A Proposed Integrated Environment for Enhanced User Interaction and Value-adding of Electronic Documents: An Empirical Evaluation

Chern Li Liew, Schubert Foo and K R Chennupati

Division of Information Studies, School of Applied Science
Nanyang Technological University, Nanyang Avenue, Singapore 639798

Abstract

This paper investigates the potentialities of a proposed information environment (PROPIE) for user interaction and value-adding of electronic documents (e-documents). The design of PROPIE was based on a thorough review of user needs and requirements in interacting with information through well-documented findings, and a focus group with twelve participants to identify features that were deemed desirable in future interactions. The design was also based on a review of developments in various user interface (UI) technologies, visualization and interactive techniques, and a consideration of new forms of information structuring and organization that pose important implications for the design of more advanced UIs. To this end, a set of interface mockups was developed to demonstrate the potential of the environment in supporting the design of a new generation of electronic journals (e-journals). An empirical evaluation of various aspects of the environment was conducted to obtain representative users’ feedback with regard to interacting with e-journals. Twenty two participants from a variety of academic background took part in the evaluation. This paper reports the results which have general implications for the design of e-documents.

1.0 Introduction

In his book “Writing Space”, Bolter (1991) heralded the computer as the fourth prominent document medium, next to the papyrus, the medieval codex and the printed books. Insinuated in his words is that the demise of printed pages is merely a matter of time. Many of today’s fervent issues in human-computer interaction undeniably point to the replacement of printed documents by digital alternatives. Many have predicted that advances in the Web, advanced hypertext and multimedia applications, digital libraries and various state-of-the-art e-document reading devices will soon make printed documents such as books and journals as we know them today obsolete. Such progress will also profoundly alter the relationships between authors and readers, and change forever the notion of users of documents as mere recipients of information and knowledge captured within the printed pages. Before that happens however, many new challenges need to be overcome.

The realism of present-day is a testimony to this claim. Print form has remained the preferred medium of many, despite the fact that technologies have greatly improved in recent years and that wireless, mobile computing and advanced input and output technologies are now widely accessible. A central question remains: “Will the scholarly world shift to purely e-documents?” If
so, “Will they be pure electronic mimic of their print counterparts, or will they be adding value in their online forms?”

The past 15 years of advances in UI technologies have provided the foundation for much more elaborate interactions with collections of e-documents and with individual documents through graphical or visual interfaces, supported by intuitive direct manipulation and interactive techniques (Myers, 1998; Shackel, 1997). Concurrently, information has become ever more digital, enabling for instance, more uniform interaction where all formats can be stored and sent equivalently. Information is also making its structure increasingly accessible as text and metadata formats move to SGML (Standard Generalized Markup Language) (Dempsey & Heery, 1998). With the transition from physical delivery of printed documents to the transmission and dissemination of bits over the network of e-documents, the granularity of information packaging has also become variable. The requirement to deal with a massive electronic world and the emergence of distinct structure has led to fractional, modular (Kircz, 1998), layers (Phelps & Wilensky, 1996) of information organization. Such evolution consequently results in the need to interact with information at many different scales.

Given these parallel developments, it is surprising how little research has been done at the nexus of e-documents and user interaction needs – addressing questions of how to create a consistent information environment where users can make seamless transitions in their utilization of multiple tools, visualization and interactive applications to meet their various needs.

Many recent works (Hitchcock, et al, 1998; Moret, 1997; Wilkinson, 1998) have indeed, summoned for a breakthrough - pointing out the need to more fully exploit the potential of the electronic environment to further improve and enhance user interaction with e-documents such as e-journals.

2.0 Research Overview

Earlier studies of enhancing interaction and value-adding to e-documents have mostly focused on isolated solutions. Some of these works have dealt specifically with the information presentation aspect (Kircz, 1998; Kreitzberg 1989) while others are concerned with providing access to additional information via means such as hyperlinks (Hitchcock et al, 1998; Hunter, 1998). Some researches into e-journals (Holoviak & Seitter, 1997) are also increasingly addressing the possibilities of transcending the limitation of the printed journals to include unprintable materials – multimedia files that contain audio, video, animation and 3D graphics.

The need to support a wide variety of basic information manipulation and analysis tasks has also given rise to many new interactive techniques, visualizations and applications. Some applications support for instance, creating new information and visualizing relationships among them (Plaisant et al., 1996). Others support controlling the level of aggregation of data and rapid filtering of data subsets (Masui, 1998; Roth et al., 1996). Still others support navigation through large data spaces (Bederson & Hollan, 1994; Robertson & Mackinlay, 1993; Mackinlay, Robertson & Card, 1991). A fundamental UI design question is how one can use the complimentary features of various visualization, interaction and analysis tools in a uniform and coordinated manner. Even for just these few example activities for instance, how can a user create new data attributes with one tool, filter the same data with another and visualize the resulting subsets with a third tool?

This study seeks to study the broader problem of supporting the wide range of information searching, analysis and communicating tasks involved in interacting with e-documents within a single UI environment, using e-journals as an example of e-documents. We aim to explore the
potential and impact of an innovative information environment in enhancing user activities in using e-documents for various tasks, and to support the value-adding of these e-documents. The study is carried out in three major stages:

1. A background and empirical investigation stage – a review and analysis of related works and elicitation of user needs and requirements
2. PROPIE conceptual design and prototyping stage – conceptual design of the environment and the task scenarios for the subsequent empirical evaluation
3. PROPIE evaluation stage – an empirical and formative evaluation of the proposed environment by representative users.

The overall objective of the study is to help make a new generation of e-documents a realism (Figure 1). A central element of our study and approach is to provide users of e-documents with multiple means for expressing their intentions during various information-seeking tasks. ‘Multiple means of expression’ in this context refers to visualization and interaction techniques that are useful for different purposes, but are often effective when used in combination as they support representations of different kinds of objects, actions and goals.

The remainder of this paper is organized as follows. We first give an overview of the related works reviewed and analyzed. Next, we discuss the applicable research and generated research questions. We then describe of the evaluation conducted, followed by presentation of the findings and discussion of the results. Finally, we discuss further works to be conducted.

Overview of related works

In this study, design considerations for such an environment are explored, based on an understanding of user needs and requirements in interacting with information, and the technologies
that are available to support the desired interactions. Hence, issues in the design of interactions with value-added e-journals arise from three main sources:

- increasing knowledge of how users interact with (seek and use) information, and the tasks they perform to achieve their goals;
- the ongoing advancement of the information world, leading to a new paradigm of electronic information; and
- developments in UI technologies that have provided the basis for much more elaborate interactions with the underlying information world.

A thorough review and analysis of related studies that includes a total of 62 references to documented works along these three inter-related issues has been presented in Liew & Foo (1999). In addition, a focus group with twelve participants was conducted to further elicit user interaction needs and requirements.

Following this, a set of desired properties for both the interaction environment and the information objects within the environment is identified as summarized in Table 1 (Liew & Foo, 1999). These properties form the foundation features for our design of PROPIE. Subsequently, an evaluation of PROPIE was conducted.

### Table 1. Interaction environment & information objects properties

<table>
<thead>
<tr>
<th>Interaction environment properties</th>
<th>Properties</th>
</tr>
</thead>
</table>
| Properties that are closely associated with the interaction environment. | (1) **Integration of workspace** - the information environment should integrate both the user’s personal workspace and the broader information world to allow a tighter connection between the user’s own larger task that is normally centered in the private workspace, and their information-seeking sub-tasks that are often focused in the broader information world.  
(2) **User-controlled malleability** – the environment must support direct manipulation to enable natural, interactive access to the various information objects and tools.  
(3) **Visual sovereignty** - the environment should also provide the user with visual representation to the various conceptual items of the user’s information-seeking task (e.g., a collection of information objects related to the task, or the user’s search and browse history records). Providing such ‘total view’ while searching gives the user satisfaction of being able to perceive the existence of related objects, be made aware of their status and be able to act upon these according to their needs.  
(4) **Multiple representation/views** - multiple representation of information objects and their organizations should also be a part of the environment, so as to support a variety of task and information-seeking perspectives.  
(5) **Integration with appropriate tools** - the environment should also provide tools for basic common interactions which include querying for information, the more heuristic navigation through information space, organizing and authoring information. The environment should enable intuitive and easy means for users to move back and forth between the more informal cursory process and the more detailed, focused efforts in information searching and analysis. |
Information object properties

Correspondingly, the information objects in the environment should also be endowed with a number of characteristics to support a variety of information searching and gathering tasks. These properties should hold for all the information objects in the interface, including objects deposited in remote collections (i.e. those in the wider infosphere) and objects (e.g., annotations) created by users themselves.

1. **Structured** - information objects should have structures both internal and external to themselves. They for instance, can contain or be enclosed in sets, collections or ordered lists, tables, trees, natural language sentence structure, paragraphs or chapters. These objects should make visually explicit their internal structures (e.g., as to navigate over) to help users in the information searching process. They should also state explicitly where they fit into various larger structures.

2. **Fractional** - ensuring the notion of ubiquitous internal and external structure is an almost fractional nature to the information objects representation. Objects should also allow manipulation and interaction at all levels of granularity in a coherent manner.

3. **Queriable and navigable** - all objects in the infosphere at any granularity should also be queriable and navigable.

4. **Explicable** - as in general, information searching and knowledge work is a temporarily prolonged process, with information seekers often moving back to previous work done and building on it, all objects should ideally come with representations of their history – where they originate from and what operations have been performed on them. The historical sequence of the objects generated should be in a visualizable, malleable history mechanism.

5. **Contextualized** - information objects should make various aspects of their context such as relationships between various contents (both established by system and the user) available to the user, to enable better understanding of both the objects and the environment. This is important to support the context-driven evolution of a user’s interests.

6. **Affiliation with metadata and additional layers of information** - evaluation, reviews, commentaries and criticisms are all value-adding properties that provide information seekers additional information for decision-making. Annotations on all objects at any granularity, both for personal and shared use should also be supported. This will become even more important when people no longer work in isolation, and where technology is used for collaborative work. It is evident that all the information objects should also be associated with a large prescription of metadata to implement many of the discussed properties. Metadata can also be used to effect value-adding to objects. Examples of meta-level value-adding include:
   - Information customization (e.g., non-prescriptive, non-linear document traversal, variable links and integration of sources) and
   - Searching, indexing and database technologies (e.g. provide dynamic, real-time analysis for document clusters, with innovative mining and clustering topologies for display of results).

3.0 Research methodology

A formative evaluation (Patterson & Bloch, 1987; Vasek & Volger, 1984) approach is undertaken in this study as too little is currently made known about the application of various novel interactive and visualization techniques within one single UI environment to enhance interaction with e-journals (or e-documents) to formulate specific hypothesis. As this study involves the evaluation of design concepts, and not of a fully operational system, it is not feasible to have subjects performing tasks that can be measured quantitatively (e.g. based on time spent on tasks and error rate). Amongst the various types of common usability tests, exploratory tests match the needs of the exploratory nature of this study as research into PROPIE at this stage aims at discovering and understanding themes, potential relations and perceptions. Methods that emphasize flexibility, comprehensiveness and understanding are hence, chosen.

A scenario-based approach is used to demonstrate a set of various scenarios of how such an environment is likely to be used for interacting with e-journals. The scenarios and tasks chosen
provide reasonable coverage of the typical and desired information-seeking tasks involved in interaction with journals, and reflect the kinds of tasks PROPIE would address if implemented as an operational system. These scenarios act as 'proof of concepts' to illustrate the ability of the environment (and the interfaces) to provide enhanced user interaction, and to add-value to e-journals. It is also aimed at demonstrating how, in general, digital information and user interaction is likely to be perceived and used in the future. The scenarios are supported by mockups of the desired output. Together, they serve as the platform for the empirical evaluation. When the tasks are put into the context of a realistic scenario, a degree of realism and subject involvement is likely to be achieved (Chin & Rosson, 1998). This is important especially when a real working system does not exist for subjects to work on, and to base their evaluations on.

4.0 The Proposed Information Environment (PROPIE)

PROPIE is an integrated and unifying environment comprising of four independent yet coordinated workspaces. Users have the autonomy and flexibility to use either all the workspaces in a unified manner, or to use each of them independently according to different needs. They can for instance, call up only the necessary workspaces, minimize or maximize them, and move the workspaces around in the environment according to their preferences and needs. Direct manipulation is the fundamental mode of interaction throughout the environment. Information objects within the environment are fractionally structured and can be laid out on the information surface to depict this fractal structure. All objects (each associated with a rich prescription of metadata) at any granularity are queriable and navigable. The ‘body-and-clone’ analogy is applied in PROPIE design so that the original body of the document is kept intact in one of the workspaces, while allowing information objects within the body (i.e. clones) to be moved to other workspaces for further operations to be carried out on these objects. Figure 2 shows the main interface and the four basic parts of PROPIE.

![PROPIE main interface](image-url)
The four workspaces of PROPIE are:

1. The **InfoSphere Organiser** - the part of a wider information work sphere whereby users organize and display their information collections that include their personal collections of information, and information residing outside the user’s current work space. Various interaction and visualization techniques can be applied to obtain a view into this sphere and the various items in the collections. To further explore an object, users can simply drag the object and drop it into other workspaces. This broader workspace is closely integrated with the following user’s personal workspaces.

2. The **Object Viewer** - the workspace whereby users get a first glance of the content of the selected object. It is closely integrated and coordinated with the **Structure Viewer/Overviewer** to provide user with a coordinated display and directed-navigation to browse through documents.

3. The **Structure Viewer/Overviewer** - provides an overview display of the object structure to maintain the overall context of the selected document. Users are given a set of display options to examine the structure and layout of the object.

4. The **Object Explorer** - the ‘value-adding’ aspect of the environment that allows users to perform a variety of other tasks to further analyze various information objects using various tools such as tools to view and add digital comments and annotations, tools to browse through related works, a ‘History Cabinet’ that serves as a ‘store’ for users to maintain a record of history for backtracking, and a ‘Pocket Register’ – serving as an interactive, multi-object, visible ‘back pocket’ whereby information objects collected at any of the workspaces can be deposited temporarily, staying ready-at-hand for further exploration while users explore some other objects in the workspaces.

A more detailed description of the environment and the various features and tools are reported in Liew, Foo & Chennupati (2000).

### 5.0 PROPIE Evaluation Design

The empirical evaluation of PROPIE was carried out to address the following research questions:

1. What are the tools and associated features proposed in PROPIE that are deemed important and useful in enhancing interaction with e-journals (and in general, e-documents)?
2. What are the concepts and interaction proposed in PROPIE that are deemed value-adding to e-journals (e-documents)?
3. What are the facets deemed inhibiting users’ satisfaction with PROPIE? What are the indications for the design of future e-journals (e-documents)?
4. Is there any other tools/features that should be incorporated into future design of e-journals (e-documents) to further enhance interaction?

**Task scenarios**

The use of PROPIE for interaction with e-journals is demonstrated through a typical scenario and some representative displays in which an information science student interacts with e-journals via PROPIE to gather relevant and useful information for a digital library project. The scenario (containing a set of 71 mini scenarios labeled as a ‘100+10’ increment – i.e. Task 100 (T100), T110, T120, and so on) took into account basic tasks involved in typical information gathering and analysis processes, and more advanced interactions such as Shneiderman’s (1998) list of visual manipulation requirements (i.e. overview, zoom, filter, details-on-demand, relate, history and
Task sets incorporated into the evaluation included - browsing through collections of documents using different display options (Figure 3), seamless access to other information sources such as a ‘Translation’ tool (Figure 2) and a ‘Thesauri & Knowledge Package’ (Figure 4), filtering information to focus on important details, ‘focus + context’ viewing and exploration, collaborating with others via digital comments and annotations, temporarily storing items of interest in the ‘Pocket Register’, interacting with multimedia objects (e.g. a live demo file, images and interactive data sets) and backtracking via the ‘History Cabinet’.

FIG.3. Alternative views to browse through one’s collections of documents in *InfoSphere Organiser*

The PROPIE design employed several principles of interface design (Shneiderman, 1998, pp.74-75). Consistent sequences of actions are ensured in similar situations; identical and simple terminology used in menus; and consistency of colors, layout, capitalization and fonts are employed throughout PROPIE. In general, the researchers also attempted to follow the guidelines proposed by Mullet and Sano (1995) of “elegance and simplicity; scale, contrast and proportion; organization and visual structure; module and program; image, representation and style” in designing the mockups for the evaluation.
Data collection techniques

A combination of techniques (in the forms of fixed-response and open-ended questionnaires) and measurement (in the forms of rating and ranking scales, and qualitative feedback) was employed. Additionally, two focus group sessions were carried out – one prior to PROPIE evaluation and the other one after the evaluation. The dependent variables in the study are divided into four major conditions as shown in Table 2.

Table 2. Dependent variables used for the study.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Operationalized Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rating of tasks/functionality</td>
<td>• Likely level of difficulty</td>
</tr>
<tr>
<td>Rating of features/tools</td>
<td>• Likely level of usefulness</td>
</tr>
<tr>
<td></td>
<td>• Likely frequency of use</td>
</tr>
<tr>
<td></td>
<td>• Preference</td>
</tr>
<tr>
<td>Perception and Satisfaction with various features/tools</td>
<td>• Overall reaction to features and functionality</td>
</tr>
<tr>
<td></td>
<td>• Conceptual understanding of the various features and functionality</td>
</tr>
<tr>
<td></td>
<td>• Comparing experience with PROPIE to traditional interaction with printed journals and</td>
</tr>
<tr>
<td></td>
<td>current versions of e-journals</td>
</tr>
<tr>
<td></td>
<td>• Preferred control of the various parts of PROPIE</td>
</tr>
<tr>
<td></td>
<td>• Perception of the overall layout and structure</td>
</tr>
<tr>
<td>Perception and Satisfaction with the overall PROPIE</td>
<td>• Overall reaction to the environment</td>
</tr>
</tbody>
</table>
Data collection environment

Control of the evaluation environment was carried out via the ‘PIE Control’ toolbox located at the bottom left-hand corner of the interface (Figure 2). This allows the complete set of mini scenarios to be advanced sequentially. Participants could advance from task to task, reverse to a previous task to for instance, alter or add comments, to reload a particular task, or to skip a task and jump straight into a chosen task at any time during and after the evaluation. The online evaluation questionnaire was implemented (using Microsoft® Visual Basic 5.0) to support the collection of data relating to participants’ ratings and ranking of preferences, and their subjective comments (Figure 5). The questionnaire was linked to a database (using Microsoft Access97 for Windows) to facilitate data collection. This database was critical in promoting the inter-activity of data collection and data analysis.

Participants profile

All participants in the study were graduate students. The majority of them (13 of 22) were part-time students enrolled in H6324 ‘Systems Analysis and User Interface Design’ course under the Masters in Information Studies program at Nanyang Technological University (NTU), Singapore. These students were from a variety of academic backgrounds, having pursued either an undergraduate degree or a Masters degree in various subjects such as Physics, Mathematics, Computer Science, Media & English Language, Information Studies, Information Technology, Business Administration and Mechanical Engineering. Three of the participants were full-time research students within the Division of Information Studies (DIS). Six additional participants were invited from National University of Singapore (NUS). All six were graduate students majoring in engineering discipline, taking part in the study on a voluntary basis. All participants had used both printed and e-journals for their studies. These experiences were necessary because PROPIE was designed with the intention to enhance user interaction with e-documents using e-
journals as the example, and to add value to these documents. The gender distribution was almost evenly distributed - 54.5% male and 45.5% female. Participants were distributed in the following age groups: 63.6% were in the 18-29 age group, 27.3% fell into the 30-39 age group and 9.1% were in the 40-49 age group.

6.0 Data Collection

A university laboratory within the DIS was the setting for data collection of the evaluation. Materials used in the evaluation included a consent form, briefing notes, tasks instructions for each of the mini scenarios, a participant questionnaire, PROPIE evaluation questionnaire and a post-evaluation questionnaire. A website containing full versions of these resources can be found in http://islab.sas.ntu.edu.sg:8000/islab/research/chernli.

A pilot study with three volunteers from DIS was designed to test various details about the investigation procedures. The results of the pilot study provided input for refining the final evaluation and provided an effective test base and framework for the final study. Timings were generated for each activity and used as a basis for planning data collection sessions for the final evaluation.

The data collection was conducted over three sessions (of one and one half hours each) as at least four and one half hours were optimally needed to complete all the activities from filling in the participant questionnaire to the completion of the post-evaluation questionnaire. Table 3 summarizes the main activities involved for each of the sessions. Data for the evaluation were collected over an approximate one-month period.

Table 3. Data collections sessions and their main activities.

<table>
<thead>
<tr>
<th>Session</th>
<th>Main Activities</th>
</tr>
</thead>
</table>
| 1 Background & Information gathering session | • Introduction to the study  
• Brief overview of PROPIE and the various tools/features incorporated within PROPIE, including demonstration via overhead projector  
• Completion of the blue consent form  
• Completion of the participant questionnaire  
• Participants were briefly informed of the additional data collection sessions |
| 2 First phase of PROPIE evaluation involving the first 37 task scenarios (T100 – T450) | • (Verbal) Introduction to Session 2  
• PROPIE evaluation started with T100 and ended with T450  
• Participants were briefly informed of the next data collection session (evaluation of the remaining task scenarios) |
| 3 Second phase of PROPIE evaluation involving the remaining 34 task scenarios (T460 – T770) | • (Verbal) Introduction to Session 3  
• PROPIE evaluation commenced with T460 and ended with T770  
• Completion of the post-evaluation questionnaire |
7.0 Research Findings and Interpretation

A selection of the findings – those we feel have the most important implications for design is presented in this section by addressing individual research questions and their corresponding research objectives at a time.

Pre-evaluation findings

The feedback received in the participant questionnaire when we asked participants for their opinion on e-journals showed that functionality of an e-journal was of paramount importance to them. Access was of primary concern, such as access to additional information (e.g. through links) and unprintable materials. Generally, the presentation and organization aspects were given a secondary prominence.

Participants’ perception of the evolution of journals is summarized in Table 4. As might be expected, while almost all of them reported an enthusiasm about e-journals being an interactive system, a few of them were rather terrified by the idea of changing the emphasis from a single journal issue to that of an article, and to bits of information within the article. For most participants, it was probably difficult to imagine the possibilities and likely advantages of the new forms of e-journals supported by various advanced interaction tools, although a short briefing and introduction had been provided.

Table 4. Participants’ perception of the evolution of journals.

<table>
<thead>
<tr>
<th>(1 = Excited; 5 = Terrified)</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-journals being an interactive system rather than as a document (in a form similar to printed journals)</td>
<td>1.55</td>
<td>0.67</td>
</tr>
<tr>
<td>Changing the emphasis from a journal issue (i.e. serial, collection of articles) to a single journal article</td>
<td>2.73</td>
<td>0.88</td>
</tr>
<tr>
<td>Changing the emphasis from a journal article to bits of information within the article</td>
<td>2.18</td>
<td>0.91</td>
</tr>
</tbody>
</table>

In the participant questionnaire, we also asked participants for their opinion on various features – in terms of how significant it was to have the features in future e-journals. The measures were averaged. For each item, the lowest possible measure was “1” and the highest “5”. Items rated higher represented a positive “Significant features to have” response, while lower rated items represented a negative “Simply a gimmick” response.

Given higher priority were searching-related features such as searching across a wide range of journal articles, searching within an article for bits of information, ability to extract and use ‘retrieved information’ as ‘query set’ for a new query/exploration, and ability to interact with information/ display to discover new information. Value-adding features such as links to glossary/definition, thesauri, comments/annotations, multimedia files and search/browse history records were also deemed significant.

It was also interesting to note that the ability to temporarily save interested objects for later exploration, and the ability to extract and use ‘retrieved information’ as ‘query set’ for further query or exploration had also been highly rated as significant features. This manifested that users often approach a document not with a fixed goal, but often utilize ‘clues’ they encounter during their
search and browse process to further refine or expand their searches and navigation. This is consistent with Bates's (1989) proposed 'berrypicking' model in illustrating the evolving and interactive search process users engage in, using online systems. Other studies on user needs such as the ones by Belkin and colleagues (1982) and Ingwersen (1996) have also emphasized on this importance of recognizing this need for online systems to support the iterative and interactive search and navigation processes of users.

Results of PROPIE evaluation

In the PROPIE evaluation, participants were asked to rate on a scale of 1 to 5 - the difficulty of each task (TD; 1 = Easy; 5 = Very difficult), the likely usefulness (LU; 1 = Essential; 5 = Not useful at all) and the likely frequency of use (FU; 1 = All the time; 5 = Never) of the tools and features discussed in each task scenario. Lower-rated items represented a positive perception with the tools/features/interaction while items rated higher represented a negative perception with them. The ranges of the mean ratings are as follows:

- Ratings for TD ranged from 1.18 to 3.09
- Ratings for LU ranged from 1.41 to 3.23
- Ratings for FU ranged from 1.59 to 3.55

The standard deviations of the ratings ranged from 0.46 to 1.13 indicating that most ratings were fairly close to the mean ratings computed. For the interested reader, a detailed reporting of the results based on thorough statistical analysis and content analysis (of qualitative comments) can be found in Liew (2000).

Findings for research objective 1

The first research objective is to determine the various facets of PROPIE in terms of its proposed tools/functionality, and associated features that enhance users’ interaction with e-journals (e-documents). A summarization of the criterion for the analyses of research objective 1 and the tasks related to each criterion is presented in the Appendix.

(1) Browsing through Collections

Users generally found it useful to have one dedicated workspace for users to access one’s personal and external collections. They particularly liked the idea of an integrated access to various journal titles without the need to go to different publishers’ Web sites. Displaying items within the collections ‘by subject/topic’ was most popular. This might be attributed to the fact that examining collections by this factor assumed less specific prior knowledge of what was being searched for as compared to searching ‘by author’, ‘by journal title’ or ‘by publication date’. Checking details of selected information objects through pop-up labels and document panels received quite a positive feedback, with many participants also welcoming the idea to utilize two to three pop-ups simultaneously to view and compare a few items.

A number of the participants were confused over the ‘Time Line’ display – stating that the timeline looked a bit confusing and that it was not very intuitive for especially first-time users to know how to make use of the feature. There was nevertheless, some appreciation of its use in showing the distribution of work, as revealed in participants’ subjective comments.

The ‘Forager’ and ‘Map’ means of displaying information received quite positive ratings. Eight participants also showed their appreciation of the ‘DocTOC’ in the additional comments provided. They particularly liked the features in ‘DocTOC’ that helped in identifying the size of
documents and the types of objects contained within documents. Participants however, mostly stated their dismay and confusion over the ‘CamTree’. They found the display to be cluttered although a few participants nevertheless, managed to see some values in this type of visualization especially in dealing with large collections of documents. The use of visualization to depict concentration (distribution) of items was received positively.

(2) **Seamless Access to other Information Sources**

Generally, participants welcomed seamless access to other information sources such as a thesauri, an attached glossary/definition, and a translation tool as value-adding features. A few of the additional comments received demonstrated participants’ appreciation of these features beyond that of the current proposed use (in e-journals) – suggesting similar features to be incorporated in for instance, knowledge management systems and, financial and personnel systems. A few participants also suggested linking to other sources such as to an encyclopedia, a yearbook or to a ‘Who’s Who’ directory.

(3) **Browsing Through Items of Interest**

The *Object Viewer* was perceived as useful to get a quick view of a selected object. When combined with *Structure Viewer/OverViewer* for highlight-directed navigation, the response received was also generally positive. Participants were also introduced to the ‘Thumbnail’, ‘Book’ (Card, Robertson & York, 1996) and ‘DocLens’ (Robertson & Mackinlay, 1993) displays. While they were obviously more familiar with the ‘Thumbnail’ display, many of the participants also recognized the potential features of the other two displays. They specifically found the ability to digitally ‘bookmark’ sections of documents useful. Many of them welcomed the idea of presenting users with multiple choices of representations to a document. Participants generally welcomed the idea of using (multi-) color-highlighting to check the distribution of selected objects. Many of them however, were not sure if the ‘Statistics’ tool was something that users would utilize frequently. Most participants realized that the ‘Find/Search’ mechanism was already a common feature in today’s many online applications. A few of them suggested ways to enhance this feature for use in PROPIE such as to incorporate more complex search function using Boolean operators and voice input. The ‘Zoom-Magnify’ was generally deemed useful. One participant also envisaged its use for checking images.

(4) **Filter/Arrange**

More than half of the participants gave the ‘Filter’ and ‘Arrange’ tools an averaged rating (“3”) in terms of their perceived usefulness. Many indicated that the ‘Arrange’ tool was not something that would be used often although appreciation of the tools in helping to focus on important details was observed.

(5) **Collaborating**

A few tools were proposed to stimulate collaboration amongst users and researchers. Participants largely adapted well to them. A number of suggestions (e.g. a point-grading system in organizing the comments and annotations; grouping by topics, dates or author) to improve the display of comments and annotations were put forward. One of the most interesting observations was that there was an emphasis on adding personal annotations rather than checking others’ notes. Many additional comments received substantiated this observation.
Participants were also introduced to the idea of sharing one’s search/browse history records as a means of collaboration. Some appreciation of this feature as a means of exchanging information was reflected in their ratings and the additional comments.

(6) Temporarily Storing Items of Interest

Consistent with the data collected in the participant questionnaire, the idea of ‘Pocket Register’ received quite a positive response from participants, with about 60% of their ratings distributed over “Essential” and “Very Useful”.

(7) Browsing Through Related Work

Within the ‘Research Compass’, ‘Citation Linking’ and ‘Document Mapping’ were received positively. Many, however, found the visualization in ‘Document Similarity’ too complicated for first-time users although some appreciation of its use as a ‘research compass’ was noted. When asked for the preferred number of shapes (or colors) to visualize information, the results were consistent with many existing findings, such as those upheld by Shneiderman (1998, p. 399) - that the use of colors or shapes in a single alphanumeric display should be limited to four (at least, for novices). Participants showed they were most comfortable with 3 to 4 shapes or colors in use.

Participants generally demonstrated an appreciation of the usefulness of the ‘Alerting/Updating’ tool in updating users to recent related works in various fields. Many still prefer the familiar ‘list’ view to display information in preference to other options – ‘Time Line’ or ‘Map’. However, a few of them exhibited an awareness that a ‘list’ might not be the best option at all times especially when the items/collections grew.

(8) Interacting with Multimedia Objects

Participants reacted positively to the multimedia-based features. Checking out a demo in Object Viewer while maintaining the context of the original document proved to be popular. Although most participants were unfamiliar with the features proposed in ‘live test’ and ‘interactive data sets’, most of them received the ideas positively, foreseeing their potential as value-adding features. Many also suggested alternate means to further enhance the features in ‘Image Quick View’, such as to have more flexible zooming mechanism. Many of them reacted positively to the ‘BioLens’ that provided additional information on the images. Almost all participants also welcomed the ability to arrange the images by ‘topic/subject’.

(9) Backtracking

The backtracking features were received positively. Suggestions to improve and enhance ‘History Cabinet’ and its ‘Archive’ included those of allowing users to undo/remove unwanted/out-of-date history records, ensuring easy access to the tools (e.g. iconic design, easy menu selection), and providing more user-friendly interface and interaction for these tools.

For the displays in ‘History Cabinet’, participants again showed a preference for the more familiar and ‘easier-to-use’ list view. Appreciation of other display options was reflected nevertheless, in some of their additional comments. For instance, the ‘Calendar’ view was deemed more value-adding in that it allowed some kind of categorization of events. Participants also liked the use of the ‘Time Line’ in depicting the distribution of activities. Some of them also expressed interests in the ‘Graphical History’ view and indicated that such graphical representation were innovative and easy to use.
Findings for research objective 2

The second research objective is to determine the various facets of PROPIE in terms of its proposed concepts and interactions that enhance users’ interaction with e-journals (e-documents). To examine participants’ feedback on the various proposed concepts and interactions, the results are scrutinized by the following activities (also see Appendix).

(1) Extracting Items of Interest

The ‘drag & drop’ mechanism was positively rated by majority of the participants. Many agreed that it was intuitive and 86.4% of them preferred it to other means of moving objects within the environment (e.g. highlight to select object, right click and select move option from a pop-up menu). Participants also indicated that more than one option however, might be necessary to suit different user needs and experience.

(2) ‘Focus + Context’ Viewing and Exploration

Participants were introduced to the ‘body & clone’ and ‘multi-clone’ analogies. In T340, three of the participants had a preconception of the ‘multi-clone’ concept before they were actually introduced to the concept (in T350) – demonstrating a learned understanding of the analogy. They were able to visualize the various use and benefits of the proposed analogies. For instance, to:

- “…gather a few ‘clones’ from a few articles … Then decide what to do with them.”
- “…apply different tools to the same clone …”
- “…create a few clones of the same paper …and use them for different projects.”
- “…take a few links in the document that don’t appear on the same page and place them all in object explorer first. Then, …check out each, one by one without going from page to page to find them again.”

(3) Controlling the Amount of Information Displayed

Most participants favored the idea to be allowed some kind of control over the proposed environment. It was also obvious that participants preferred having some kind of control of the amount of details presented to them (e.g. by layers/levels). Many went on to suggesting breaking down the ‘layers/levels’ into even smaller sections so that user could choose as precise as they could on the details they wished to check out. Participants’ opinions were split when asked if they thought using different colors for the different layers/levels would enhance navigation.

Findings for research objective 3

The third research objective is to elicit descriptive information to determine the various facets of PROPIE which inhibit users’ satisfaction with the proposed environment in terms of interaction, tools/functionality, and features of tools.

Participants’ overall judgment of the environment was quite positive. The various functions within PROPIE were perceived as capable of enhancing interaction with journals and more than 86% of participants acknowledged the possibility of using PROPIE to enhance one’s searching and browsing tasks. The distribution of the ratings revealed that participants had more problems understanding the layout and structure, and display of PROPIE, rather than with the tools and
functionality available. The underlying reason for this may be due to the fact that participants were not familiar with having to work simultaneously with various workspaces and information objects.

Almost all participants (90%) perceived the use of PROPIE for interacting with journals as being ‘much more in control’ and ‘somewhat more in control’ in comparison with printed and currently available online journals. Particularly ranked at top as important features that enhanced interaction with journals included - integration of querying, navigation and visualization in a single environment, learning and collaborating through annotations/comments/discussions, interaction with information objects down to the level of a single word, image, equation, etc., temporarily saving of information objects for further exploration, backtracking, a visually-rich interaction environment – with coordinated workspaces, and the visualization of search output.

An interesting observation was that ‘visualization of search output’ was amongst those most positively rated even though participants had earlier experienced some difficulties with some of the visualization techniques (e.g. ‘CamTree’). An earlier speculation of some participants facing problems with working simultaneously with multiple workspaces and information objects was substantiated in that a few of the participants did perceive it to be ‘somewhat more cumbersome’ to have to work with various workspaces and objects, and in applying the ‘body & clone’ analogy.

Participants welcomed some kind of control over the overall interaction environment (as already reflected earlier). None of them thought that the workspaces should be fixed in a particular mode or position and about 91% of them stated that users should be allowed to minimize or enlarge any workspaces, and to hide or display any of such workspaces according to various needs and preferences. All participants perceived a 17” monitor as the minimum requirement for an environment such as PROPIE to ensure visual clarity throughout the interaction environment for normal vision.

Findings for research objective 4

The fourth research objective is to provide important input for the continued development of an environment/ graphical user interface of future e-journals (e-documents).

Five participants (33.3%) expected e-journals in the future to be easier to use and to provide end-users with more control over the environment and functionality. Comments from five participants contained the word “useful”, articulating their expectations for future e-journals to be much more useful than what are currently available. An interesting and encouraging observation was that 46.7% (7 participants) of the expectations and enthusiasms asserted were associated with PROPIE in a positive manner. The overall tone implied an optimistic response to the many possibilities presented in PROPIE.

Areas or aspects of PROPIE that was found particularly confusing or difficult to understand, or annoying was also elicited from participants. This was aimed at identifying participants’ feeling of disorientation or ‘getting lost’. 77.3% of them responded. Many of these were a direct result of having too many various tools and features within PROPIE. A second problem related to the understanding of some visualization features such as the ‘Map’ and ‘CamTree’ that were found confusing especially at first glance. A third category of problems related to having to work with too many workspaces and cluttered screen.

Participants were also asked to describe the PROPIE informally to a friend or colleague and to write an informal description of their account. This was geared toward discovering if participants possessed a conceptual understanding of the purpose and design of PROPIE. A content analysis
was conducted on this question that generated 81.8% responses. A list of keywords and terms was used as a template for determining participants’ understanding. These included – ‘integrated environment’, ‘collection of tools and features’ and ‘enhanced interaction with e-journals/e-documents’. These were compared against participants’ responses. Overall, more than three-quarters of participants (77.3%) demonstrated an understanding of the basic purpose of PROPIE as an environment for enhanced integrated access to e-journals (e-documents).

8.0 Discussion

The empirical evaluation has provided valuable insights to the proposed functionality, tools and interactions of future e-documents. We discuss the general implications in the context of the features and interaction properties presented earlier in Table 1.

Integration of workspace - In general, the findings support the interpretation that users perceive the integration of one’s personal workspace (Object Viewer, Structure Viewer/Overviewer and Object Explorer) and the broader information world (InfoSphere Organiser) an important feature. It facilitates the launch of queries based on current work, and therefore, enables a uniform paradigm for accessing a user’s own workspace and the information world at large. This integration also facilitates the task of consolidating intermediate and final information searching results into the user’s initial task.

User-controlled malleability - Throughout PROPIE in all the workspaces, users are able to perform direct manipulation on information objects at multiple levels. Users are given the ability to re-arrange, filter and zoom in on selected objects for more details when required and desired, using the ‘Arrange’, ‘Filter’ and ‘Zoom’ tools in the Structure Viewer/Overviewer. Users can also explore, navigate and perform queries almost simultaneously throughout PROPIE. Users are able to intuitively select, drag and drop objects throughout the various workspaces.

Visual sovereignty - PROPIE provides users with contextualized views during the information gathering and analysis tasks, indicating how an item fits within a collection set and within the broader information world. This is achieved for instance, through the visual and interactive tools and features used to browse through collections in InfoSphere Organiser (e.g. ‘Time Line’, ‘Map’, ‘Forager’ and ‘CamTree’ displays, with pop-up features), through the coordinated and highlight-directed navigation between Object Viewer and Structure Viewer/Overviewer, through the use of the various tools in ‘Research Compass’ to browse through related work, and through the ‘Alerting/Updating’ tool in Object Explorer. As importantly, users are also given visual representations of their browse and search history records through the ‘History Cabinet’ and the ‘Archive’, and the ‘Pocket Register’. The ‘focus + context’ viewing supported by the ‘body & clone’ and ‘multi-clone’ analogies have also been found popular amongst users.

Multiple Representations/Views - To support a variety of needs and preferences, users are given a multiple representation of information objects. PROPIE’s interface allows users to directly manipulate various aspects of the representation and view, and their organization. Within the InfoSphere Organiser, Object Viewer, Structure Viewer/Overviewer, and within the ‘Research Compass’ tools, the ‘History Cabinet’ and the ‘Alerting/Updating’ tools, users can choose a view of interest from multiple display and organization options according to the task(s) at hand and their needs. Users also generally prefer to have some kind of control over the amount of information being displayed. The ‘layer/level’ approach is thought to be important.

Integration with appropriate tools - PROPIE provides users with a suite of interactive tools for querying, navigation, organizing and authoring information. Throughout the environment,
users find it useful to be able to for instance, specify a query against a set of objects, browse and navigate with aids of visual clues about where items are, and to seek for specific information by a zoom mechanism. The findings also show that it is important to allow user to make and save digital comments and annotations, and attach these to an object (e.g. an image, a sentence or an article). The subjects’ response also show that seamless access to other information sources such as to a thesauri, an attached glossary/ definition and a translation tool are value-adding features to be desired in an e-journal. Other tools and features seen as having the potential to add value to e-journals include the ability to interact with for instance, a demo file, interactive data sets and images.

**Malleable information objects -** To support a variety of information searching and analysis tasks, all information objects in PROPIE are fractionally structured. Users are able to manipulate the objects at multiple levels of granularity in a coherent manner. The structure of each object is also made explicitly visible to the user – for instance, stating precisely where they fit into various larger structures (e.g. lists, trees, sections). All objects at any granularity are also queriable and navigable. Users can for example, interact with a collection of articles, a selected article from the collection, a page of the article, a section and down to the level of interacting with an image or a word within the article. History sequences of the objects generated are visualizable and malleable in the ‘History Cabinet’. Users are able to browse and navigate toward or backward items of interest. Information objects in PROPIE are also affiliated with a large prescription of metadata and other additional layers of information (e.g. digital comments or annotations) that are all value-adding properties, that provide users with additional information to facilitate decision-making.

Overall, we have observed the coalescence of characteristics arrived at in PROPIE to be abounding – propagating a variety of possible rich interactions within one single UI environment to enhance user interaction with e-journals, and to add value to these e-documents.

**Limitations of Study**

As a result of the assumptions made in the design of PROPIE and the chosen evaluation techniques, a number of limitations are apparent in this study.

The choice of using e-journals as a form of e-documents has invariably implied that the results will not be totally generalizable to all other online documents. Nonetheless, some of the more general findings related to the assumptions about PROPIE as an environment for interaction with e-documents may be useful for a general discussion of other e-documents.

The sample size of the study is small (22 participants) and should ideally be increased to provide a better representation of the user population, thereby allowing population statistics to be applied, which will in turn yield more conclusive findings. Nevertheless, the current sample comprised highly motivated respondents who have provided a fairly substantial set of data that were used for analysis and the derivation of findings. As an indicator, an average of 70% of the respondents provided qualitative comments on a per-task basis (so that a total of more than 1,000 comments were accumulated during the data collection process). The prolonged hours (approximately 5 to 6 hours) spent per participant in the data collection process indicate that the sample size cannot be substantially increased due to practical reasons.

The simulated mockup used in the evaluation is obviously inferior to that of a working prototype. Such a prototype will allow participants to interact in a more ‘real-life’ manner on a set of real data, which will in turn, likely to generate a set of superior evaluation results. However, reasons of feasibility and implementation made this impractical.
Although issues raised by this study maybe relevant to aspects of systems design, the focus of the study is on how the content of the information environment alters and enhances the user’s interaction with electronic information. The study is not about searching and retrieval in particular, but rather, it is about how users make use of various features and tools for enhanced information gathering and analysis. It should also be noted that although principles of screen design were considered in the conceptual design of PROPIE, it was not the priority of the study. Nevertheless, simply having the augmented information environment without a well-organized screen presentation of the information may have presented a hidden variable that may affect the evaluation results, and poorly-designed screens do little to highlight the proposed enhancements. Hence, in future study, it may be interesting to implement an enhanced version of the screen design for a number of tasks (based on feedback from this evaluation) and repeat the evaluation of these tasks to detect if findings are significantly different from those already collected in this current study.

We believe that there will be a time when reading only printed journals (documents) is no longer sufficient. Users will be missing so much of the enhanced contents that electronic makes possible if they do so. Market forces and competition will also propel changes to happen in the near future so that user-centric e-document systems satisfying real user needs will ultimately evolve. In this study, we have taken a prodigious leap to examine functionality and features required and desirable in a new generation of enhanced e-documents. What we have not done however, is to carry out a thorough feasibility and cost evaluation, and to look at the legal and practical issues. Such investigation and estimates will be essential to make what have been proposed in this study a realism, and as such, will need to be looked into.

9.0 Conclusions

Our goal in the design and evaluation of PROPIE has been to understand how various tools and features can be integrated into one single UI environment, whereby users can apply different tools and features flexibly, and in a complimentary manner so as to facilitate and enhance their various needs in interacting with e-journals. PROPIE has also been designed and evaluated to appreciate how such an environment can, apart from enhancing user interactions, add value to e-documents such as an e-journal.

We believe that we have made substantial progress toward that goal through the empirical evaluation conducted – by studying representative users’ perception and satisfaction with various aspects of the proposed environment. Participants in the study were able to perceive the usefulness of the various tools and features incorporated in PROPIE, and to appreciate their potential in serving different purposes and needs. Based on the findings, we further believe that our success with PROPIE can be improved with some modification to the UI, increased user training or user experience with PROPIE.

As part of our future work, we intend to investigate how an online help facility can be incorporated within PROPIE to explain and guide the use of the available functionality and features. We also intend to look into improving the screen designs by for instance, examining alternative means to present the tools and features. We have also targeted a larger pool of participants to participate in our next stage of study. We hope to carry out further detailed investigations to explore possible relationships of various variables. We particularly intend to verify empirically - whether user individual characteristics (e.g. gender, age, spatial ability) and experiences (e.g. computer and journal usage) have an effect on how participants perceive the various aspects of PROPIE, especially on features that are visualization-based, that demand certain degree of spatial orientations and scanning ability.
References


## Appendix

Research objectives - the criterion for evaluation and related task scenarios.

<table>
<thead>
<tr>
<th>Research Objective</th>
<th>Criterion for Evaluation</th>
<th>Related Task Scenario(s)</th>
</tr>
</thead>
</table>
| #1 To determine the various facets of PRO PIE in terms of its proposed (i) tools/functionality and (ii) associated features that enhance user’s interaction with e-journals. | (1) Browsing through collections | - T100 - Checking external collection in InfoSphere Organiser  
- T110 - Checking works on a particular subject in the external collection through TimeLine display  
- T120 - Checking details of selected information objects through pop-up labels and document panels  
- T130 - Keeping more than one document panel in display using different colours to distinguish  
- T150 - Checking Personal Collections in InfoSphere Organiser  
- T160 - Viewing Personal Collections using the Forager View  
- T170 - Viewing Personal Collections using the Map View and checking details through pop-up labels and panels  
- T190 - Viewing Personal Collection through DocTOC display  
- T200 - Viewing Personal Collection through CamTree display & preference for the display of items within the collections in InfoSphere Organiser |
| | (2) Seamless access to other information sources | - T140 - Thesauri & Knowledge package in Object Explorer  
- T370 - ‘Glossary & Definition Lens’ in Object Explorer  
- T380 - ‘Translation’ in Object Explorer |
| | (3) Browsing through items of interest | - T230 - Using Object Viewer workspace to get a quick view of selected object using scrolling mechanism and choice of what section(s) to display  
- T250 - Highlight-directed navigation between Object Viewer and Structure Viewer to assess document length, structure and layout with multiple display options  
- T260 - Using colour-highlighting/directed-navigation to check distribution of selected a selected object  
- T270 – Using colour-highlighting to check distribution of more than one object  
- T280 – Using ‘Statistics’ to check distribution of selected object (eg. term/phrase)  
- T290 – Using ‘Statistics’ to check distribution of more than one selected object  
- T300 - Using ‘Find/Search’ mechanism to locate specific information/section  
- T330 - Using ‘Zoom - Magnify’ in Structure Viewer to examine details of object |
| | (4) Filter/Arrange | - T310 - Using ‘Filter’ in Structure Viewer to (temporarily/permanently) filter unnecessary information  
- T320 - Using ‘Arrange’ in Structure Viewer |
| | (5) Collaborating | - T400 - Using ‘Comments – View’ in Object Explorer to learn from others  
- T410 - Searching in ‘Comments-View’ by author  
- T420 - Display options (eg. “Display All”, “Display Only Accessible Comments”) in ‘Comments-View’  
- T430 - Using ‘Annotation-View’ in Object Explorer to learn from others  
- T450 - Using ‘Annotation-Add’  
- T760 - Sending history records in History Cabinet to others for discussion/learning purposes |
| | (6) Temporarily storing items of interest | - T440 - Using ‘Pocket Register’ to temporarily store objects of interest for later exploration |
### Browsing through related works

1. T460 - Examining related work through ‘Research Compass - Citation Linking’ in Object Explorer.
2. T470 - Various display options (eg. by author, by publication date) in Citation Linking.
3. T480 – Performing keyword search to locate specific citation(s) in Citation Linking.
4. T490 - Locating works of specific author(s) in Citation Linking.
5. T500 - Checking details of related work in Citation Linking through pop-up labels and panels.
6. T510 - Checking details of related works through more than one pop-up panel in Citation Linking.
10. T540 - Locating works by specific author(s) in Document Similarity.
11. T550 - Changing criterion in Document Similarity to retrieve different sets of related work.

### Interacting with multimedia objects

1. T570 - Viewing interactive demo in Object Explorer.
2. T580 - Carrying out a ‘Live test’ to interactive graphs/equations by allowing user to enter their own sets of data.
3. T590 - Interacting with parts of author’s data and observations through ‘Data Sets’.
4. T600 - Having a quick view of all images/diagrams within an article through ‘Image Quick View’ and using ‘Magnifying lens’ to check details.

### Backtracking

1. T180 - Checking use/history records on selected article.
2. T240 – ‘Small panel’ in Object Viewer to display use/history records of selected object.
3. T620 - Checking objects temporarily saved in Pocket Register.
4. T630 - Saving items stored in Pocket Register to Personal Collection.
5. T640 - Checking recent search history records in ‘History Cabinet’ to trace interested data/information.
6. T650 - Checking recent search history records in ‘History Cabinet’ using ‘List view’.
7. T660 - Checking recent search history records in ‘History Cabinet’ using ‘Calendar view’.
8. T670 - Checking recent search history records in ‘History Cabinet’ using ‘Timeline view’.
10. T690 - Checking recent search history records in ‘History Cabinet’ using ‘Graphic History view’.
11. T700 - Checking recent search history records in ‘History Cabinet’ using ‘DocTOC view’ & preference for the display of items within the collections in History Cabinet.
12. T750 - Saving search and navigation processes into History Cabinet for future reference.
13. T770 - Viewing previously saved history records in Archive (in History Cabinet).
<table>
<thead>
<tr>
<th>Research Objective</th>
<th>Criterion for Evaluation</th>
<th>Related Task Scenario(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#2 To determine the various facets of PROPIE in terms of its proposed concepts and interactions that enhance user’s interaction with e-journals</td>
<td>(1) Extracting items of interest</td>
<td>• T210 - Extracting objects of interest using the ‘drag &amp; drop’ mechanism</td>
</tr>
<tr>
<td></td>
<td>(2) ‘Focus + Context’ viewing and exploration</td>
<td>• T340 - Using ‘Body &amp; Clone’ analogy to get a ‘focus + context’ view in examining selected object&lt;br&gt;• T350 - Using ‘Multi-Clone’ analogy to get a ‘focus + context’ view of selected objects – to eg. compare results of different queries performed on the same object/ same query performed on different objects</td>
</tr>
<tr>
<td></td>
<td>(3) Controlling the amount of information displayed</td>
<td>• T220 - Controlling PROPIE workspaces.&lt;br&gt;• T360 - Presenting details by layers/levels.&lt;br&gt;• T362 - Presenting details by layers/levels (use of colors to distinguish layers/levels).&lt;br&gt;• T390 - Drag &amp; drop selected object into Object Explorer and get full content view directly.</td>
</tr>
</tbody>
</table>