Web Information Gathering, Which Subtask to Investigate? A User Study

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Abstract - **This paper is an attempt to re-identify the subtasks of the task of information gathering on the web which require further research. The study confirms the types of subtasks that need further consideration yet with different ordering of significance from what users indicated in a previous study. The different ordering was concluded based on the frequency of activities performed within each subtask. The study in Alhenshiri, et al. [1] recommended that web users performing information gathering tasks should be able to: re-find information from previous sessions for the same task more effectively, should also handle multiple sessions more effectively, and they should be able to manage and organize information for the entire task not dispersed parts of it. The research discussed in this manuscript revisits those recommendations in a user study comparing a tool designed specifically for information gathering tasks on the web and the plain browser while used with other assisting applications.**

Index Terms - **information, gathering, task, web, user, visualization, management.**

I. INTRODUCTION

Information gathering tasks - also labeled informational - are complex, highly search reliant, often require more than one session, and typically result in an information product; such as notes or a report.

The task of information gathering has been found to represent between 48% and 61.25% of all the tasks users perform on the web [2, 3]. Amin [4] identified many of the defining characteristics of information gathering. The task of information gathering on the web was chosen for investigation in this research for several reasons. First, information gathering typically requires collecting information from different sources. Second, information gathering requires the completion of subtasks requiring multiple applications and tools. Finally, information gathering typically requires multiple sessions to complete.

The effectiveness of current web tools to support users dealing with information gathering tasks has been shown to be problematic for users [5].

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In a previous study, Alhenshiri, et al. [1] developed recommendations for the design of web tools intended for information gathering including: support the re-finding of pages, save information between sessions, and integrate the management and organization of information related to the task.

Based on those recommendations, a prototype was built for use in the study described in this paper. The purpose of the study was to compare specific features built in the prototype to support the recommendations against the use of a conventional browser for information gathering tasks. This paper attempts to describe how the recommendations were confirmed by answering the following question:

Do the behavioral characteristics of users performing information gathering tasks on the web confirm the recommendations devq22eloped in the earlier studies? This question is answered by using:

1. The data logged during the study.
2. The user responses to issues regarding their behavior while performing information gathering tasks.

The remainder of this paper is structured as follows. Work related to the investigations of the task of information gathering is illustrated in Section 2. Section 3 explains the research study. Section 4 provides a detailed discussion of the study results. Section 5 concludes the paper.

II. RELATED WORK

Researchers have categorized the tasks users perform on the web and information gathering is consistently identified as a very frequent task. Information gathering tasks involve collecting information possibly of different types from different sources to achieve an overall goal [1]. Information gathering tasks are mostly search-based as shown by Kellar, et al. [6] and Amin [4]. Information gathering was recognized as the most frequent goal for users who are re-finding information on the web [7] and even for users involved in a search [3].

Earlier research [1, 7] identified subtasks that are typically part of the overall task of information gathering. The core subtasks identified were: finding information sources, finding information, managing information, handling multiple sessions, and re-finding information. A

model was created of the relationship of those subtasks to the overall task as shown in Fig. 1.

Information gathering tasks have been studied over the past few years as part of examining user interactions on the web for searching and navigation, for example Kules, et al. [8]. Researchers have investigated general aspects of the information gathering task. For example, Yamada and Kawano [9] used sections in web pages located for an information gathering task to extract links to other pages. The target pages were considered a part of the user plan for the task and suggested to the user to continue gathering related information. In a similar approach, Bagchi and Lahoti [4] used hyperlink connectivity among web pages to assist users in gathering information on the web. They argued that providing links to pages currently being viewed by the user can facilitate the process of information gathering. However, the only subtask of information gathering considered in these two studies was locating web information, i.e. finding.

Dearman, et al. [10] investigated the subtask of finding sources of information during information gathering tasks. Re-finding information on the web has been investigated with respect to locating previously found results [11, 12] and for monitoring web sources of information [6]. Issues with how users deal with information gathering and how they manage their time for the task were discussed in the work of Murphy (2003). Tao and Li (2009) addressed the problems of information mismatching and overloading during information gathering using concept-based personalized techniques. They suggested that improvements are needed for the representation and acquisition of user profiles in personalized web information gathering. Earlier, Zilberstein and Lesser [14] looked at decision making as an intermediate step in information gathering tasks.

The research conducted prior to the study discussed in this paper attempted to model the subtasks comprising the overall task of information gathering on the web. The subtasks are shown in Fig. 1 and described as follows:

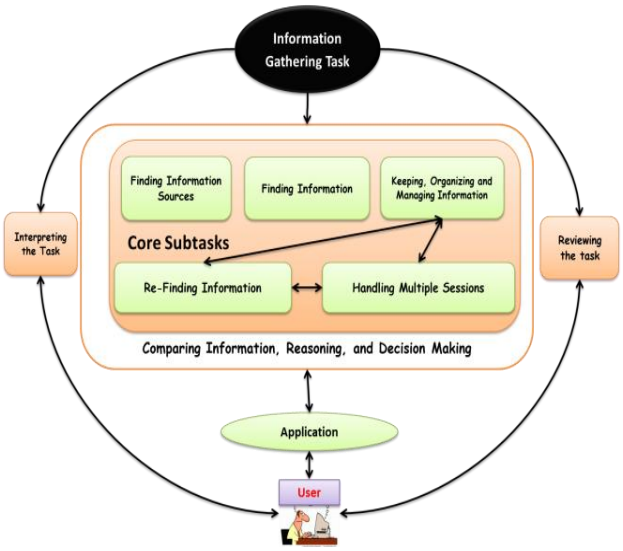

Figure 1. A Model of the Information Gathering Task

A. Core Subtasks

1. **Finding information sources.** This subtask involves activities intended to located websites and pages that have the potential of being considered for collecting information for the task.
2. **Finding information.** A continuation of the previous subtask is the subtask of finding actual information on web pages located. Information may involve parts of pages such as text, pictures, and so on.
3. **Keeping, organizing, and managing information.** This subtask involves preserving information organized as required in the task for: either working on the same task in subsequent sessions; or finalizing the task requirements. It also involves other managerial activities such as moving, copying, and editing objects.
4. **Re-finding the task information.** Activities regarding relocating information sources by revisiting links to web pages and sites comprise this subtask.
5. **Handling multiple sessions.** This subtask involves activities to manage the task information and context for restarting the task in subsequent sessions.

B. Other Subtasks

1. **Comparing information, Reasoning and Decision Making.** This subtask involves user behavioral activities that concerns comparing information sources, comparing information, and decision making for selecting information appropriate for the task at hand.
2. **Interpreting the task.** The interpretation of the task results in the choices of tools and kinds of information to gather for the task.
3. **Reviewing the task.** This subtask involves activities to ensure the completion of the task requirements or the session requirements in a multi-session task.

Following the proposal of the task model, the features of tools to support information gathering needed to be validated and best practices to be established to help users meet the challenges of this frequent task. The research discussed in this paper is an investigation of the effectiveness of recommendations for the design of features in web tools intended for gathering information from the web. The features developed and tested in a prototype are compared in the study to the use of a conventional web browser. The purpose is to revisit the recommendations from a previous study and confirm to what extent they are valid.

III. Research Study

A prototype interface called WIGI (**W**eb **I**nformation **G**athering **I**nterface) was designed and implemented to investigate specific features for particular subtasks of the information gathering task as identified in a previous

study. The recommendations developed in Alhenshiri, et al. [1] identified the following subtasks as highly relevant: re-finding information, handling multiple sessions, and managing and organizing information. WIGI, shown in Fig. 2, consists of three main parts illustrated along with the features implemented as follows.

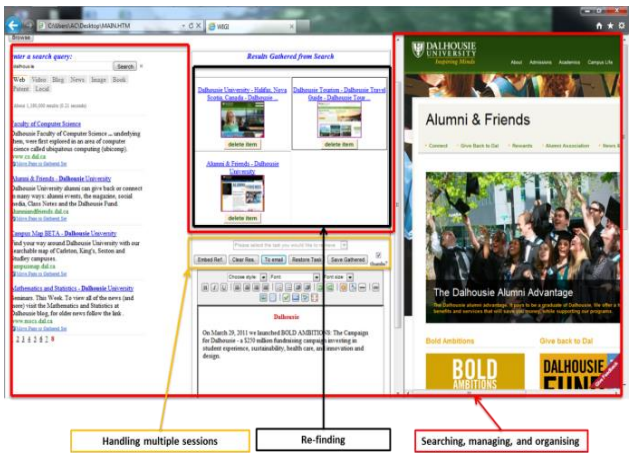

Figure 2. The WIGI Interface

(1) Re-finding Information: the Reference Tracking Area.

- Users can keep track of every URL clicked in the search results.
- They can click each URL during any session within the same task.
- Links clicked from the search hit list are captured and shown to the user associated with the thumbnail as recommended in the works of Morgan and Wilson (2010) and Teevan et al. [13].

(2) Handling Multiple Sessions: the Control Bar.

- Users can save the session information including: the tracked links, the information collected in the editor, and the links embedded as references as one integrated unit representing the task.
- Users can restart the task in subsequent sessions and have the information gathered in previous sessions retrieved as one integrated unit.

(3) Searching, Managing and Organizing the Task Information: three panes within the browser window.

- **The Embedded Editor**
  - Users can drag and drop information from *web pages/search hits summaries* into the editor.
  - They can add their input to the task using the editor.
  - Users can format the information in the editor as required in the task.
  - They can embed references into the information gathered in the editor.
- **The Browsing Area**
  Users can browse search results (pages) and typed in URLs on the same display along with editing, searching, and reference tracking.
- **The Search Area**
  - Users can search the web for information using a search engine.
  - They can track every search hit clicked to appear in the reference tracking area.
  - They can browse search hits on one display along with the list of hits being viewed.

A. Study Population and Tasks

Thirty participants were recruited for the study. All of the participants were computer science students from Dalhousie University. Of the participants, 15 users were males and 15 were females. Fifteen participants were graduate students while the remaining were undergraduate students. Participants in the study were between the ages of 18 and 30.

The study used four different information gathering tasks each of which had two parts (e.g. Task 1_a and Task 1_b). The reason for splitting each task into a sequence of two related parts was to provide a context in which participants might find some advantage in re-finding information for Task1_b that was found or kept during Task1_a. The tasks were created using principles described in the work of Kules, et al., [8]. A focus group was used to ensure that the tasks were at the same level of complexity as described in the work of Alhenshiri, et al. [1]. An example of one of those tasks is provided in Table 1.

Table 1. Task Example

Task (Part a). First Session	Task (Part b), Second Session
You have a friend who asked you to provide her with valuable information about Canadian universities that she may consider for a graduate degree in business. What kind of information would you like to send to your friend providing her with a comparison of two universities? Provide your choices of the universities. Provide links to at most five web pages you find helpful in making your choices. Also, provide a copy of the information you would send to your friend, which shows the comparison you made. You will need to come back to reuse the information you found in this task.	Last time, you selected two Canadian universities for your friend to pursue a graduate degree in business. Now, your friend asked you to provide her with two choices of American universities to consider for a graduate degree in business. Choose two American universities that provide graduate degrees in business. Find up to five web pages that would allow you to make a comparison between the Canadian universities you already selected and the two American universities you will choose. Provide the results of your comparison (information you used in the comparison) in addition to links to at most five web pages you find useful in making the comparison.

B. Study Design

The design of the study was complete factorial and counterbalanced. Four different tasks were used in the

study (from the work of Alhenshiri, et al) [1]. Every task had the same chance of being used in the study. The order of distributing the tasks over the tools (WIGI or browser) and participants was random. Every participant performed a total of two tasks with one task (divided into two parts) executed on WIGI and one task on the ordinary browser. Both the browser and WIGI had the same chance of being used first. The browser used in the study was Internet Explorer (version 9). This browser was selected due to the need for using ActiveX components. The study had four conditions: two processes (browser + WIGI) and two tasks.

C. Study Methodology

Each participant was randomly assigned two of the four tasks. The study was conducted over two sessions. On the first day of the study, each participant signed the consent form after being introduced to the study and after explaining the participant's role in the study. Then, the participant was given a short training session on WIGI (five to ten minutes). The participant then completed an online pre-study questionnaire. After completing the questionnaire, the participant performed the first part of the first task on either WIGI or the browser. Then, the participant was given the first part of the second task to complete on the tool (WIGI or browser) the participant did not use for the first task.

On the second day, each participant returned to complete the second session of the study. First, the participant completed the second part of the first task on the same tool (WIGI or browser) they used for the first part of the first task. Following completing the post-task questionnaire for the first task, the participant completed the second part of the second task on the same tool they used for the first part of that task (which they completed in the first session). Afterwards, the participant completed a post-task questionnaire for the second task. Then, the participant was interviewed shortly to answer questions related to the way the participant completed the study with regard to why certain tools and strategies were used.

D. Study Results

The study data came from two sources: the log file of activities performed in the study and the questionnaires. Overall, 5436 activities were logged during the study. Of the activities, 2539 activities were recorded while using the browser and 2897 activities were recorded while using WIGI. The activities were counted for each subtask mentioned in the recommendations of the previous study. The frequency of activities that belong to each subtask may help with deciding on the significance of each subtask. As a result, the recommendations from the previous study may be further confirmed or rather changed.

i. Pre-study Questionnaire Data

The pre-study questionnaire involved collecting data regarding the age of the user, their experience with web information gathering, the tools they usually use, and the difficulties they encounter while gathering information on the web. All users were under the age of 31 and the study had equivalent numbers of both genders (15 males and 15 females). All users (30) were regular web information gatherers. The tools users indicated they usually use for information gathering tasks are shown in Table 2. The difficulties and issues users reported with information gathering on the web are shown in Table 3.

As shown in Table 2, handling multiple sessions has issues including saving pages and sessions, saving the information of the task integrated, and re-locating the task instead of parts of the task. With regard to re-finding information, users were concerned with creating and re-opening bookmarks as the main issue encountered for the purpose of re-finding. Lastly, with regard to managing and organizing information during gathering, users were concerned with editing and browsing simultaneously as well as editing and searching. To a lesser extent, users seem to have had issues with dealing with open browser tabs.

Table 2. Tools and Applications Users Usually Use

Tool or Application		Responses	# Users
Web Browser		100.00%	30
Text editor		86.70%	26
Local bookmarking		50.00%	15
Online bookmarking		23.30%	7
Session saving		23.30%	7
Other:			
	Email	6.00%	2
	Query Saving	3.00%	1
	Paper	3.00%	1
	Plug-ins	3.00%	1

As shown in Table 2, the web browser, the text editor, and local bookmarking were indicated as the most frequently used tools for information gathering. Other features and tools such as online bookmarking, session saving, and emails were indicated on very few occasions. Even though these results reflect what the users believe they use in usual, the study was expected to reveal findings that could differ.

The issues indicated by high percentages of user responses are those related to handling multiple sessions and re-finding information during information gathering tasks on the web. Managing and organizing information had fewer issues as shown in the user responses. Interestingly, these three main issues confirm the recommendations from the previous study with regard to the kinds of subtasks that require further investigations. Consequently, those recommendations are consistent with the user responses. However, the data logged in the study with respect to the number of activities involved in each subtask contradict the order of significance of the subtasks as indicated by the user.

Table 3. Issues Users Reported Having with Information Gathering Tasks on the Web

Related Subtask	Issue	# Participants	% Responses
Handling Multiple Sessions	saving pages	19	63.30%
	saving information together	13	43.30%
	re-locating a task on which the user worked in previous sessions	11	36.70%
	saving sessions	10	33.30%
Re-finding Information	creating bookmarks	12	40.00%
	retrieving bookmarks	12	40.00%
Managing and Organizing Information	editing along with browsing for information	9	30.00%
	searching along with browsing for information	8	26.70%
	searching and managing information for a task	5	16.70%
	saving open tabs together	5	16.70%

ii. Study Data

The study although logged all user activities, only a portion of those activities was considered. To investigate the research question, the data logged during the study was analyzed. The following discusses each part of the data that is related to each subtask considered.

1. Re-finding Information

The study logged activities related to re-finding information in the case of the browser and WIGI. The re-finding activity used in the analysis of the study data was revisiting references (links to web pages) to information accessed in the first session. On WIGI, users made 185 (3.4% of the total activities) re-finding activities while they made only nine re-finding activities on the browser (0.16% of the total activities). The difference between the two cases was significant according to ANOVA ($F(1, 58) = 14.15$, $p < 0.0005$). The total number of re-finding activities in the study was very small (194 activities) compared to activities involved in other subtasks.

2. Handling Multiple Sessions

To save a task for subsequent sessions while using WIGI, all users used the *save gathered* feature built in the control bar. This feature allowed users to keep the task information integrated in one unit permitting them to restart the task in later sessions. Users kept the information they had collected and organized in the editor and the references they accessed during the first session which were accumulated in the reference tracking area. During the second session, restarting the task required the use of the *retrieve task* feature, which is also built in WIGI. None of the users used any files or emails to handle multiple sessions with WIGI.

On the browser, users used four different strategies to handle multiple sessions. Twenty six participants (26/30) created text files (using either MSWord or Notepad) to keep the task information and restart the task in the subsequent session. Four users (4/30) created 15 bookmarks. However, the same users re-opened the bookmarks they created only 10 times. Four users (4/30) created email drafts to keep the information for subsequent sessions. Two users (2/30) saved complete pages to be used in the second sessions. Interestingly, neither of those two users re-opened the pages they saved.

The difference between the number of users who used the *save gathered* feature in WIGI (30/30) and the number of users who used text files to keep the task information in the case of the browser (26/30) was significant (z-test, $z = 2.15$, $p < 0.04$). The comparison took the use of text files being the most frequently used activity for handling multiple sessions on the browser.

Although there was a significant difference between the number of activities conducted for re-finding on the browser and those performed for the same purpose on WIGI, the total number of activities recorded for re-finding information remains relatively small. Subtasks such as managing and organizing the task information—discussed next—had many more activities than re-finding information.

3. Organizing and Managing Information

To manage and organize the task information, users followed different strategies on each tool (WIGI or browser). All users indicated that they understood the tasks and had no problems with the descriptions of the tasks. Organizing and managing activities logged during the study regarded: formatting, typing, copying and pasting, result hits clicking, menu and page link clicking, and *reference embedding*/*reference copying and pasting*. In the case of the browser, some of these activities required the use of other applications such as emails and text editors. In addition, while using the browser, users performed activities such as: creating bookmarks, opening bookmarks, creating files, opening files, closing tabs, creating email messages, and opening email messages.

A. Copying and Pasting Information

One important activity related to managing and organizing the task information is copying and pasting information during the task. The study logged copying and pasting information from web pages into the information pool (e.g. editor) where the user collected the task requirements. The study recorded 330 pasting activities in total (6.01% of the total activities).

B. Typing Information

While gathering information, not only do users copy information from web sources(pages) but they may provide their own input to the task or perform re-phrasing such as when they write a report or a survey article. Users may type information along with the information they find on pages such as to make their own conclusions. Every time the user hit letter or number keys on the keyboard, the activity was considered typing. A typing activity ended with the use of the mouse or a control key such as the *carriage return* or the *tab* key. The study recorded 490 typing activities on both the browser and WIGI. The number of typing activities represented 09% of the total activities.

C. Embedding References to Manage Information

In this context, embedding references is an activity intended for keeping links to web pages as part of the managing and organizing subtask to produce the final form of the task information. The study recorded a total of 410 referencing activities (07.54% of the total activities).

D. Formatting Information

Formatting information collected for the task of information gathering includes using headings for the gathered text, changing fonts and colors, moving objects within the gathered information (within a file, an email draft… etc.), and resizing objects such as images. These are examples of formatting activities logged during the gathering process. The total number of those activities was 572 which represent 10.50% of the total number of activities logged.

The total number of managing and organizing activities that were logged in the study represented 25.51% of the total activities. This percentage was much higher than any of the other subtasks considered. Consequently, managing and organizing information can be considered as an important subtask in the information gathering process. These subtasks should go on top of the list of subtasks to be considered for further research.

4. Finding Information

Finding information is a fundamental subtask of the information gathering task. The finding activities recorded in the study included: search queries submitted to search engines, search queries submitted on web pages, links clicked on web pages, result hits clicked, and the use of find-on-page feature in the browser. These activities allowed users to find information sources and to find information on the located sources. The total number of finding activities was 955 (17.57% of the total activities). The total number of finding activities on WIGI was 565 while the total number of finding activities on the browser was 390.

On WIGI, users submitted 250 queries to Google (the underlying search engine) to locate information sources (web pages). None of the participants typed in URLs to start searching for information. Similarly, participants submitted 251 queries to search engines in the case of using the browser. Google was the dominant search engine used in the case of the browser. There was no difference between the browser and WIGI with regard to the numbers of search queries submitted to search engines. The number of querying activities represented 09% of the overall activities in the study. This indicates the complexity of the task of information gathering which requires more than submitting search queries for finding information independent of the tools used.

Users of WIGI did not submit any search queries using the search box provided on some web pages. On the browser, six users (6/30) submitted a total of 22 queries to find information on web pages. Even though there is a difference between the two cases, the number of search queries submitted while using the browser was very small. Moreover, the results indicate no significant difference between the links clicked on pages in the case of WIGI and the number of links clicked in the case of the browser (ANOVA, $F(1, 58) = 1.8, p<0.19$).

With respect to search hits clicked, users performed the activity much more frequently on WIGI (432 times) than they did on the browser (179 times). The difference between the number of search hits clicked on WIGI and the browser was significant according to ANOVA ($F(1, 58) = 34.37, p<0.0001$).

The activities performed for finding information show a significant difference only in the case of clicking search hits. Users behaved similarly in the cases of clicking links on web pages and submitting queries on websites. They also submitted almost the same number of queries to search engines in the cases of using both WIGI and the browser. Finally, the data show that users of both WIGI and the browser rarely used the find-on-page feature. There was no significant difference between the data recorded on WIGI and the data recorded on the browser for the use of the find-on-page search feature.

With regard to the total number of finding activities recorded in the study, the finding subtask should considered for further investigations. The recommendations in the previous study did not consider this subtask based on what users indicated in their feedback of disturbing issues during the process of information gathering. However, the frequency of its activities during information gathering makes is one of the important subtasks that should be re-considered in the context of information gathering on the web.

IV. Discussion

In the pre-study questionnaire, it was shown through the user responses that re-finding information followed by handling multiple sessions and managing information are the most important subtasks from the user's perspective. However, the data logged during the study showed that managing and organizing the task information has much more frequent activities than activities that belonged to the other subtasks. Managing and organizing information is followed by the subtask of finding information according to the number of activities logged during the study.

While reporting issues users usually have with gathering web information, they indicated that handling multiple sessions has more issues than re-finding or managing the task information. These issues were concerned with saving pages or saving information and relocating the task as one unit. The WIGI interface helped the user deal with these issues in the study. Re-finding information had issues such as saving sessions and saving and retrieving bookmarks. However, users had the least number of issues with managing and organizing the information as they themselves indicated.

Nevertheless, the study data showed that managing and organizing the task information had the highest number of activities. Compared to the other subtasks, managing and organizing the information required more

actions by the user which may give an indication about the complexity of this subtask. Furthermore, it gives indication about the possible lack of effectiveness in the current tools used for information gathering. Managing and organising the information involves the use of more tools and applications than any other subtask. Furthermore, finding information - opposite to what users first thought - was the second subtask in terms of the frequency of activities involved.

Managing and organizing information for the task as well as finding information are two subtasks that should be considered for further research. In the case of managing and organizing the task information, research may look at the browsing model for involving managerial features in the browser. It should focus on decreasing the need for switching among applications for managing information. For example, editing features may be added to the browser.

Finding information should also be looked at in terms of assisting the user to find information and information sources while organizing the task resources. Searching pages and sites for information while being able to capture the current view of the task is necessary for more effective gathering.

In addition to those two subtasks, re-finding information for the task and handling the usually multiple sessions of information gathering are mandatory concerns to users gathering web information. Research may look at the ability of the user to keep the task integrated for subsequent sessions such as keeping references to information with the information gathered altogether. It should also look at the current ways of storing references such as bookmarks and their actual effectiveness in the case of gathering web information.

V. CONCLUSION

The study conducted in this research showed that by looking at the user perceptions of what subtasks are more important, users indicated an order that was contradicted by the number of activities logged for each subtask. The study showed that if one looks at the activities performed within each subtask in terms of their frequency and variation, managing and organizing information is the most complicated subtask followed by finding information. Nonetheless, users showed that re-finding information and handling multiple sessions were the most important. All in all, these subtasks should be studied and further analyzed individually for improving the effectiveness of how users gather information on the web.

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