Hall (1993)
• The sequence of browsing, chaining, and monitoring processes of the model can flexibly switch. • Ellis's work process sequence does not match the present digital environment and needs some changes to support the searching and using stages. • Although people have different job titles, the features of the information-seeking patterns of their IB were similar.
Information-seeking model in electronic environments by Marchionini (1995)
• There are stages where users need to acknowledge and comprehend the problem before starting the search process. These stages allow users to ponder upon their goals more clearly. • Due to its lack of data chaining and monitoring stage, the model does not entirely comply with user IB despite being proposed on the basis of an electronic system.
Information seeking on the web by Choo, Detlor, & Turnbull (2000)
• Work process analysis is collaboratively performed with processes on a website, which is in line with the present user IB. • The model is devoid of the verifying and evaluating processes to verify the selected data.
Information-seeking behavior model by Meho and Tibbo (2003)
• The model operates under sub-processes such as information management, data analysis, and synthesis. Moreover, flexible process switching can be requested within the sub-processes.

designs is tied to the ever-changing nature of IB and the notion that an effective IB model's framework must, by all means, demonstrate the work processes right from the beginning of information needs to information usage. If it can only respond to certain aspects of human IB, much more effort and time on the part of humans will be demanded for information seeking, which may result in failure in accessing the information needed (Spink & Cole, 2001). Dresang (2005) studied the research about youth information-seeking behavior with the Radical Change digital age. The use of computer technology provides greater connectivity in a social environment. Specific factors, for example, gender and collaborative behavior, may alter the interpretation and application of earlier research and may bring new and perhaps more positive perspectives to researchers. Yuan and Belkin (2014) applied an information-seeking dialogue model that integrated the system and user to evaluate the IR system. Results demonstrated that the dialogue structures indeed supported effective human IB patterns in a variety of ways. It is important to design an interactive IR system that can provide different types of support in a manner that searchers can easily understand, navigate, and use as they change information seeking strategy.

What has been discussed above testifies to how significant an IB model is and how it can dictate the developed IR system's capacity and success. As a result, it is highly crucial that the design and development guidelines for the IB model and the IR system be in absolute concordance with each other. Nevertheless, as a result of changes in the digital environment generating changes to user IB, IR systems which provide users with services that are adapted to user behavior must change as well. This is consistent with the concept put forward by Saracevic (1996), where he proposed a solution to seek information with the consideration of the electronic environment.

Although studies and research on IB models have been around for a long time, there are still many more behavioral models that are presented. However, by changing the context and human behavior, research on human IB is still a challenging task and needs to be constantly developed. It is preferable to integrate new technology into a behavior model's work processes (e.g., data mining and log file) so that the IR system developed under the model's framework can comprehend and serve users to its fullest potential.

3. METHODOLOGY

The research question addressed how to assimilate the user IB with the system to enhance the current IR capacity to comprehend and interact with the user and to apply intelligent approaches enabling the system to learn, recognize, and understand individual human IB better. The research steps are as follows.

3.1. Document Analysis

In order to study the characteristics and capacities of current IR systems, the study was divided into two major parts, i.e. study of a current IB model in the digital environment, and study of the characteristics and capacities of IR systems.

3.1.1. Study of a Current Information Behavior Model in the Digital Environment

This part started with determining the research topic, purpose, and scope of the studies; and then proceeded to assembling documents concerning today's IB models from journals, books, and meeting minutes, as well as online databases. After that, the IB models were screened and selected. The inclusion criteria encompassed sources, citation counts, and further studies conducted based upon any applications in coordination with IR systems or other systems. At the end, there were five models that met the inclusion criteria: the (1) information search process (Kuhlthau, 1991), (2) information-seeking behavioral model (Ellis, Cox, & Hall, 1993), (3) information-seeking model in electronic environments (Marchionini, 1995), (4) behavior model of information seeking on the web (Choo, Detlor, & Turnbull, 2000), and (5) information-seeking behavior model (Meho & Tibbo, 2003). The researcher synthesized all of the gathered IB models together based on the concept of classification so that the IB models sharing profound similarities and differences were grouped together. The classification process also made it possible to determine the stages of the behavior of the IB model that can cover IB in the digital environment to be used in the next issue of the study.

3.1.2. Study of the Characteristics and Capacities of Information Retrieval Systems

The researcher deliberately selected only online databases whose functions are in concordance with the IB models. Of all the inclusion criteria, the first was that the database must embody the IR services relevant to user IB and adopt stages as in an IB model. Second, the online database was extensively subscribed and accessed by many users. Additionally, the researcher was able to study and analyze in-depth data or tried using the system in different work processes. There were nine databases in total, namely ABI/INFORM Complete, ACM Digital Library, EBSCO host, Emerald Management, IEEE/IEE Electronic Library, ProQuest, ScienceDirect, SpringerLink, and

Web of Science. Data analysis was oriented toward comparing the system's similar and different characteristics as specified in the crucial stages of an IB model, which can cover IB in the digital environment.

3.1.3. Proposing a Framework for an Information Behavior Model in the Digital Environment

The two parts of the results were put together for result synthesis and to propose a framework for an IB model in the digital environment. The framework was constructed on the basis of the defining principle that an effective and forward-looking IR system must encompass the promotion of absolute intelligence to the degree of being able to learn, recognize, locate patterns, and comprehend each individual's personalized IB. Intelligent methods were applied to solidify the system, promote the users' ability and cognitive process, and ensure the users' needs were genuinely and promptly being met, using less effort on the part of the user but getting more effective results.

3.2. The Delphi Technique

The Delphi technique is a forecasting process framework based on the feedback of multiple rounds of questionnaires and in-depth interviews with experts. This research used the Delphi technique in order to evaluate and improve the proposed framework for an IB model in the digital environment. This emphasized a cutting-edge design for an IR system, encapsulating absolute intelligence that can search for patterns and understand personalized IB.

The research population and samples in this study were comprised of experts and instructors equipped with years of extensive experience in IR, IB, and data mining. Purposive sampling was used to recruit the study samples theoretically described as "information-rich cases." In other words, with their expertise and insight, exceptionally in-depth and the most illustrative data were contributed. There were six instructors specializing in IB, library and information science, data mining, and computer science.

The research instrument used in this study was questionnaires based on the results from Section 3.1.3. The questionnaires were divided into three parts, namely (1) an overall feature of the conceptual framework for an IB model supporting and covering user IB in an IR system, (2) work stage and workflow evaluation based on the conceptual framework for the IB model, and (3) log file storage and the concept of applying data mining methods for the conceptual framework for the IB model.

Data collection in the Delphi process was conducted in three rounds by using the questionnaires, in which the responses were analyzed and then used to construct the next round of questionnaire. For the first round, the experts provided a list of as many suggestions as they could for each one of the open-ended questions addressing human IB in order to identify a diversity of ideas, characteristics, and other issues about the proposed conceptual framework. The researcher adjusted the proposed conceptual framework to align with the list of crucial suggestions provided. For the second round, the experts were asked to rate and rank the importance of each one of the issues relating to the various items of the proposed conceptual framework, such as consolidated lists of work stage, alternative workflows, log file data which need to be stored, and the intelligent techniques which are important in each stage of the design of sophisticated IR systems in order to learn, recognize, search for patterns, and understand each personalized IB. The researcher analyzed the responses from the experts and adjusted the proposed conceptual framework accordingly. For the third round, final questions along with in-depth interviews were designed for the experts to confirm the accuracy of the proposed conceptual framework and to recommend more details about the components of the framework in all items from the previous round.

3.3. Focus Group with Experts

A focus group with the experts was organized to conduct a qualitative study that was based on the analysis of the results from the Delphi technique in Section 3.2 in order to confirm the proposed conceptual framework for the IB model based on the collaboration between the user and system for IR.

This study was conducted with a team of ten experts with practical experience in an IR system, which included system analysts, programmers, database designers, and also stakeholders who are involved with system usability (e.g., project managers, librarians, lecturers, and instructors). Before the study was conducted, all participants in the focus group were provided with a debriefing sheet, which reminded them of the purpose of the study and provided them with the research results from the Delphi technique.

During the processes of the focus group, the debriefing sheet was disseminated to all participants. The items consisted of (1) an overview of the proposed conceptual framework for the IB model, principles, work stages and procedures, and workflow; (2) data mining and intelligent techniques that might be used in each step; and (3) log file and data storage under the conceptual model of the collaboration between the users and the system. Participants were also asked questions pertaining to their experiences to evaluate the proposed conceptual framework for coping with techniques, scope of data set, database design, system testing, and also their expectation about the user-friendly characteristics of the IR system.

Based on the research results from Section 3.1 and 3.2, the data analysis was summarized, and it focused on improving the model and transforming the suggestions and opinions of the experts concerning human IB and the IB model together with the suggested log file, into an IB model based on the collaboration perspective between the user and system for an IR system which is capable of learning, recognizing, searching for patterns, and understanding personalized IB. Data mining methods could be applied to promote system performance for predicting and generating the results that met user needs. Results drawn from this study are intended to be used as fundamental data upon which other IB models can be developed and presented based on the collaboration perspective between the user and system.

4. RESULTS AND DISCUSSION

4.1. Analysis of the Current Information Behavior Models in the Digital Environment

The results of the analysis and synthesis of the current IB model in the digital environment showed that it can categorize the characteristics of IB according to similar and different behaviors. This made it possible to determine the stages of the process of the IB model that could cover IB in the digital environment (Yangyuen et al., 2016) as displayed in Table 2. The eight stages are composed of: (1) Starting & Understanding, which is the starting process where users need to understand their problems and determine relevant information such as choosing and entering interesting websites; (2) Searching & Chaining, which consists of searching for the topic or other interesting data and chaining the information to sources related to that information; (3) Browsing & Scanning, which consists of browsing through data or exploring what users are searching for in order to locate featured contents; (4) Differentiating & Choosing, which consists of differentiating the gathered information and choosing what is considered useful; (5) Monitoring, which consists of monitoring new and updated information associated with the usage information, and staying attuned to the information's instant changes by means of pushing from the system or entering websites marked as favorites; (6) Extracting, which consists of extracting useful information or information related to user needs; (7) Verifying & Evaluating, which consists of checking and evaluating the accuracy of the information received and the information sources; and (8) Ending & Using, which consists of ending the

Table 2. Comparative analysis of the information behavior model's operating stages

Process	Information behavior models				
	Information search process by Kuhlthau (1991)	Ellis's information-seeking behavioral model by Ellis, Cox, & Hall (1993)	Information seeking in electronic environments model by Marchionini (1995)	Behavior model of information seeking on the web by Choo, Detlor, & Turnbull (2000)	Information-seeking behavior model by Meho and Tibbo (2003)
S.1 Starting & Understanding	S.1 Initiating	S.1 Starting	S.1 Understanding	S.1 Identifying	S.1 Searching & S.2 Processing S.1.1 Starting
S.2 Searching & Chaining	S.2 Selecting	S.2 Chaining	S.2 Planning and Executing	S.2 Following	S.1.2/2.1 Chaining S.1.7 Networking
S.3 Browsing & Scanning	S.3 Exploring	S.3 Browsing		S.3 Scanning	S.1.3 Browsing
S.4 Differentiating & Choosing	S.4 Formulating	S.4 Differentiating		S.4 Selecting & Choosing	S.1.5/2.3 Differentiating S.2.5 Information managing
S.5 Monitoring		S.5 Monitoring		S.5 Receiving, Revisiting	S.1.4 Monitoring
S.6 Extracting	S.5 Collecting	S.6 Extracting		S.6 Extracting	S.2.6/2.7 Synthesizing, Analyzing S.2.8 Writing S.1.6/2.2 Extracting S.2.4 Verifying
S.7 Verifying & Evaluating		S.7 Verifying	S.3 Evaluating and Using		
S.8 Ending & Using	S.6 Presenting	S.8 Ending			S.3 Accessing S.4 Ending

S stands for Stage (Example: S.1=Stage 1).

search process and using the retrieved information.

All of these eight stages were deemed to cover the entire IB model's work processes, complying with human IB and effectively serving user IB in the digital environment, under the condition that certain sequences of the work processes of the model were adjusted. This is because today's human IB positions itself under the streaming digital environment, which is defined by constant growth in terms of culture, technology, and information and communication systems. Furthermore, when there is integration between an IB model's work stage and an IR system, it must be conceived with a bigger scale of flexibility, and internal work stages must be interleaved.

4.2. Analysis of the Current Information Retrieval System

The researcher used the system trail to investigate the characteristics of online databases. Two studied perspectives included: (1) characteristics and functionalities providing for information search and IR, displaying, and interacting between the user and system; and (2) log file storage and use. Data analysis was conducted to compare the systems' similar and different characteristics as determined by the important stages of the work processes for an IB model covering IB in the digital environment. The outcomes yielded from the study are described as follows.

4.2.1. Characteristics and Functionalities of Online Databases

To analyze these aspects, the researcher utilized an Input-Process-Output: IPO concept. The subject matters used in the analysis included login, search and methods of search, displaying, sorting, scanning, differentiating, extracting, verifying, evaluating, using, and other related stages. Rigorous comparison with the IB model's eight work processes was carried out (Yangyuen et al., 2016). The characteristics and functionalities of the online databases are shown in Table 3. The abbreviations of the online databases are as follows. ABI: ABI/INFORM Complete; ACM: ACM Digital Library; EDS: EBSCO host; EM: Emerald Management (EM92); IEEE: IEEE/IEE Electronic Library (IEL); PQ: ProQuest; SD: ScienceDirect; SL: SpringerLink; and WoS: Web of Science.

The following findings encapsulated all featured characteristics of the present IR system.

(1) Starting and Understanding: The researcher focused on design and system services regarding member subscription, login, and user account setup. Findings showed that every online database was equipped with member subscription and account creating functions. In some databases, the detail saving process simultaneously progressed with the search process, such as keeping records of an output display, which was processed for future relevant notifications when the user logged back into the system. Such a process was in congruence with the making of a user model for recommendation systems, with emphasis on a personal profile's database in order to analyze and predict the system's user behavior, which was also proposed by Knijnenburg, Willemsen, Gantner, Soncu, and Newell (2012).

(2) Searching and Chaining: The researcher investigated function designs and searching and chaining techniques or methods. It was found that every online database encompassed identical search patterns and functions. Both basic search and advanced search functions were available. Apart from this, a search history saving service in several databases was also available. There was search query saving consistent with the notions proposed by Sugiyama, Hatano, and Yoshikawa (2004) and Speretta and Gauch (2005), which had taken search history into account for future relevant searches. Of all the available functions, it was evident that the IR system needed to have saved search history and the chaining of user data to get it oriented toward the users' behavior effectively.

(3) Browsing and Scanning: The researcher studied the use of conditions in browsing and search result scanning. Every online database was found to have the same functionalities. Browsing under determined conditions or filters could be done, such as for titles, authors, A-Z alphabetical sorting, or fields of study. Users could access the targeted data in a timely manner.

(4) Differentiating and Choosing: An investigation in this aspect was dedicated to the system's tools defined to differentiate data to properly choose genuinely useful and relevant information. The results of the analysis affirmed similar functionalities for all the online databases. Users were entitled to specify search filters and sorting or displaying through a result refining, sorting, and showing function. In addition, there was also a recommendation function that was designed to assist users in choosing information so that related information was selected. The function would constantly analyze other users' search results and propose related data. This function required less effort on the user's part and allowed for quicker searches. Therefore, the information proposing function was deemed to be indispensable in today's IR so that the system could properly match dynamic user IB.

(5) Monitoring: Information tracking was studied with

Table 3. Characteristics and functionalities of online databases

Process	Function	Database name								
		ABI	ACM	EDS	EM	IEEE	PQ	SD	SL	WoS
S.1 Starting & Understanding	Sign up/Create account or profile	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Login/Sign in	✓	✓	✓	✓	✓	✓	✓	✓	✓
S.2 Searching & Chaining	Basic/Advanced search	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Searching within results	✓			✓	✓			✓	✓
	Search history			✓	✓	✓		✓		✓
	Recent searches/Search save	✓	✓	✓	✓	✓	✓	✓		✓
	Searching with indexing terms or book	✓			✓	✓	✓			
	Related keywords			✓	✓	✓				
	Open/Clicked links	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Export/Download search results	✓	✓		✓	✓		✓	✓	✓
S.3 Browsing & Scanning	Browse by (Discipline, Subject, Journal, Book)	✓	✓	✓	✓	✓	✓	✓	✓	✓
S.4 Differentiating & Choosing	Refine results by/Refine by (People, Publications, Conferences, Years, Content type, Language)	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Sort by (Relevance, Newest first, Oldest first, Times cited, Usage count, Most cited)	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Show by (Years, Article type, Publications)	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Preview abstract	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Open/Clicked links	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Recommendation	✓	✓	✓	✓	✓	✓	✓	✓	✓
S.5 Monitoring	Journal/Book alerts			✓	✓			✓		
	My subscribed/My favorite	✓		✓	✓	✓		✓	✓	
	Citation alerts			✓	✓	✓				✓
	Search alerts	✓	✓	✓	✓	✓	✓	✓		✓
	Subject alerts			✓	✓					
	Push/E-mail/Alerts	✓	✓	✓	✓	✓	✓	✓	✓	✓
S.6 Extracting	This stage is operated by the user									
S.7 Verifying & Evaluating	Metrics/Bibliometrics/Usages		✓			✓			✓	✓
	Cited by	✓	✓	✓	✓	✓	✓	✓		✓
	Citation count		✓			✓			✓	✓
	Highlighting	✓		✓	✓	✓	✓	✓		✓
S.8 Ending & Using	Download/Save/Export/Print results	✓	✓	✓	✓	✓	✓	✓	✓	✓
	E-mails	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Download citations	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Share on social media	✓		✓	✓	✓	✓	✓	✓	✓
	Logout	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Usage time	✓	✓	✓	✓	✓	✓	✓	✓	✓

ABI, ABI/INFORM Complete; ACM, ACM Digital Library; EDS, EBSCO host; EM, Emerald Management (EM92); IEEE, IEEE/IEE Electronic Library (IEL); PQ, ProQuest; SD, cienceDirect; SL, SpringerLink; WoS, Web of Science.

methods for tracking new information that met the needs or interests of users. Most databases were designed to have alerts in various formats that tracked information and alerted users through various channels, especially via e-mail. Monitoring the systems' newly added information was by all means of absolute importance for present IR systems.

(6) Extracting: The study focused on function designs, techniques, or methods for extracting relevant useful information. It was found that at this stage, users needed to rely on themselves and no online database has been designed to extract information yet.

(7) Verifying and Evaluating: The study found that the information system's work processes could assist the users through its various functions, such as highlighting, biometrics, usage, or citations, to help users identify and select the relevant information. These data assisted learners in evaluating and choosing relevant information.

(8) Ending and Using: This aspect was concerned with functions for data saving, using, sharing, ending, and logging out. It was found that every online database adopted the same fundamental functions, such as downloading, saving, exporting, printing, logging out, and sharing on social media.

The analysis suggested that the characteristics and functions of online databases comprehending user IB were similar, which was in accordance with the principles of the process of the IR system. Further analysis demonstrated that each database's unique function stemmed from different IB for that particular database. Examples included the display function, which showed relevant data to promptly facilitate the inexperienced user's seeking of information. Sharing data on social media is a vital function for the digital era's users, who are generally oriented to data sharing. It was evident that several online databases endeavored to design a system's work processes in parallel with user IB for the best search experience to be achieved.

It is utterly significant that the user IB analysis concept and IB model be employed as the foundation for the IR system's design and development. Such practices establish congruence between the system and user IB, especially those engulfed in the digital environment. Nevertheless, analysis and synthesis of all the eight stages of an IB model and IR systems strongly indicated the necessity for modification of the models' work processes, including modifications in process switching, flowing, and classifying of the models' work processes. Principal reasons to affirm the modifications included:

(1) User IB does not naturally occur in a fixed sequence from Stage 1 (Starting & Understanding) to Stage 8 (Ending & Using) in a linear fashion. It, in fact, functions in a loop manner. For example, users will be compelled to navigate back to the search and chaining stages after having acknowledged data irrelevance from their first search attempts. Therefore, the models' process flow should develop flexibility and non-sequential work processes.

(2) Human IB inherently evolves in close relation to the digital environment contexts. Information, for instance, is being increasingly shared on social media to other interested users.

(3) The currently available IB model's capacity has been intensively governed by human abilities. This fact implies both benefits and drawbacks. Inexperienced users were likely to face certain difficulties in their search information attempts, and so practical behavior model design and analysis carried out under collaboration perspectives were deemed suitable for user behavior.

(4) In Stage 1 (Starting & Understanding), the users were required to actively acknowledge their problems and be able to identify the information they needed. However, the IR systems should allow easier and more convenient access to source data for searches.

(5) In Stage 2 (Searching & Chaining), it was found that the chaining process could be conducted under multiple processes within the behavior models. For example, after having differentiated the data, the users proceeded to chain them to choose information. Furthermore, the chaining could also be carried out in the search stages to choose information from search results. Consequently, a number of sub-processes could be embedded within more than one core process.

(6) In Stage 3 (Browsing & Scanning) and Stage 4 (Differentiating & Choosing), the holistic foundation of the user work behavior was not covered. Quite a few sub-processes existed within each of the major processes, such as displaying and sorting.

(7) In Stage 5 (Monitoring), keeping track of newly updated information and making suggestions to users were an exceptional part of the work process. Its work sequence must, however, be reordered. That is because potential information monitoring should function 24/7 even when users are not active.

(8) In Stage 6 (Extracting), the users' ability was intensively involved in order to extract relevant information. Nowadays, it has become a habit for users to export all the data before logging out. That process occurs in the Ending & Using stage, reflecting the obvious change in user behavior.

From what has been discussed above, the IR system must accommodate the aforementioned user's IB in the digital environment. It has been proven that the gap between the evolving IR system and today's IB model is still huge. Such a gap urgently requires analysis and synthesis in order to develop new IB models that are commensurate with the digital environment's contexts. That includes a redesign for more practical work processes and workflows within the behavior model.

4.2.2. Log File Storage of Online Databases

Because of the limitation of revealing log file data from the online databases, the researcher used the system trail to observe the response behavior of the system instead. The researcher analyzed log file data storage by means of studying the systems' functions, allowing users to save data such as member subscription, search history, subscribing for interesting information, and also observing the interaction between the

Table 4. Analysis of log files by observing the interaction between the information retrieval system and the user of online databases

Process	Function	Observable data storage	
		Related data	Stored data
S.1 Starting & Understanding	Sign up/Create account or profile	User profile	First name, Last name, E-mail, Job title, Subject area of interest, Organization
	Login/Sign in	IP address, User profile, Date, Time	Date, Time
S.2 Searching & Chaining	Basic/Advanced search	Query, Result	-
	Searching within results	Query, Result	-
	Search history	Query, Result	Keyword, Search option, Result
	Recent searches/Search save	Query, Result	Keyword, Result, Time saved, Alert frequency
	Searching with indexing terms or book	Query, Indexing terms (Keywords), Fields (Author, Publication title, or Subject)	-
	Related keywords	Related keywords	-
	Open/Clicked links	URL, Title, Clicked link	-
	Export/Download search results	Result	Export/Download statistics
S.3 Browsing & Scanning	Browse by	Topic, Discipline, Subject, Journal, Book, etc.	-
S.4 Differentiating & Choosing	Refine by/Sort by/Show by	Refine options, Sort options	-
	Preview abstract	Abstract, Keywords	-
	Open/Clicked link	URL, Title, Clicked link	-
	Recommendation	Title, Keywords, Related keywords, etc.	-
S.5 Monitoring	Journal/Book/Citation/Search/ Subject alerts	Journal, Book, or Article	Saved journal alert, Saved book alert, Saved citation alert, Saved search alert, Saved subject alert
	My subscribed/My favorite	Journal, Book, or Article	Saved journal alert, Saved book alert, Saved citation alert, Saved search alert, Saved subject alert
S.6 Extracting	This stage is operated by the users.	-	-
S.7 Verifying & Evaluating	Highlighting	Keywords	-
	Metrics/Bibliometrics/Usages	Usage statistics	-
	Cited by	Cited data	-
	Citation count	Citation count	-
S.8 Ending & Using	Download/Save/Export/Print results, Send e-mails, Download citations	Results	Usage statistics, Download history
	Share on social media	Results	-
	Logout	Time spent	Time spent

IP, internet protocol.

proposed information from the systems and users. The analysis revealed findings which are detailed in Table 4.

The following findings revealed observable stored data of the online databases.

(1) Starting and Understanding: Regarding signing up, the researcher studied the data storage of member signup, login, user account setup, and data saving. All databases were equipped with sign-in and personal setting functions, which basically consisted of the name and e-mail address of users. Some databases stored additional personal data (e.g., job title, subject areas of interest).

(2) Searching and Chaining: During the use of the systems, the users entered keywords and operators which are referred to as a query, and then the systems displayed search results. There are several sub functions; for example, in some databases, search results featured vividly highlighted search terms, or the features of display and query saving were adopted. Systems also had a search saved function for storing queries and search results, and a search history function was available to save keywords, search options, and results. The systems could notify and also remember the search terms entered for each search. Such capacity allowed an easier and faster process in case users needed to use certain outputs again. In the searching and chaining process, with a data storing system designed to holistically save the user's log file, the systems' capacity will be elevated to achieve better orientation toward user behavior or interest and analyze and predict behavior patterns. Hence, IR systems in the present digital environment must be designed to effectively save users' searching and chaining log file data (e.g., keywords, related keywords, search terms, search operators, queries, search histories, and URLs). This needs to be carried out in order for the systems to assist users in achieving better and faster work and to perform analysis based on the stored data to propose search terms relevant to the user's interest.

(3) Browsing and Scanning: An array of browsing functions was available, but the log of data for browsing was not included. If the system stored the log of data for browsing in that regard (e.g., topics, subjects, journals, and books), then a user behavior analysis could be performed to determine the user's marked data browsing characteristics. An IR system with such features possessed the capacity to automatically propose user matching data browsing patterns. This was consistent with the notions put forward by Jiang, Pei, and Li (2013), which involved analyzing data for browsing and estimating behavior patterns based on it.

(4) Differentiating and Choosing: The databases provided a function for choosing, filtering, sorting, and displaying data. The system trial revealed a lack of data storage. If an IR system possessed the ability to save data on filtering, sorting, and displaying, it would help users save time. This was consistent with Jiang et al. (2013), who stipulated about extracting data from the users' system and recording search history to analyze user behavior. Moreover, when users chose information from the databases equipped with the recommendation function, data playing a large role (e.g., titles, keywords, download histories, related keywords, etc.) were presented. This was to facilitate the system to analyze and search relevant information more effectively.

(5) Monitoring: The online databases stored data (e.g., alert settings – journal alert, book alert, citation alert, search alert, and subject alert; my subscribed; and my favorite) and used the monitoring function to track new information and push information that matched the interests of users via e-mail.

(6) Extracting: The researcher studied data storage in terms of the users' useful data for extracting. The online databases were not equipped with this capacity.

(7) Verifying and Evaluating: The result was clear that the users' ability played a role in this stage. The systems could only propose data concerning usage history (e.g., metrics or bibliometrics, citation count, and cited by). This was to demonstrate the estimated level of the information's reliability as well as its relevance.

(8) Ending and Using: The data stored by the systems were usage statistics, including the statistic of download, save, print, and export results.

It was concluded that all online databases were equipped with user accounts and personal profiles, where data regarding the users' interests or favorites were stored. However, each online database was characterized by its uniqueness and different purposes for information usage. For example, ScienceDirect and Emerald Management provided "recommended articles" and "your favorites" functions, where both functions recorded data regarding the users' favorite information, indicating each user's interest and associating them with IB. This demonstrated that all online databases were launched with the design, data storage, and analysis of the users' system usage in order to facilitate the users' work.

Therefore, the design and development of IR systems required proper log file data storage analysis and design. The stored data must accommodate system user IB analysis and allow data mining as well as other applicable approaches to be applied

in order to accommodate each personalized IB. Without the storage of data useful for data analysis, an IR system will not be able to accommodate each personalized IB.

4.3. Study Results on the Information Behavior Model's Framework Development

The researcher assembled and took all the results into consideration on the basis of the system approach's participatory principle, which was utilized in an information system's abilities in enabling an IR system to learn, search for patterns, recognize, and understand an individual's human IB in terms of the behavior and interaction between the users and systems. This is to empower the users' ability and cognitive process to be considered as a principle guideline for IB model development. The created behavior model must appease and support all aspects of human IB in the digital environment, which is highly beneficial for further development of IR systems, such as online databases and library automation systems, as illustrated in Fig. 1.

Fig. 1 illustrates the IB model's internal functionalities right from the start until the end. Within the process, the model can work in a loop fashion. The IB model was comprised of seven stages which included: (1) Starting and Suggesting, (2) Filtering, (3) Differentiating, (4) Selecting and Proposing, (5) Verifying and Evaluating, (6) Using and Ending, and (7) Monitoring. The goal was to align the functionalities with the IR system's user's IB under the framework of the IB model's functionalities. Symbols that were used included: S, symbolizing actions carried out by the system; U, symbolizing those taken by the users; and a disk representing the saving of the users' log files for later user behavior analysis. Each stage can apply data mining techniques to support the work processes to be more efficient. The collaboration between the system and user in the IB model, based on the collaboration perspective of the user and system for IR and the related log data recommendation, is shown in Table 5. According to the conceptual framework for the behavioral model, the details for the seven steps are as follows:

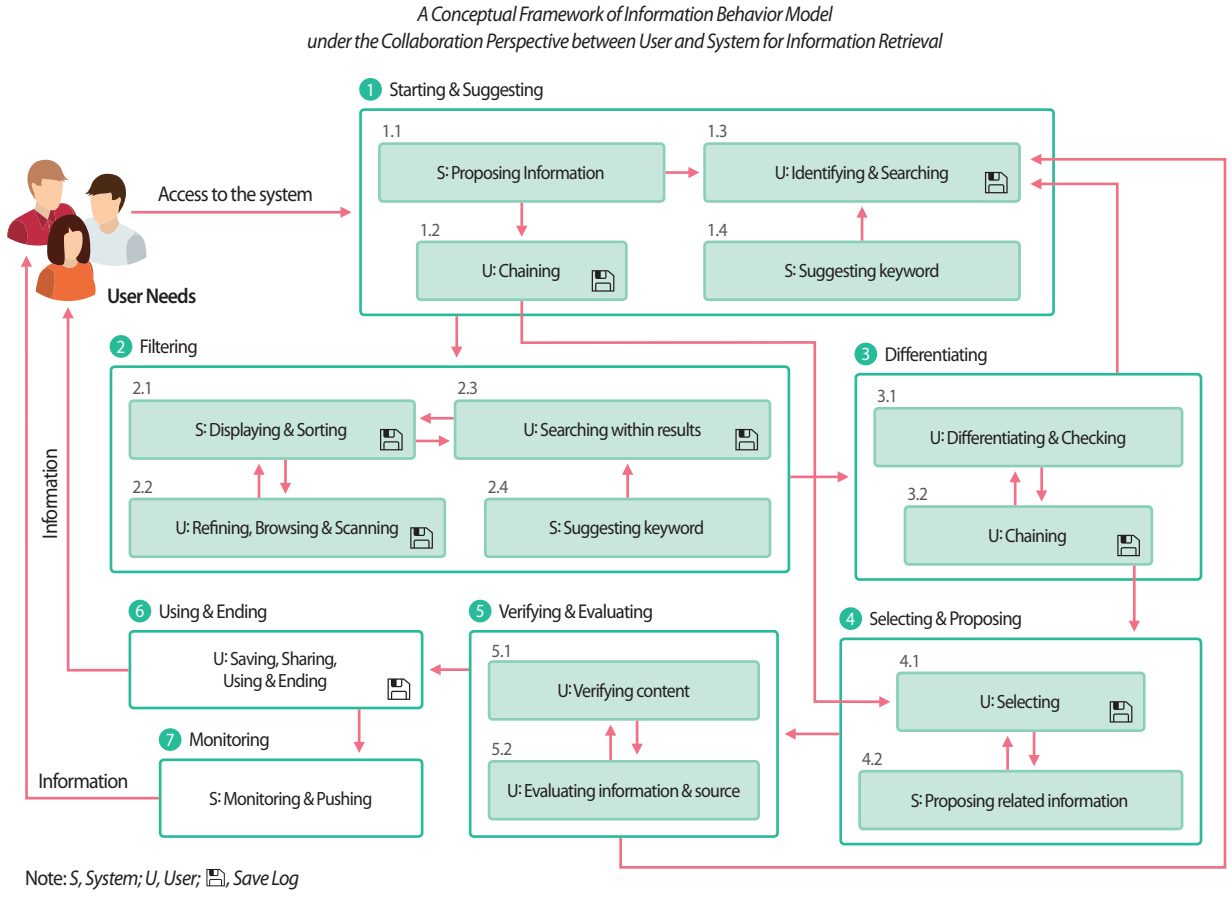

Fig. 1. Conceptual framework for an information behavior model based on the collaboration perspective between user and system for information retrieval.

(1) Starting and Suggesting: The entire functionality began with starting and suggesting information, which was initiated once the users logged into the system. After that, the system proposed information relevant to the users' interests by taking the user's log file into account (e.g., profile, search history, subjects of interest, my favorite, or my subscribed). The chaining process will automatically transfer to Stage 4 if the suggested information has been selected by the users. If not, the users can still identify and search. While this process is being carried out, the system will automatically suggest keywords as analyzed from the user's usage history (e.g., related keywords, popular keywords). In Stage 1, the users' log file consisted of three parts, which included: Stage 1.1, comprising the log files that were stored if users chose the offered documents that comprised keywords of the clicked documents, or if not then removing the keywords of the unclicked proposed documents from the storage; Stage 1.2, comprising keywords of documents, URLs clicked, or visited links; and Stage 1.3, comprising keywords, search terms, search operators, and queries.

(2) Filtering: This loop-operating process started with displaying and automatically sorting information in accordance with the users' usage history of the recent data displays and sorting. After that, the users can browse and scan the information. Additionally, this stage allowed for searching within results, helping users save time from having to search for entirely new information. While this was being processed, the system will automatically suggest keywords as well. In Stage 2, log files were stored in three parts, which included: Stage 2.1, displaying and sorting, which contained the history of displaying and sorting (e.g., relevance, newest first, oldest first); Stage 2.2, browsing and scanning, which contained the history of searches (e.g., topics, authors, publishers); and Stage 2.3, searching within results that contained data about keywords, search items, search operators, and queries.

(3) Differentiating: This stage denoted the process of differentiating and checking the searched results. This stage was grounded on the system's capabilities in Stage 2 to sort information based on certain conditions or display the result's distinctive details. Finding the searched information incomplete, the users could navigate back for searches in Stage 1.3, which demonstrated the characteristics of a loop-operating behavior model. The loop fashion complies with the user IB of today's information search, which does not function on the sequence basis but in a loop until the information needed has been found. This was corroborated by the experts, who shared a favorable view toward the behavior model's loop process. In Stage 3, log file storage consisted of Stage 3.2 (Chaining), which contained keywords of documents, URLs clicked, or visited links.

(4) Selecting and Proposing: This stage involved selecting information to be used and the system's recommendation of similar or related information. This stage was subject to a loop process, which started with analyzing other users' information, selecting history, and identifying similarities between the user-selected information and the system-embedded information, in order to extend a search scope which allowed for a time-saving process for the users. Furthermore, the IB model's framework will equip the IR system with functions or tools, which enable users to quickly analyze and select the desired information. In Stage 4, log files were stored as follows: Stage 4.1, information selecting, which included titles, authors, topics, keywords of documents, clicked links, URLs, etc. It was highly agreeable to the experts that an effective IR system should be able to propose useful information for the users to select. Like Stage 1.1, if the users did not select the proposed information, then the keywords of the unselected proposed documents would be removed from the storage.

(5) Verifying and Evaluating: This stage entailed the display of the users' selected information for the users to verify and evaluate content accuracy as well as reliability of the sought information sources. In case of the selected information being evaluated as lacking reliability, relevance, or completion, the users could navigate back to Stage 1 to redo the search process easily.

(6) Using and Ending: In this stage, the users put the searched results to certain uses. Users were able to save and share the information to other data sources, such as sharing on social media. In Stage 6, the users' log file data were classified and consisted of saving histories, including information such as titles, authors, topics, keywords of documents, download history, sharing history, information usage history, and other types of data such as my favorite and my subscribed.

(7) Monitoring and Pushing: This stage referred to the system's process of monitoring new information. By detecting potentially needed information matching the users' interests as analyzed from the information selecting history, the system proceeds to push the information to a variety of channels, such as e-mail.

Table 5. Collaboration between the system and user and the related log data recommendation according to the proposed conceptual framework

Process/Function	Collaboration		Storing log data	Using log data
	System	User		
S.1 Starting & Suggesting				
1.1 Proposing information	Proposing the information relevant to the users' interests			Profile, Search history, Subjects of interest, My favorite, My subscribed, etc.
1.2 Chaining	Chaining if suggested information has been selected by the users	Selecting the interested information	Keywords of the chained information, URLs, or Visited links	
1.3 Identifying & Searching		Continuing to identify and search	Search history (Keyword, Search operator, Query)	
1.4 Suggesting keyword	Automatically suggesting keywords as analyzed from the user's usage history			Related keywords, Popular keywords
S.2 Filtering				
2.1 Displaying & Sorting	Displaying and automatically sorting information		History of displaying and sorting (by newest first, by relevance)	Recent data displays and sorting
2.2 Refining, Browsing & Scanning		Browsing and scanning the information	Search history (Keyword, Author, Publisher, etc.)	
2.3 Searching within results		Searching within results	Search history (Keyword, Search operator, Query)	
2.4 Suggesting keyword	Automatically suggesting keywords			Related keywords
S.3 Differentiating				
3.1 Differentiating & Checking		Differentiating and checking the searched results or navigating back to search again		
3.2 Chaining	Chaining to the information source	Selecting the interested information	Keywords of the chained information, URLs, or Visited links	
S.4 Selecting & Proposing				
4.1 Selecting		Selecting information to be used	Keywords of the selected information, URLs, or Visited links	
4.2 Proposing related information	Recommending of similar information or related information as analyzed from the other user's usage history			Other user's usage history
S.5 Verifying & Evaluating				
5.1 Verifying content	Displaying the details of selected information	Verifying the accuracy of the content, evaluating reliability of the sought information sources, or navigating back to search		
5.2 Evaluating information & source				
S.6 Using & Ending				
Saving, Sharing, Using & Ending		Saving, sharing, using, or printing	Information use history (Titles, Authors, Topics, Keywords, Download History, Sharing history, My favorite, My subscribed, etc.)	
S.7 Monitoring				
Monitoring & Pushing	Monitoring new information and pushing the information to a variety of channels such as e-mail			

All of these seven stages of the IB model's conceptual framework were unique and consistent with the digital environment in order for the IR system to be able to learn, search, recognize, and understand an individual's human IB. The model's featured characteristics were as follows:

(1) The IB model design and development conformed to a collaboration perspective by considering the IR system's abilities in conjunction with the users' behavior. The experts had a favorable view toward the model development based on various perspectives, because that will groom it to reach its fullest potential and cooperate with the digital context.

(2) The model's loop processing was commensurate with the IB users' iterative. In addition, the conceptual framework also classified sub-work processes under the model in accordance with the users' IB. For example, the filtering process in Stage 2 encapsulated the loop process with iterative sub-functionalities in the process under close coordination with displaying, sorting, browsing, and scanning. The experts were highly in favor of this iterative nature within the model because it is in line with the users' IB in the digital environment.

(3) The model had an automatic operation. An automatic function was marked by information proposed in Stage 1 and Stage 4, which empowered the system to assist users in instantly seeking and searching information and to help inexperienced users to benefit from assistance in analyzing and choosing the needed information. Additionally, there was also the process of monitoring and pushing new information in Stage 7, which worked in synchronization with the users' log files, basically consisting of a profile, my favorite, my subscribed, saved, shared, downloaded, etc. This equipped the IR system with the abilities to analyze and propose need-relevant information to the users and also to respond to users' IB even if the users were not using the system.

(4) The model recorded the users' log files or data concerning interactions between the users and the system. This was carried out so that the system could learn, search, recognize, and understand IB and propose useful information that met the users' need, resulting in relatively better interaction between the users and the system. For example, in Stage 1, the system was capable of suggesting search keywords related to users' interests; and in Stage 2, the filtering process could choose to display and sort data according to the patterns used before. With these capabilities embedded, the system can claim to be a user-friendly system for inexperienced users.

(5) The IB model's framework was designed to provide an IR system allowing users to skip certain procedures. For example, in Stage 1.2 after the users had received the needed information, the users can skip to Stage 4.1. Essentially, faster and easier work, expected in the users' IB in the digital environment, was achieved as a result. Such a prompt process was well received by the experts, confirming that today's information system users preferred spending as little an amount of time as possible while working on any system.

(6) The system was designed for users to be able to share and use the searched results in Stage 6, as supported by the experts, who pointed out that the present system analysis and design should allow information sharing between the users of the same system or other systems.

5. CONCLUSION

A huge leap in technology and change in the digital environment have generated a profound impact on human IB, and humans now rely more on an information system. Therefore, adjustment of the information system to that new rhythm to properly accommodate changing user IB is necessary. However, exceptional information system analysis and design cannot be performed without user IB analysis so that IR systems are able to learn, recognize, and understand human behavior better. The study results showed that most online databases have provided several functionalities in every stage of the information behavior to facilitate users, such as the search save and recommendation function. However, an individual's personalized support from the system needs further investigation to implement appropriate intelligent techniques behind such functionalities. The findings led to the suggestion of the framework design on the basis of the collaboration perspective by considering the capacities of IR systems and user IB together. This move will upgrade the IB model to better suit the present digital context and be adapted to the evolving human IB. Distinctive characteristics considered useful included:

(1) Empowering characteristics and functionalities of IR systems. First, the users' individual characteristics, recognizing the capacity to the system in favor of the evolving personal user IB, were added. For example, the recommendation function to suggest information related to the users' interest by means of modern techniques and log file storage should be added, such as the user's usage history and favorites. This was to enable inexperienced learners as well as users lacking data seeking skills to access

information more easily. Second, this would help the IR system to be more automatic. For example, suggesting keywords simplified and eased the search process. Automatic data displaying and sorting from recent use in the log files were constantly updated, which led to easier information access as well.

(2) The IB model framework featuring iterative and flexible operating processes put interaction between the users and systems in line with real-life situations.

Integrating the IB model framework based on the collaboration perspective between the users and systems into the design and development of online databases, library automation systems, and IR systems led to the systems' capacity to understand, learn, recognize, and accommodate changing user behaviors in today's digital context. Relevant and useful information can be accessed more effectively and conveniently in a timely manner. Additionally, an IR system can match behavior according to personalized characteristics, which requires other technologies to support the objectives of the conceptual framework. This includes data mining and data structures of the log file. Shortage of the data highly useful for analysis is equivalent to the inability to apply data mining as well as useful information suggestions. From what has been discussed, further research into this area requires investigation into various data mining techniques, such as the association rule and clustering techniques to analyze log data and apply them with an IB model in order to achieve more efficient IR systems, so that the information to genuinely satisfy user needs is accessed. Additionally, the IB model framework can boost users' ability and cognitive process, resulting in relatively less searching time and the more convenient work processes required to effortlessly achieve a more effective outcome.

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