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Multitasking Made Easy: Supporting Academic Writing in Digital Libraries with an Ambient Search System

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1. Introduction

When personal computers first arrived, many predicted that by the end of the century our desktops would become free from clutter as we moved to the paperless office. However, if we look at desktops of current researchers, we can see that this has definitely not happened (see Figure 1). But it is not only researchers' physical desktops that are cluttered; their computer desktops (and file systems) are just as cluttered. This should not come as a surprise. Because the process of writing is such a complex process, people need this space to lay out their notes, readings, drafts, printouts, etc. As a result, the desktop is literally disappearing under piles of paper, just not in the way predicted.



Fig. 1. Example of a cluttered desktop and office of a person (one of the authors) engaged in research and academic writing.

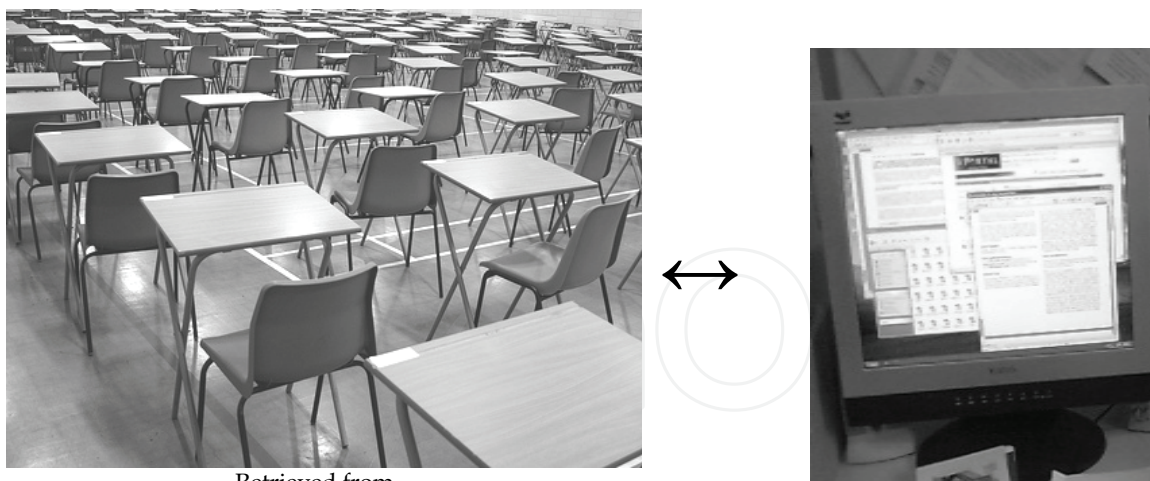
Writing is an extremely complex process, consisting of multiple components that can occur in many different combinations. With respect to academic writing, these components include planning and organization, presentation of facts, marshalling of arguments, preparing tables, figures, diagrams and references, searching for references, reading, annotating related and possibly related work, citation chaining, countering argument threads in related work, searching for inspiration, and searching for supporting and refuting evidence in the literature (Brockman et al., 2001; Fister, 1992; Kuhlthau, 2004; Palmer, 2005; Torrance et al., 1994; Wolber et al., 2002). At times it can help to consider these activities, some of which are very different, as a special kind of multitasking, raising the question of how best to support it.

Before personal computers, writing involved the accumulation of resources from books, journals, preprints, the authors' prior work, notebooks, outlines and previous drafts. These paper sources might be laid out on available flat surfaces (desks, tables, often the floor) in order to be easily available during writing, not only for immediate reference, but to serve as passive reminders and awareness agents of other activities to do and issues to consider. Working in an office means that even vertical surfaces can be recruited – whiteboards containing the results of discussions with co-authors, and bookshelves serving as reminders of other resources that might be considered, or as sources of inspiration when writing meets an impasse.

What is so noticeable is that since the arrival of personal computers in the mid 1980s, and despite the enormous improvements in processing power, memory capacity and screen size, as well as the dramatic improvements in online access to digital libraries, web pages, scholarly repositories etc., the paper-strewn scenario of the previous paragraph is still all too familiar. If anything, access to more resources more quickly just means that it is easier to print out and strew more documents around one's office while writing. Additionally, the access to online full text versions of papers means that researchers can also accumulate substantial personal digital collections of papers on their hard drives. If poorly organized, these collections themselves are difficult to navigate, and are in need of a context-aware retrieval system (Kljun & Carr, 2005).

The issue in interface design is that in the context of writing the desktop metaphor is *not* necessarily bad or obsolete. Rather the problem is that it has never really been tried. Desktop computers have limited screen real estate and so must employ various tricks of overlapping, iconization, listing of files, links and other tricks to manage the quantity and diversity of materials needed to support writing. Even with 24" screens and double, even triple monitors, the available space is small compared to most people's actual desktops (let alone their floors and walls that can be employed in the more intense periods of writing). If anything, current screens resemble the tiny individual desktops used by examination candidates (typically less than 3' by 3'), with just enough room for a question paper and an answer booklet (see Figure 2). That is fine for a test of memory, but is wildly unsuitable for rich, contextualized writing, let alone thinking and searching while writing.

The growing availability of academic literature on the Internet makes it possible for authors to multitask by switching between writing and information searching; as easy as switching between two windows on their computer monitors. However, this poses a new challenge to writers. The complexity of information searching (generating query, browsing, assessing results, etc) makes it very hard to stay focused on writing. Furthermore, an overwhelming diversity of poorly connected online research tools (search engines, digital libraries, bookmarking sites, etc) often leads to information fragmentation among their users (Boardman & Sasse, 2003).



Retrieved from
<http://www.flickr.com/photos/comedynose/3571102858>

Fig. 2. The existing manifestation of the desktop metaphor implies a very tiny desktop, more like that used for examinations involving writing from memory than larger office desktops (plus floors and walls) used for writing from resources.

We are exploring the design of an online context-aware retrieval system that allows users to multitask by writing while still actively engaged in research activities online. We have developed a web-based prototype called PIRA (Personal Information Research Assistant) available at <http://writeNcite.com>. PIRA relies on external digital libraries and search engines to produce a list of academic references related to what a user is writing at the moment; thus, allowing authors to stay focused on their writing.

PIRA attempts to support many of the awareness features provided by a papers strewn desktop and floor, but with a more active approach, providing an ambient awareness of work that *may* be relevant and inspirational. In its current form, PIRA remains locked into a single screen, although attempting to use it in a more integrated manner for supporting writing.

This paper focuses on the methodological aspects of user-centric evaluations of PIRA. More specifically, we investigate influences of multitasking as supported by PIRA on users' writing.



2. Related work

Previous research in this area produced a number of interesting design solutions for context-aware retrieval systems that can support writing and reading. Some examples of earlier work in this area include: Watson to support desktop-based writing/reading activities (Budzik et al., 2002), Implicit Queries (IQ) to support composing/reading e-mails (Dumais et al., 2004), Phrasier to support interactive document retrieval using keyphrases (Jones & Staveley, 1999), and systems like Letizia and PowerScout (Lieberman et al., 2001) and WebTop (Wolber et al., 2002) to support browsing and reading of web pages. There are also some context-aware desktop search engines for local files like Remembrance Agent, Margin Notes, and Jimminy (Rhodes, 2003). And more recently, there are also the Context Creation Tool which is designed to support interactive reference gathering, academic note taking and writing (Berendt et al., 2010), CONTEXT – a context-aware information retrieval system for bloggers (Gruzd & Wong, 2010), and the Context Awareness Tool (CAT) – a general-purpose “writing for the web” tool (Powell et al., 2009).

The existence of these tools show that there is both interest and progress being made to develop a truly context-aware retrieval system that can better support users' information behavior. However, there is still a lot more work that needs to be done to address all of the challenges associated with writing (especially, academic writing) in the context of using digital libraries. Some of the challenges include designing interfaces that are more context-aware (e.g., Ruthven, 2008) and interfaces that enable users to serendipitously discover new ideas (e.g., Toms & McCay-Peet, 2009). One system that has been designed to address some of these challenges is PIRA.

3. PIRA's user interface

In this section, we provide a brief overview of PIRA. A more detailed description of PIRA and review of the related work can be found elsewhere (Gruzd & Twidale, 2006; Twidale et al., 2008).

PIRA is a web-based writing tool with two main interface components. On the left is a basic text editor. On the right is an area for searching and managing references. As the user writes (or pastes) new content in the editor, PIRA automatically extracts significant search keywords, displays them in the "Suggested Search Terms" pane, and retrieves and presents suggested references in the "Auto References" pane (see Figure 3). These can be simply ignored if the user is focusing on writing, or glances at them and deems them irrelevant. They are gradually replaced by alternate suggestions based on the current area of writing activity in the text editor. Mousing over a reference provides more details including the paper's abstract. If a user sees a potentially useful citation among the sources suggested by PIRA, they can temporarily lock the citation by clicking on the Pin  icon in the front of the suggested reference. Along with temporarily locking the citation, a user can also open the full-text of an article in a new window (if provided by the digital library) or save the citation for use in future sessions using the Disc  icon. If a user decides to save a citation for later use, he or she will have the option of associating the suggested reference with the current document or with any other (previously saved) documents. This is done to help users avoid situations when they "often don't remember that they've already saved potentially useful or meaningful material" (Fister, 1992). Once a citation is saved, it can be later accessed using a built-in bibliographic management interface (see Figure 4).

PIRA automatically and continuously suggests new reference sources related to the content of users' writing. Reference sources are suggested from various open-access digital libraries and search engines. By default, Google.com and CiteUlike.org are automatically selected. Users can leave the default selection or build their own personal list. For example, depending on their research topic, users may prefer to only use specialized data sources like CiteSeer.IST (Information and Computer Science - oriented), or they might choose to use only general sources like the Directory of Open Access Journals (DOAJ) (<http://www.doaj.org>). To select or deselect an external data source, users just simply need to click the "USE" or "DON'T USE" button accordingly (see Figure 5).

PIRA has been built as a web mashup, using a variety of different web services (different text editors, text and concept extraction services, and different user-specifiable digital libraries) enabling us to undertake a systematic exploration of the design space of variants on writing support and ambient search.

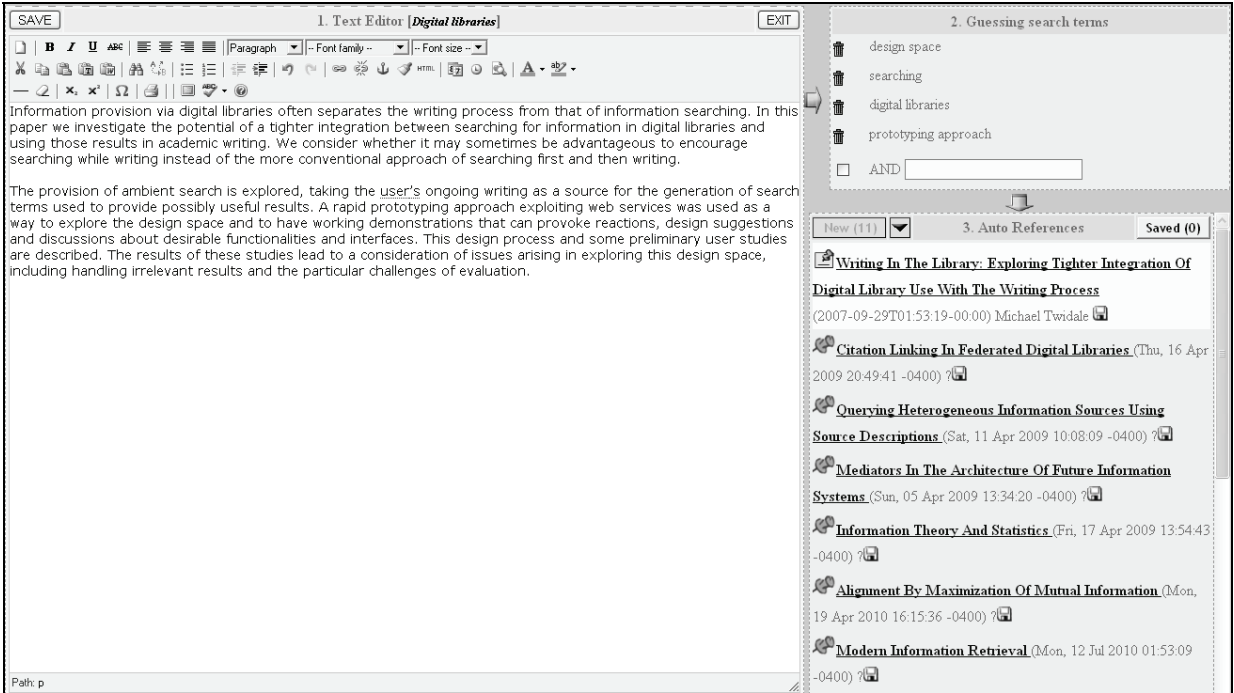


Fig. 3. PIRA’s main display showing integration of writing and ambient searching.

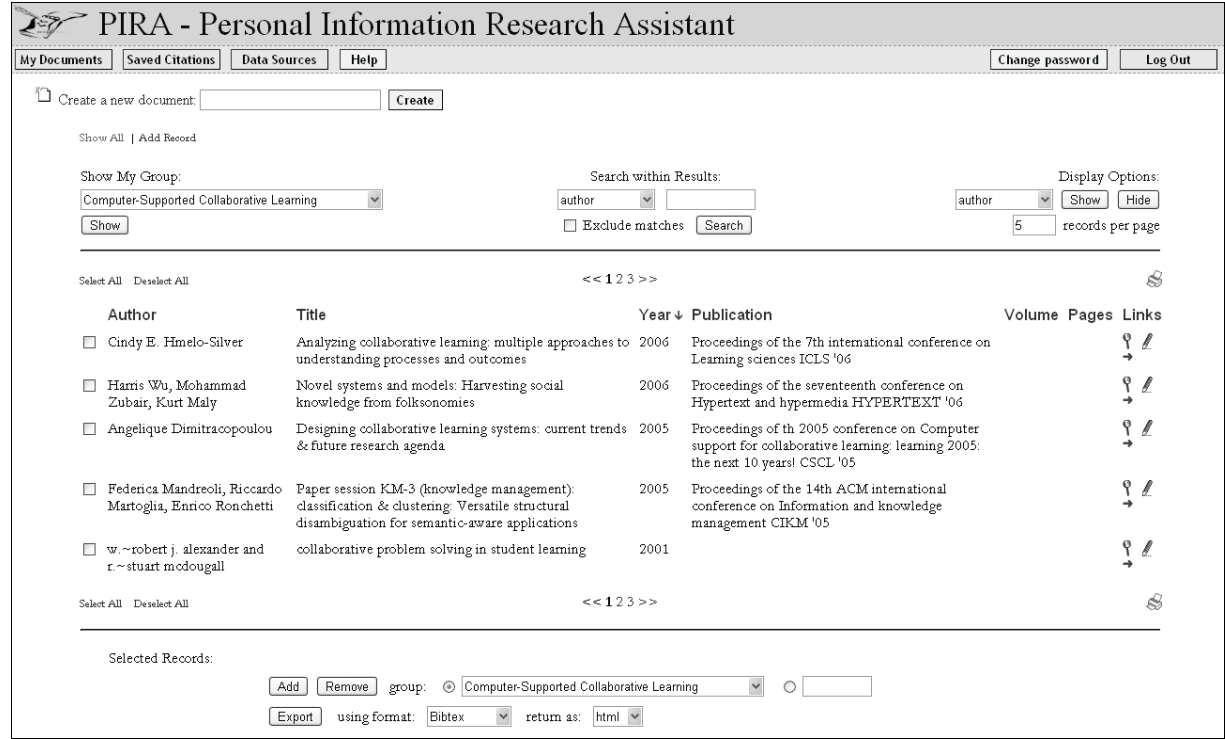


Fig. 4. Built-in bibliographic management interface based on RefBase, open source software.

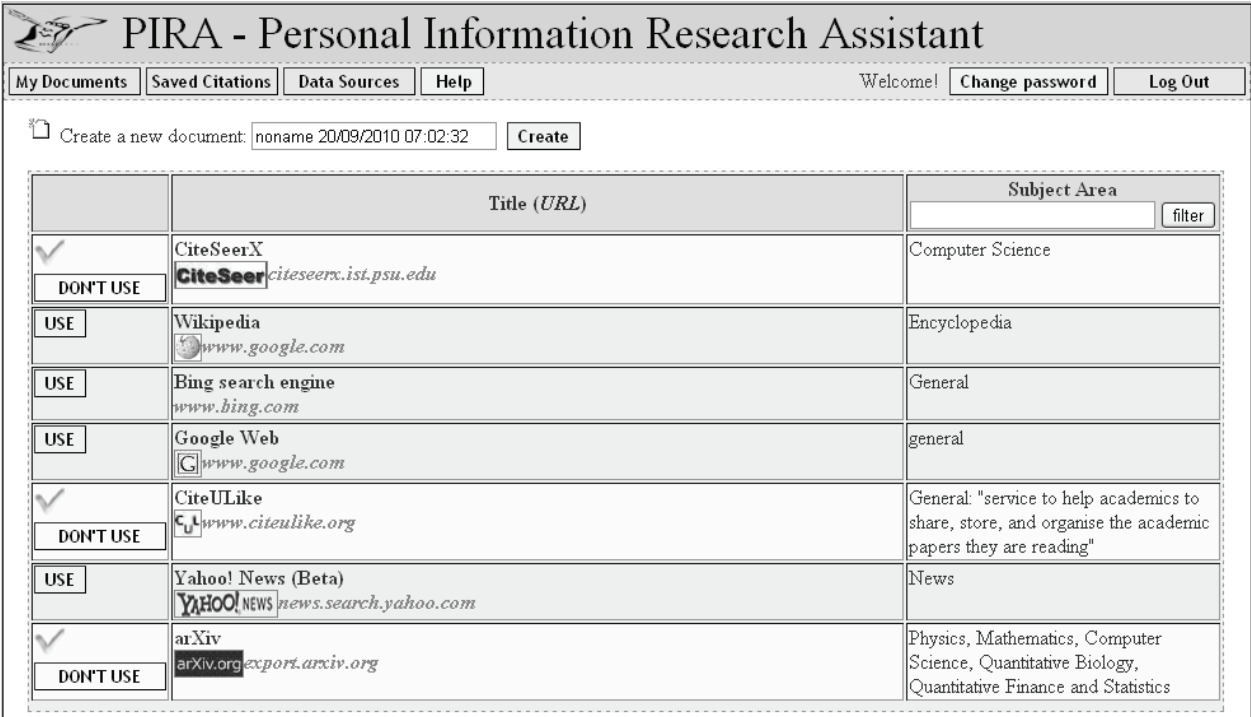


Fig. 5. Reference sources that are available in PIRA.

4. User study design

4.1 Research questions and method

In this chapter we try to address two research questions:

- Is multitasking in the context of writing and searching (as supported by PIRA) a manageable process that might be adopted and accepted by the average user?
- Is multitasking (as supported by PIRA) more effective than the more traditional approach to academic writing (first searching and then writing)?

To answer the first question, we need to identify whether users were actually engaged in the process of writing and searching in a sequential manner (one activity followed by the other) or in a more parallel manner (working on both simultaneously or frequently switching between the two). We will refer to the parallel manner as multitasking or a Write While You Search (WWYS) approach. In our analysis, we look for instances when a user was switching back and forth between writing and searching activities. We note that a user applied the WWYS approach whenever he or she consulted (e.g. accessed or saved) references suggested by PIRA in between making any changes to the text. Or, better yet, when a user actually cited any of references suggested by PIRA.

To answer the second question, we need to operationalize the effectiveness of PIRA usage. One way to do this is to conduct an assessment of reference gathering productivity. There are two parameters that can be used for this purpose: the number of references accessed by the user and the number of references saved by the user. The higher value of either of these parameters per user per session may be characterized as evidence of a higher level of effectiveness of PIRA usage. The reason we need to examine both parameters is because a user may access a relevant reference without saving it into his or her online account, or vice versa. Finally, we compare average effectiveness between users using the WWYS approach and those using the sequential model.

To answer both questions, we rely on content analysis of each user's drafts, quantitative analysis of users' interaction logs and users' responses to an online questionnaire.

4.2 Users and data collection

All participants in our study were volunteers invited at our demo sessions or by their colleagues or professors who attended our demo sessions. To become a user, a person has to create an online account with PIRA and agree to the terms of the informed consent. Participants were asked to use PIRA for their research-related writing tasks. Users could create and modify any text documents and reference collections. They could discontinue their participation at any time for any reason.

PIRA recorded users' writing, what it recommended, and what if anything users chose to do with those recommendations. After the user has used PIRA for three times, the user was asked some questions via an online questionnaire about what he or she thought about the use of PIRA, and how it might be improved. Completing this questionnaire was optional.

The log data was collected for the period of four months. During this period, our users consisted of two main groups: 11 undergraduate students in the English program and 14 graduate students in the Library and Information Science (LIS) program. On average, users in each group visited PIRA a similar number of times; 7 and 5 for undergraduate and graduate users respectively.

4.3 Data analysis

We began the analysis by identifying common approaches to writing used in PIRA by examining the content of papers and how that content changed over time. We distinguished four main writing approaches:

- **Keywords.** This approach is very similar to the way people search on the Internet. The user starts with a list of main keywords/concepts to describe a problem domain, and then modifies this list depending on the retrieved results.
- **Freewriting.** The user writes down full sentences about issues they want to address and/or statements about their prior knowledge of these issues.
- **Copy & Paste.** The user copies a chunk of pre-written text to PIRA's text editor. The chunk may range from a short paragraph to several pages.
- **Think by Writing.** The user writes down his or her thoughts when assessing the relevance of suggested references.

In addition to four common writing approaches described above, we added one new approach for the graduate students - *Proof Reading*. This approach involves only minor changes to the text, mostly to make one's writing sound better.

Tables 1 & 2 below show which approaches and in what order were used by each user. To indicate whether or not the user switches between writing and searching activities (the WWYS approach) or only was focusing on one activity at the time, we use an additional category: *Monitoring References*. If the user is engaged in *Monitoring References* this means that he or she completely stopped writing (at some point) and exclusively began interacting with some suggested search keywords and references.

Although *Copy & Paste* can be conducted in parallel with searching, we will not consider it as an indicator of the WWYS approach. This is primary because the copied text was already written prior to the session with PIRA. Similarly, we will not consider the use of the *Keywords* only approach as WWYS because this approach does not produce any coherent

Approach \ User ID	Keywrods	Freewriting	Copy & Paste	Think by Writing	Monitor References
49	#1	#2			
50		#1			
51		#1			
52		#1			
53	#2			#1	
54		#1			
58		#1			
59		#1			#2
60		#1			
67		#2	#1		
71			#1		#2

Table 1. Common writing approaches in PIRA for **undergraduate** students (each cell value indicates the order in which the particular approach occurred).

Approach \ User ID	Keywords	Freewriting	Copy & Paste	Think by Writing	Proof Reading	Monitor References
28			#1		#2	
31			#1			#2
32		#1				
33		#1				
37*	#1					#2
41		#1	#2			#2
44*		#1				#2
55	#1					#2
57*			#1			#2
62*			#1			#2
65	#1	#3		#2		
69*	#1					#2
84*		#1				#2
92			#1			#2

Table 2. Common writing approaches in PIRA for **graduate** students (each cell value indicates the order in which the particular approach occurred).

text that can be used in the future paper. However, if a user started with *Copy & Paste* or *Keywords*, but then switched to *Freewriting*, and he or she was not engaged in *Monitoring References*, then the overall user's approach can be considered as WWYS.

The following section presents results for each group separately. To ensure confidentiality, we refer to each user by a code number.

5. Results

5.1 Undergraduate students

Q1. Is multitasking in the context of writing and searching (as supported by PIRA) a manageable process that might be adopted and accepted by the average undergraduate user?

Based on the content analysis, we can conclude that the majority of undergraduate students in the study preferred to use *Freewriting* as their primary writing approach. This preference may be influenced by the fact that they are all English majors. The log data shows that as they wrote, the users were also interacting with various search features of the system such as accessing and saving relevant references. Different users were more or less involved in the use of these features. Although the majority of users accessed and read potentially relevant references as soon as they noticed them; there were two users (ID# 58 and 60) who preferred not to stop writing when they saw something interesting. Instead, they simply saved any potential relevant references to read later. (Such behavior is characterized by the much higher number of saved references than those that were accessed while in the midst of writing.) Despite these differences in reactions to potential relevant references, we can consider both types of behaviors as multitasking to some degree since both involved writing and reference assessment/gathering.

Additional evidence that multitasking as supported by PIRA was manageable can be found in the responses to the online survey. Many undergraduates expressed their support of the idea of multitasking and switching between writing and searching. As one student noticed, nowadays multitasking is part of their normal behavior on the Internet. They often do instant messaging with their online friends, browser websites, work on a class assignment, search for information, etc, simultaneously. This is a more extreme form of multitasking than the one we are referring to in this chapter – the switching between different components of the overall single goal of writing.

In general, our analysis of the current data suggests that the majority of the undergraduate users were able to successfully adopt the WWYS approach.

Q2. Is multitasking (as supported by PIRA) more effective than the more traditional approach to the academic writing (searching and then writing)?

The fact that two users, who were not engaged in the WWYS approach, accessed and saved a significantly smaller number of references compared to the group's average, may suggest that the WWYS approach is *likely* to be more productive than a more traditional approach. Unfortunately, since the majority of users preferred the WWYS approach over the other, we do not have enough data to draw a conclusion as to which of two approaches is more productive. Further testing is necessary to answer this question.

5.2 Graduate students

Q1. Is multitasking in the context of writing and searching (as supported by PIRA) a manageable process that might be adopted and accepted by the average graduate student user?

Graduate students did not multitask much (except 4 users). About half of all graduate students in the study re-used parts of their papers written elsewhere and simply pasted them into PIRA. Many other users either wrote one or two sentences stating their research topic or simply typed a few search keywords into the text editor. After this, they were mostly monitoring references. This type of behavior suggests that graduate students in our study perceived PIRA primarily as a searching tool rather than a writing tool. This does not necessarily mean that multitasking was not manageable, but rather that users adopted other ways of using PIRA (to our pleasant surprise) which will be one of the subjects of our future evaluations. As with other context-aware interfaces, it is important that developers be reminded that a measure of success is not merely that the application is adopted by those users who work in the way that the developers intend, but that the application is flexible enough that alternate, even novel uses are facilitated or at least not impeded.

Q2. Is multitasking (as supported by PIRA) more effective than the more traditional approach to the academic writing (searching and then writing)?

To conduct a reliable comparison, we decided to exclude the 6 “spectators”-users from this analysis (marked with an asterisk * in Table 2). This is due to the fact that their interactions with PIRA were limited to only few minutes. As a result, it is hard to say which approach they really followed or would follow. (After a close examination of the log data and documents created by these 6 users, we came to the conclusion that these users were just checking out PIRA’s functionalities.)

Among the 8 remaining users, there were 4 users (ID# 28, 32, 33, 65) who were engaged in multitasking (further referred to as Group A) and 4 users (ID# 31, 41, 55, 92) who were not (Group B). Group A accessed an average of 20 and saved an average of 13 references per user. Group B accessed an average of 8 and saved an average of only 4 references per user. In sum, users who were engaged in multitasking accessed about 2 times more and saved 3 times more references per user than those who were not. Therefore, although based on our very small sample, we would claim that in general, multitasking seems to be a more productive approach, despite the risks of distraction.

6. Conclusions and future consideration

The results from our small scale user study suggest that undergraduate users are more likely to multitask between writing and search-related activities than graduate users. The difference between two groups may be due to the difference in their tasks. Most graduate users were focusing on finding relevant references (Keywords approach) or making sure that they had already cited all relevant references (Copy & Paste approach); whereas undergraduate users were more concerned with producing coherent text. This, in turn, may be explained by many different factors such as specific requirements of the assignment, students’ major and/or upcoming deadlines. However, this matter requires further investigation.

Our second conclusion is that in general those users from both groups who did use the multitasking approach demonstrated a more productive reference gathering behavior than those who did not. This can be explained from the system’s point of view. Users who multitasked were often modifying their drafts. As a result, PIRA was able to suggest references that are related to newly emerged themes in the text. Furthermore, users who multitasked also interacted with suggested search keywords and references more frequently than those who did not. Since every such interaction provided PIRA with user’s relevance feedback, the system was able to significantly improve the relevance of its suggestions.

PIRA enabled users to manage the information that could inform their evolving thinking, supporting that fine line between an overly narrow focus just on the resources currently on the users' mind, and the insights and balance that come from a larger perspective, but one that can lead to endless distraction.

In our future work on PIRA, we are planning to increase the size of our user sample as well as diversify its population by including students and faculty members from disciplines other than English and LIS. Also we are planning to explore other ways to measure the effectiveness of PIRA usage to consider the quality of gathered references as well as their impact on the completion of the user-specific tasks (for example, to complete a literature review versus prepare a paper outline versus come up with creative ideas).

The challenge of context-aware retrieval for supporting the web-based writing process is similar to that of the more conventional issues of planning, coordinating appointments and organizing and accessing personal files. However, it has rather different emphases. The fluid, rapid multitasking nature of the different components of web-based writing means that it is important to support low-effort context-aware information retrieval. There is also a need to support both awareness of the familiar (papers already read, issues that must be considered), as well as the unfamiliar (new papers not yet considered, possibly relevant related work, interesting inspirational insights etc.). As with much research on Digital Libraries, there is a recurrent need to help people handle complexity and diversity, and to exploit context and visibility as a way of supporting ambient rather than distractingly intrusive awareness. Finally the diversity of ways in which people accomplish complex tasks such as writing reminds us that digital libraries must accommodate a wide range of use patterns rather than forcing users to conform to an idealized mode of acting. Such diversity typically means allowing for a range of appropriation activities including combination with other resources and tailoring to fit both long term user preferences and the particular needs of the current task at hand.

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Digital Libraries - Methods and Applications

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Digital library is commonly seen as a type of information retrieval system which stores and accesses digital content remotely via computer networks. However, the vision of digital libraries is not limited to technology or management, but user experience. This book is an attempt to share the practical experiences of solutions to the operation of digital libraries. To indicate interdisciplinary routes towards successful applications, the chapters in this book explore the implication of digital libraries from the perspectives of design, operation, and promotion. Without common agreement on a broadly accepted model of digital libraries, authors from diverse fields seek to develop theories and empirical investigations that to advance our understanding of digital libraries.

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