Determining the Effectiveness of User Organised Content in Digital Libraries

Hugh Bedford
University of Cape Town
Cape Town, South Africa
bdfhug001@myuct.ac.za

ABSTRACT

There is an abundance of information and research available online, which is ever increasing. Digital libraries provide a central portal to access different types of information but often lack the features to digest and analyse the information effectively. There is a growing demand for enhanced services that allow researchers to perform their tasks more efficiently. This paper presents a set of enhanced user services that allow users to organise content by creating public and private reading lists. Public reading lists are recommenced to users to expose them to more potentially relevant content. The results indicated that private and public reading lists are effective tools for finding more relevant content and efficiently organising resources.

KEYWORDS

Digital library, NDLTD, research workbench, reading lists, user-organised content, ETD, academic search engine

1 INTRODUCTION

Over the last 25 years, the Internet's creation and progress have resulted in the digitalisation of publication and a significant growth in the amount of online material [11]. Academic content is no exception, with the majority of academic literature currently being published and kept electronically, such as electronic theses and dissertations (ETDs). As a result, there was not only a need to manage the large amount of online content, but also a need for a tool to assist users in digesting the information or content available [8].

The creation of digital libraries provided a way to address the need of managing online content by storing the content in an electronic format and allowing users to manipulate the content to a degree [14]. However, digital libraries have mostly failed to provide an adequate set of user services. There are now many digital libraries in existence, with several of them focusing solely on storing academic content. The Networked Digital Library of Theses and Dissertations (NDLTD), which will be a focus of this paper, is an example of such a digital library.

Most digital libraries have extensive resources but often lack sufficient user services to engage with them effectively and efficiently [16]. Bush argued in his 1945 essay "As We May Think" how our systems for analysing research results are generations old and insufficient for their goal, which has largely remained unchanged. [6]. Users frequently struggle to access information or resources relevant to their needs, not because the information is scarce, but because few services are available to help them find it [16].

The efficient distribution of knowledge across the globe is critical for society's advancement. This was a view held by Bush, as he believed that the ability to access and exchange information facilitates improvement across many aspects of society [6]. The fundamental aim of an academic library, according to Lombardi, is to assist users access materials effectively and readily online with a variety of disorganised resources [18]. This is not an easy task and is why few digital libraries are effective in doing so.

Digital libraries, especially the NDLTD, may be able to improve research efficiency by implementing a set of enhanced user services to help users navigate the content. The goal of this paper is to investigate whether this is true.

1.1 Research Objectives

Several academic search engines, the most well-known of which is Google Scholar, include capabilities to assist scholars in finding relevant content. However, their utility and efficiency, like most digital libraries, leave a lot to be desired. When compared to some of the prominent academic search engines, the Global ETD Search [1], which searches NDLTD, has even less capability. Users of the Global ETD Search can run a variety of searches against the NDLTD resources, but they are only given a few tools to help them digest the data. NDLTD has metadata for approximately 6 million electronic theses and dissertations, making it difficult to choose which to read [13]. This makes the process inefficient and time consuming. This research project aims to improve Global ETD Search's user services to allow better research organisation, find important material more efficiently and expose users to more resources than they would with a basic search. The research will aim to achieve the above results by improving the user services via one central theme: user organised content.

The system will provide users with the functionality to organise content via the use of reading lists. Reading lists will provide users with a way of managing their research in any way they choose. Users can create public or private reading lists containing any ETD available on NDLTD. Users may choose to create private reading lists that are only visible to themselves or a public reading list, which can then be viewed and accessed by all system users. Users will be able to toggle the reading list between public and private with ease. These features will allow users to organise their research into different categories and preserve it for later reference. The final feature will enable users to bookmark ETDs to a "read later" list quickly and easily. Bookmarking ETDs intends to be a quick and easy way to save ETDs of interest.

In order to test the effectiveness of these features, the following research questions will be answered:

[1] http://search.ndltd.org

(1) Will public reading lists provide a useful recommendation feature to help users find relevant content?
(2) Will private reading lists provide a better user experience than the current bookmarking tools users have at their disposal?

1.2 Paper Overview

The remainder of the paper will be organised as follows:

Related Work: This section will provide a formal introduction to the problem. The need for certain user services will be highlighted by looking all related work in the field.

System Design and Implementation: The design and implementation of the system to test the user services will be explained.

Experimental Design: This section will provide a detailed account of how the experiments were designed and formulated to achieve accurate results.

Results and Analysis: The results from the experiments will be given. It will provide all the necessary results obtained to answer the research questions, including the participant information and both a quantitative and qualitative analysis. The results will be analysed and explained. Key findings and insights will be discussed.

Conclusions: After analysing the results, conclusions will be drawn and the research questions will be answered.

2 RELATED WORK

This section aims to highlight the need for the proposed user services by considering at related work within the field.

2.1 User Support

Overall, it should be simple to learn how to use a digital library [10, 17]. Researchers will find the work they are seeking faster if the digital library is simple to use. This highlights the importance of having a user interface that is easy to learn and has a great user experience. The user interface should make clear to users the different choices available for resources that meet their search criteria [1]. A digital library with extensive resources and user services that are hard to use will not be effective for the user. Several papers emphasised the importance of having support structures to aid users with their tasks, which will enable users to extract the maximum benefit from a digital library [2, 5, 17]. As previously said, user features should be simple to comprehend; nevertheless, if they are slightly more complex, the user should be given clear instructions [17]. Having clear instructions will allow users to extract the maximum benefit from the user services available. When developing the proposed user services for Global ETD Search, the features need to be easy to understand to allow the users to extract the most benefit out of them.

2.2 Resource Recommendation

The literature presents evidence that there is a user need for digital libraries to recommend other literature that may be of interest to the user based on what the user is currently looking at [2]. Researchers often wanted to or needed to view most of the content from the same subject area and were not able to [10]. Agosti and Orio also found that professional researchers often wanted to consider similar resources from the same collection of resources [2]. It was also found that users wanted to be able to list the most important resources within a particular category but are not able to with the current tools available [10]. A recommendation feature could make it easier for researchers to find potentially relevant papers. This research project will aim to address this need by making use of public reading lists. Public reading lists recommend different lists of resources to users that have been created and organised by other users of the system, providing users with a recommendation of other literature. The user interface of a digital library should make clear to users the available choices for resources that meet their search criteria [1]. However, many digital libraries do not provide a clear representation of all the relevant content available to the user [1].

2.3 User Collaboration

There is an increasing demand from users and researchers to be able to collaborate in some form on content within a digital library. Kani-Zabihi, Ghinea and Chen explained that digital libraries currently have a lack of support for users to work and collaborate [10]. The introduction of public reading lists will provide a form collaboration because users are able to see content from collated into different lists by other users of the system.

It was also found that users wanted the ability to create a profile on digital libraries [10]. Users would be able to specify their areas of interest, and information would be recommended to them based on their interests and frequently searched topics. A user's profile would allow them to bookmark search results, keep track of their interactions with a resource, and organize their bookmarks for future reference [17]. Again, some of the user services that are proposed are motivated by the literature. Users found that being able to add comments to resources and see feedback from other users would make digital libraries a more effective research tool [2, 10]. The ability to add comments and in-line annotations on resources may increase the involvement of non-domain users and would help new researchers to engage with the content more effectively [2, 17]. The ability to comment on resources would also enable a form of collaboration between researchers.

NDLTD makes use of the Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) to harvest metadata from remote repositories [15, 16]. Harvesting is the process whereby a digital library collects metadata from remote repositories in XML documents via OAI-PMH [16]. Digital libraries harvest the metadata from remote repositories, store it locally and then perform searches on the local data [16]. The OAI Protocol is flexible enough to implement many of these mentioned services in a digital library with rich metadata. The OAI Protocol would make it possible to add annotations to documents, which is mentioned above as a desired feature amongst digital library users [16]. The protocol is also powerful enough to enable profile-based filtering [16]. As mentioned above, users could indicate interests, and then all resources matching those interests would be presented to the user.

It is critical to use a user-centered approach while building and constructing a digital library, because the product must directly serve the demands of its consumers. [10]. This is an approach that was taken to design and implementation the system in this paper.

The features that are proposed to benefit the user of a digital library are centered around the user.

After analysing the literature, the features that will be introduced in this system are sought after and relevant to existing user needs.

3 SYSTEM DESIGN AND IMPLEMENTATION

3.1 System Design

The system's design and development are essential components in determining the effectiveness of the user services. This section details the system design and development that was implemented to ensure the experiment obtained accurate results. The system design followed a layered architecture, allowing the development and refactoring of each layer to occur independently. The layers follow a Model-View-Controller (MVC) design pattern, meaning different layers perform the application's Model, View and Controller functions. Figure 1 illustrates the architecture of the system.

The system makes use of the existing Global ETD Search features and data. All the ETD metadata existing on NDLTD is indexed and searched using an Apache Solr Index [7]. A new Solr instance was created for use by the system and a copy of the Solr index used by the Global ETD Search was added to the running instance. Apache Solr handles all the search queries of the current Global ETD Search site.

The system was designed as a web-based application. This approach was taken for several reasons. For starters, the Global ETD Search was already a web-based service. Second, users can easily access the program through their browser without the need for any installation. If a native system was designed, the architecture of researcher's machines would need to be considered.

3.1.1 Model. This layer involves the storage and organisation of the user data. The database was designed and developed in MySQL following the 3rd normal form. The database stores users, reading lists, reading list items and bookmarks. Figure 2 illustrates the design of the database in an entity-relationship diagram. The User table stores users whenever a user creates a user profile. Since the system was designed to be a test system, users are only required to choose a user name and enter their email, which acts as a unique identifier. Users then needed to have the ability to create reading lists and bookmark resources, so a UserList and Bookmark table were designed to enable these features. Finally, a ListItem table is required to store the resources on a reading list. The Model also consists of several Java classes with parameters that mirror the columns in the database tables. This allowed for easy manipulation of Bookmarks, UserLists and ListItems in the form of Java objects.

3.1.2 Controller. The layer handles the manipulation of content by the user when they are making use of all the available user services. The Controller connects the user interface with the database objects.

The system was developed as a Java web application. The Controller consists of Java Servlets that are used to manipulate the database with a variety of create, read, update and delete (CRUD) methods and to pass dynamic data to the View of the application. When a user creates a profile, a Java Servlet receives a HTTP Post request from the View, and updates the Model accordingly. Similarly, when a user logs in, the User table is checked for the user details. A similar process is followed when a user manipulates bookmarks or reading lists. A HTTP Post or Get request is sent to a Java Servlet, which performs the required functions on the Model depending on the request and then returns data to the View. There are several Java Servlets which are responsible for the user profile, reading lists and bookmarking functionality.

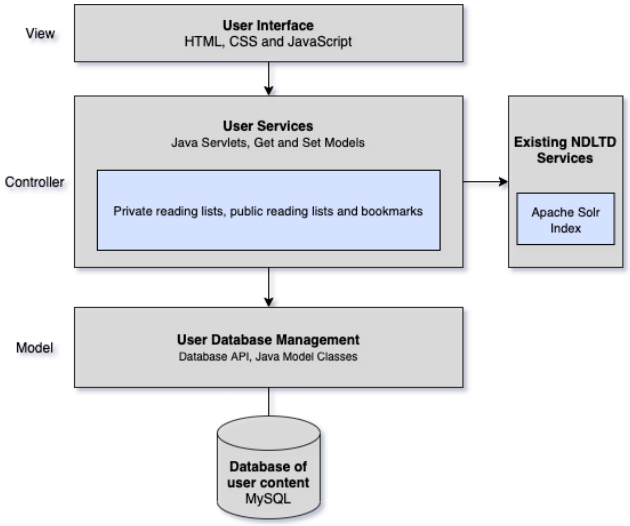

Figure 1: Architecture of the system

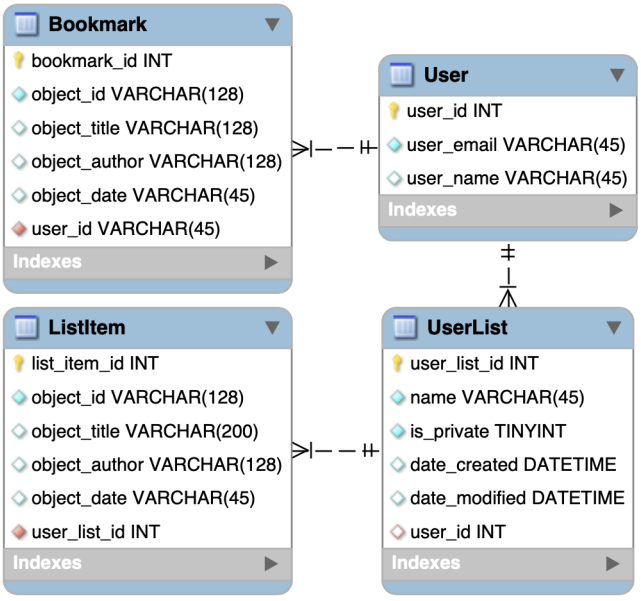

Figure 2: MySQL Database Design

The Controller is also responsible for handling the search queries performed by the user. When a user enters a search query, a Java Servlet receives a HTTP GET request from the View and passes the search query to the running Apache Solr index already mentioned, containing all the ETD metadata. The data returned, which is in

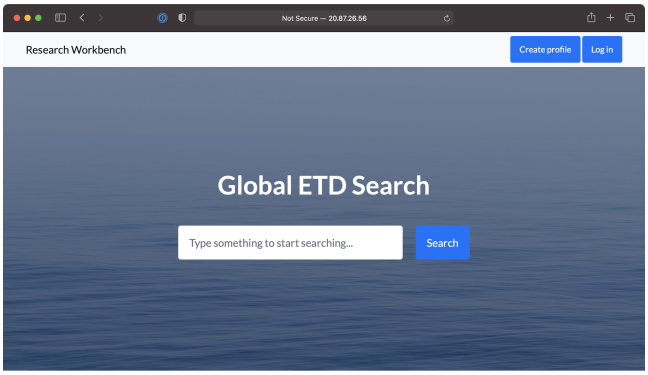

Figure 3: Landing page with sign up and log in

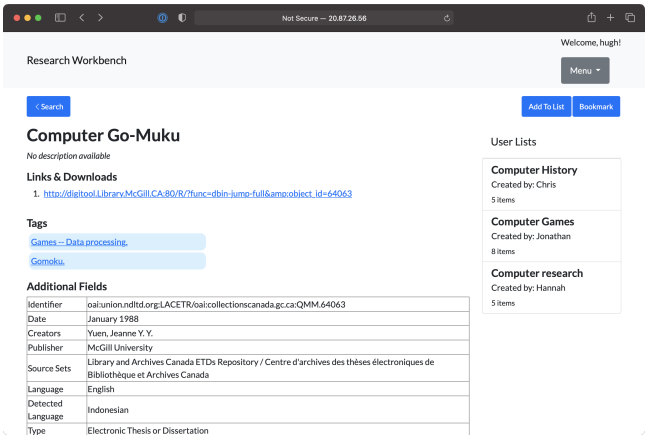

Figure 4: Reading lists recommended to a user

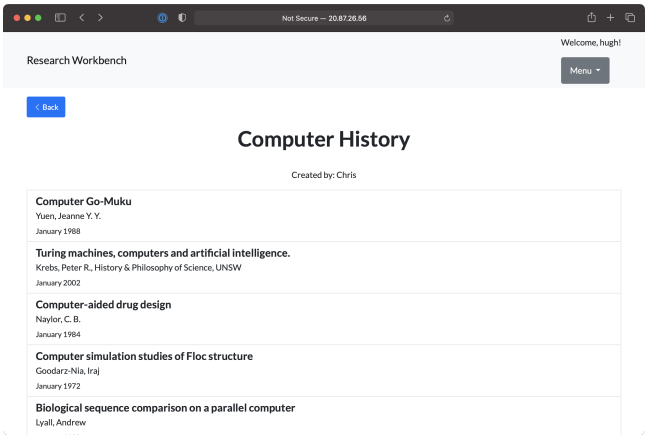

Figure 5: Viewing a particular ETD's details

JSON format, is parsed by the Controller and then returned to the View of the system, where the search results are displayed.

After the search results are displayed, the user may click on a particular ETD to view more information about it. If this event

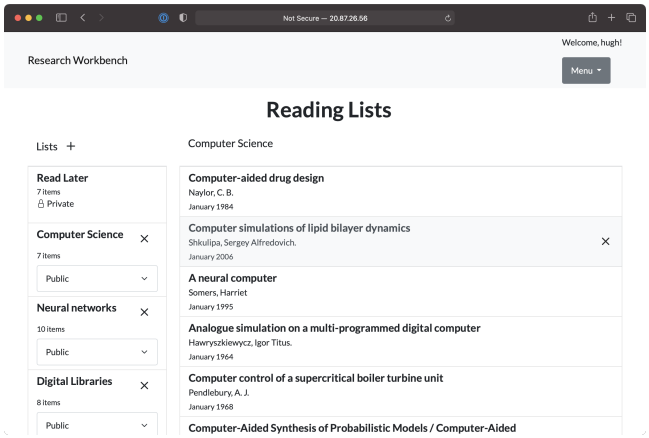

Figure 6: Managing the items your different lists

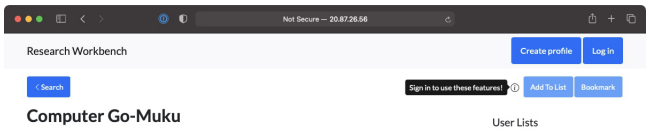

Figure 7: Feature buttons

occurs, the View sends an HTTP Get request to a Java Servlet in the Controller. The Controller then has to retrieve data from two different sources. The Controller fetches all the ETD metadata of the ETD that the user wants to view. It also calls a Model layer method that executes a SQL query to find all the public reading lists that contain the ETD that the user wants has requested to view. The results from each request are returned to the View and displayed to the user.

3.1.3 View. This layer is vital to the system's success since the users only interact with the View of the system. Thus, the development had a strict focus on user experience. The View presents all the user services to the user and allows the user to manipulate the system. Since the system is web-based, the View was developed in HTML, CSS and JavaScript to create a responsive and sleek interface. Bootstrap 5 was also used to speed up the development process and enhance the user interface by using many of Bootstrap's UI elements [3].

The design and development of the View had the aim of being simple and easy to use. The literature analysed in Section 2 emphasises the importance of a system being straightforward to use.

The system provides users with all functionality that already exists on Global ETD Search. Users can open the system and make full use of the search functionality just as they can on the Global ETD Search. However, if users decide to create a profile or log in to their already existing profile, they will have access to the set of enhanced user services offered by this system. Figure 3 shows the start page of the system where users can perform a search and the buttons to create a profile or log in. After logging in, users can create reading lists and choose whether to make a list public or private.

Users are then to add ETDs to their different reading lists. They are also able to bookmark ETDs to a "read later" list. The buttons shown in the top right of Figure 4 illustrate how a user would use these features. If not logged in, the buttons that perform these functions are greyed out, and a prompt will be shown to the user to sign in if they try to use the features (shown in Figure 7). When viewing more information about a particular ETD, if that ETD exists on another user's public reading list, that user's reading list will be recommended to the current user. The recommended reading lists are shown on the right of Figure 4. Section 3.1.2 explains this process. If the user decides to view one of the recommended reading lists, they are able to browse the ETDs on the respective list. Figure 5 shows what the user would see. A user can view all the content on their own reading lists, toggle a list between public and private, and remove ETDs from lists. A user would see the interface shown in Figure 6 when doing this.

3.2 Implementation Strategy

The development of the system followed an iterative development strategy. This strategy was followed from the start to allow for evolving requirements and challenges encountered. The strategy was correct since there were several changes in the user interface and architecture design.

The development of the system occurred in stages, with each stage focusing on a different layer within the system. The first step was to set up a virtual machine to run the system on. A virtual machine was created on Microsoft Azure. Once complete, the development of the system began.

The Model was the first layer of focus. The MySQL database was designed for the system needs and then created. The database management methods - create, read, update, delete (CRUD) - in the Model layer were created based on the planned features and then extensively tested with different data to ensure the methods were performing as intended.

The next step was to run the existing Apache Solr index from Global ETD Search on the Azure virtual machine so that the system could perform search queries on the NDLTD metadata. Since the data was already indexed for the existing Global ETD Search, this was a simple process, so the index was added to the running Solr index on the Azure virtual machine.

Once the Model was complete, and the system had access to the NDLTD metadata, the simultaneous development of the View and Controller began. Since a change in a requirement of the View would result in changing a Java Servlet, the development of the two layers coincided.

Each part of the system was documented during the development process to ensure that if the system achieved its goal, parts of the system could be taken into production or easily maintained in the future.

There was a focus on modularity, which was one of the reasons for the decision to follow a layered architecture. The View can easily be adjusted or changed without affecting other parts of the system. The system also supports portability. The system can run on any Apache Tomcat instance, meaning it is easy to deploy on any running server, provided the server is running Apache Tomcat.

On completion of the technology development, extensive testing followed. Unit tests were conducted manually on each component of the system. The testing process ensured that each feature worked as intended. All faults and bugs were fleshed out throughout the testing process. Since the system's goal is to test usability and user experience, this was essential for the system implementation. Testing was the final step in the development process.

4 EXPERIMENTAL DESIGN

This section aims to give a detailed account of how the experiments were designed to test the system accurately. The goal of the experiments was to gather sufficient data to answer the research questions as effectively as possible. To do so, quantitative methods were used by making use of the *Usefulness, Satisfaction and Ease of Use (USE)* questionnaire and qualitative data was gathered by asking the participants several open-ended questions about the system. Having both quantitative and qualitative data would provide adequate data to test the hypothesis.

4.1 Participants

All participants in the study were students from the University of Cape Town, recruited via social media and email. Since the system's features are focused on providing enhanced user services for the act of research, the inclusion criteria for the study was any student who has performed research. Students in their third year of study or higher were preferred since they have performed more research than students in lower years of study. Students from different faculties and disciplines were contacted with an invitation to participate in the study. Students from different research backgrounds would be beneficial for the study. Students from different backgrounds would allow investigating whether results would differ depending on the researcher's discipline. Although there was no required number of research participants, a sample size of 30 responses was the aim.

4.2 Research Measures

A variety of data was gathered from the test participants. The data gathered fell into three different categories: Participant information, quantitative data and qualitative data.

4.2.1 Participant Information. The first part of the questionnaire gathered participant information. The participant information included faculty, discipline and year of study. This information would help when analysing the results of the study. This participant information would allow determining whether results differ depending on the participant's research experience. Results could also be evaluated to determine whether the researcher's discipline affects the results.

4.2.2 Quantitative Data. The quantitative data of the study was gathered by the *Usefulness, Satisfaction and Ease of Use (USE)* Questionnaire [12]. This questionnaire was chosen for the types of questions in the questionnaire. The questions were well suited for answering the research questions. The USE questionnaire consists of 30-items falling into four different categories: Usefulness, Satisfaction, Ease of Use and Ease of Learning [12]. The original questionnaire was modified slightly for the use of this study. Item

3 ("It is useful") on the original questionnaire was split into two items: "The public lists are useful" and "The private user lists are useful". The custom items offered a more specific statement that relates to the research questions. The custom items also catered to a user liking one of the features, but not the other feature. The user may take a neutral position in this case despite finding one of the features useful. The questionnaire, therefore, had 31 items. The answer scale is 10-point Likert items [9]. The response format allows for quantitative analysis when considering the responses. The 31 items in the questionnaire are shown in Part A.1 of the Appendix.

4.2.3 Qualitative Data. The participants were then asked four open-ended questions, which allowed for qualitative analysis. The following questions were asked:

(1) What feature did you enjoy the most? Why?
(2) What feature did you enjoy the least? Why?
(3) If you could change one thing about this system, what would it be and why?
(4) Any general comments about this system?

The open-ended questions give the participants more freedom to express their opinion on the usability and user experience of the system. Open-ended questions also provide the researchers with the opportunity to identify possible reasons behind participant responses in the USE questionnaire.

The choice to go with anonymised responses allowed the participants to give their honest opinions on the system, ensuring accurate results.

4.3 Test Procedure

Participants need a thorough understanding of the system to provide accurate results. Therefore, users were required to perform a set of tasks on the system before answering the questionnaire. The instruction set was designed to give the participants the best possible understanding of all the features available on the system within a short time frame.

The instruction set given to the participants (shown in Part A.2 of the Appendix) required them to create a profile, then perform the three search queries: "computer", "neural networks", and "digital libraries." After each search, users were required to browse some recommended reading lists, add ETDs to their reading lists, and bookmark some of the ETDs. In the end, users were asked to view their created lists and bookmarks.

Due to the nature of the public reading list feature, there had to be existing reading lists on the system that could be recommended to the participants. The system, therefore, had to be set up to be tested before being tested by participants. Six dummy profiles were manually created with random names: "Hugh, Chris, Dean, Daniel, Hannah and Jonathan." The set of instructions instructs the participant to search for "computer", "neural networks", and "digital libraries." Therefore, reading lists had to exist for these queries in order for the participants to test the recommendation features. For each dummy user, one public reading list was created for each search query, resulting in 18 different lists. The public reading lists were designed such that the top 5 results for each search query overlapped across different reading lists. This ensured test participants would be recommended different reading lists when selecting a different top result when performing one of the mentioned searches. The reading lists were also designed to show content that was not shown when performing the searches.

The test procedure was designed to be standardised and repeatable to see how different users found the same tasks. The test procedure would ideally give the most accurate results possible. Once complete with the system instructions, the participants were asked to complete the questionnaire mentioned in Section 4.2.

4.4 Ethical and Professional Issues

Before the system evaluation could begin, ethical clearance was obtained from the UCT Faculty of Science Research Ethics Committee in order to carry out the research. Participants were clearly informed about the risks, procedures, confidentiality, and voluntary involvement via an informed consent document. There were no physical risks involved in the study.

Responses from participants were anonymised, and their name was never asked for in the questionnaire; nevertheless, no identifiable participant information was released with the results and individual participant responses were not seen by anyone outside the research team and were only used for this study. No physical contact was made with any participant at any time during the study.

Although the software has not been licensed under an open source license, the software will be released under an open source license if interest is shown.

5 RESULTS AND ANALYSIS

Thirty complete responses were gathered during the experimental phase of this project. However, one response was discarded as illegitimate because the participant rated 7 for all the Likert items in the questionnaire and gave the answers "Hi", "bye" and "hello world" for the open-ended questions. Therefore, the remaining 29 complete responses were analysed.

5.1 Participant Information

The first part of the questionnaire identified the participant's faculty, discipline and year of study. 62% of the responses were from students in their fourth year of study (Honours) or higher and from varying disciplines (mathematics, engineering, finance, computer science, psychology, actuarial science, statistics and medicine). The most common responses came from students in the Science and Commerce faculties, with 34% and 38% of the responses coming from those faculties, respectively. The final 33% of participants were made up of third-year undergraduate students and students who have graduated with a bachelor's degree. Students in their third year of study or higher are believed to have completed sufficient research to provide reasonable responses. Upon analysis of the results, no meaningful correlations were identified between responses and the participants' year of study. A larger sample size may enable correlations between responses and participant research experience to be identified.

5.2 Quantitative Analysis

5.2.1 Overall Results. The results collected from the system evaluation was overwhelming positive. When considering the overall

results of the USE questionnaire, the participants found the system useful, easy to learn and use and were satisfied with it. Table 1 indicates the average, median and standard deviation for each category in the questionnaire. The overall average response from the questionnaire was 8.36, and this has a relatively low standard deviation of 1.79. With ten representing "strongly agree" on the Likert scale, the participants overwhelmingly approved of the system's user experience. To investigate this average further, a 95% confidence for the true population mean of the responses was calculated using a t_{28} distribution. A 95% confidence interval for the true mean is given by (7.68, 9.04). There is a 95% probability that the true mean of responses would be between 7.68 and 9.04.

Table 1: Overall results of USE questionnaire

Categories	Mean	Median	SD
Usefulness	8.09	8	1.68
Ease of Use	8.41	9	1.88
Ease of Learning	9.33	10	1.09
Satisfaction	8.07	9	1.90
Overall	8.36	9	1.79

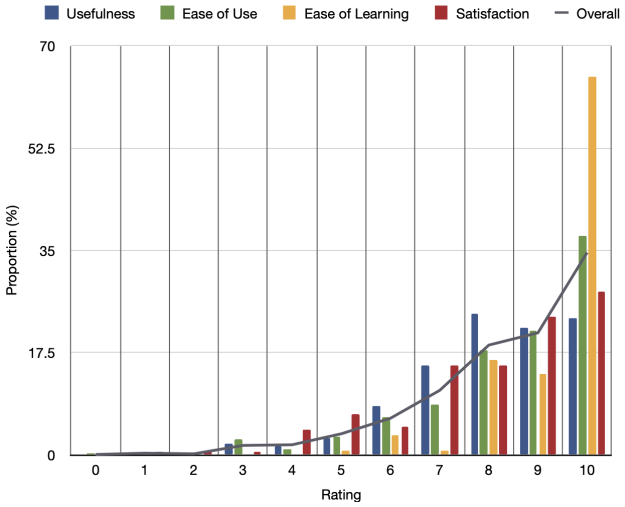

Figure 8: Proportion of responses for each category

Figure 8 illustrates the proportion of scores for each category in the questionnaire and the overall proportion of responses. The data in each category was negatively skewed, shown in Table 1, with each category median larger than their respective mean. The overall data was also negatively skewed. The overall mean and median were 8.36 and 9, respectively, showing a negative skew on the data. 55.84% (502/899) of the total responses were either 9 or 10 on the 10-point Likert item, showing how most participants strongly agreed with the items in the questionnaire. This skew can be seen graphically in Figure 8, with most of the data greater than 8. Table 2 shows a breakdown of the proportion of responses for the whole questionnaire. Ease of learning, shown in yellow in Figure 8, is a clear outperforming category when compared to the overall proportion. This is discussed further in Section 5.2.3.

Table 2: Overall proportion of responses

	U	EoU	EoL	S	Total	Proportion
0		1			1	0.11
1	1	1		1	3	0.33
2		1		1	2	0.22
3	5	9		1	15	1.66
4	4	3		9	16	1.77
5	8	10	1	14	33	3.65
6	22	21	4	10	57	6.31
7	40	28	1	31	100	11.06
8	63	57	19	31	170	18.81
9	57	68	16	48	189	20.91
10	61	120	75	57	313	34.62
Total	261	319	116	203	899	100

Before conducting a deeper analysis on the results, it can already be said that participants approved of the system usability and user experience. Of the 899 responses gathered in the questionnaire, only 37 (4.11%) disagreed with an item in the questionnaire. Of the 37 responses that disagreed, only one was rated 0 ("strongly disagree"). Given the level of detail covered in the USE questionnaire, this is extremely positive. 829 (92.21%) of the responses were in agreement with a statement. As already mentioned, 502 of these responses were either a 9 or 10.

5.2.2 Custom Items in USE. Item 3 on the original USE questionnaire was split into two separate items, item 3 and item 4, as explained in Section 4.2.2. Item 3 ("The private user lists are useful") and 4 ("The public reading lists are useful") are arguably the two items most important when considering the research questions. Item 3 received an average response of 8.83 and a standard deviation of 1.20, while item 4 received a mean of 8.79 and a standard deviation of 1.59. Most participants agreed strongly agreed with these two statements. Item 3 had 13 (44.83%) participants select 10 and 24 (82.76%) participants selected 8 or higher. Similarly, item 4 had 14 (48.28%) participants select 10, and 24 (82.76%) participants selected 8 or higher. The responses are represented graphically for item 3 and item 4 in Figure 9. Figure 9 illustrates how all but one participant agreed that both the features - the private and public reading lists - were useful.

Only one user disagreed with item 4 ("The public lists are useful"). After analysing this participant's comments further to find potential reasons why they disagreed, it was found they could not see the ETDs on a particular list when trying to view their list items. The user must have tested the system on a very narrow screen because this forces the ETDs on the list to be shown below the list names and not side by side (as shown in Figure 6), which harms the user experience. Since most users would use the system on a computer and not use the system on such a narrow screen, this result could be discarded, meaning the mean for this item increases further to 9.00, and the standard deviation decreases to 1.16. The increased mean further emphases how the participants agreed strongly that the public reading lists were useful.

5.2.3 Usefulness. In the usefulness section of the questionnaire, item 2 ("It helps me be more productive") had an average response

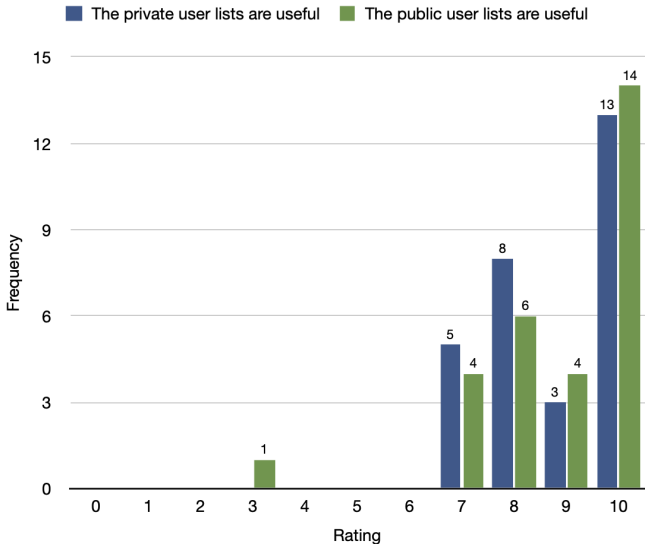

Figure 9: Frequency of responses for items 3 and 4

of 8.03, standard deviation of 1.50 and a median of 8. 27 (93.10%) participants agreed that the helps them be more productive, while only one participant disagreed and one participant was neutral with the statement. The participant that disagreed did not provide any reason for their response when answering the open-ended questions. Item 7 ("It saves me time when I use it") recorded an average of 8.62 and a standard deviation of 1.29. 58.62% of the participants rated item 7 with 9 or 10, meaning most users strongly agreed that the system saved them time. This point was further strengthened, with four participants commenting that they think the system will save them time by suggesting relevant resources.

The system developed in this paper had several aims. One of the aims was to provide researchers with a method of finding important material more efficiently than existing research platforms. If this system saves the participants time by suggesting relevant content, it performs tasks more efficiently than other systems. This data is a further indication that the system provides a superior user experience.

The two custom items mentioned in Section 5.2.2 were also in the usefulness section.

5.2.4 Ease of use. In the ease of use section, item 10 ("It is easy to use") was a notable response with a mean of 8.76 and a standard deviation of 1.50. Item 10 had a median of 9 since 62.07% of the participants rated item 10 with 9 or 10. Only one participant disagreed with the system being easy to use. After analysing the comments from this participant, they felt that finding the user lists was confusing. Since no other participant made mention of this, this issue was not substantial. Therefore considering the responses, participants overwhelmingly agreed that the system was easy to use. Since it was emphasised in the literature analysed in Section 2 that a digital library should be easy to use, this is a positive result.

Two items within this section had users agree reasonably strongly ($\bar{x} = 8.03$ and $\bar{x} = 8.41$) with the statement but saw a relatively large deviation in responses. There were item 14 ("It is flexible") and item 19 ("I can recover from my mistakes quickly and easily") with standard deviations of 2.08 and 2.02, respectively. Both items had a median of 9, greater than their respective means, illustrating a negative skew on the data. Figure 10 illustrates the negative skew on the data and the greater deviation in responses than that seen in Figure 9. The comments of the low scoring participants were analysed to investigate possible reasons for the deviation in responses. It was found that these participants tried to change the names of their existing lists. This feature was not available on the system. The inability to change a list's name forced users to make a new list if they made a mistake. Some participants could not recover from their mistakes quickly and easily, hence the deviation in responses. The lack of this feature was an oversight during the system development stage of this project. Editable list names should have been a feature included in the system.

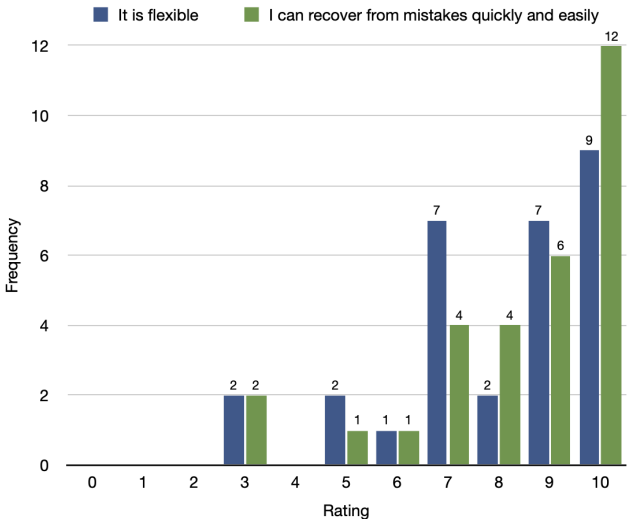

Figure 10: Frequency of responses for items 14 and 19

On average, most users agreed that the system would be liked by both occasional and regular users ($\bar{x} = 8.24$, $\sigma = 1.81$). An essential feature of a digital library is being usable by both new and experienced users [5]. Based on the responses from item 18 ("Both occasional and regular users would like it"), the participants agreed that both regular users and inexperienced users would use this system. Again, this can be considered a success because researchers with varying levels of experience would need to use a system like this.

5.2.5 Ease of learning. A noticeable result in Table 1 is the ease of learning the system, which achieved an average score of 9.33 and a standard deviation of 1.09. Most users agreed that the system was easy to learn. The low standard deviation shows the consistency of the results. 64.66% (75/116) of the responses were rated 10, resulting in a median of 10. The responses for the easy to learn statements were negatively skewed, illustrated clearly in yellow in Figure 8. This is a positive outcome since it was discovered when analysing the literature that digital libraries should be easy to learn [10, 17].

Two of the highest-scoring items across the entire questionnaire occurred in the Ease of Learning section. These included item 21 ("I

learned to use it quickly") and item 22 ("I easily remember how to use it"). Item 21 achieved a mean of 9.34 and a standard deviation of 1.08. 19 of the 29 participants agreed strongly with this statement, giving it a rating of 10. The highest scoring item, item 22, achieved an average of 9.62 and a standard deviation of 0.73 for its responses. It had 22 participants rate the statement 10/10. Participants unanimously agreed that they were able to remember how to use the system easily.

5.2.6 Satisfaction. Under Satisfaction, users were overwhelmingly satisfied with the system. However, there was a relatively large deviation in some responses when compared to others in the questionnaire. This high deviation was most noticeable in item 30 ("I feel like I need to have it") with a standard deviation of 2.42. The relatively large standard deviation resulted from three participants disagreeing with the statement and four neutral with the statement. While two of the three disagreeing participants did not explain why they would not use the system, one participant stated they frequently use Google Scholar's citation feature. Since this system lacks that feature, they would struggle to use this system. Since this system is intended to be an academic search engine, further work on this system should include a citation feature. This is discussed further in Section 7. Although there was a high standard deviation and some participants disagreed, most participants (22 of 29 participants) agreed that they needed the system.

Overall, Satisfaction was marginally the lowest-performing category on average in the questionnaire. This is a result of the category containing some of the lowest scoring items in the questionnaire. Item 30 was one of the lowest scoring items for the reasons mentioned above. Item 27 ("It is fun to use") was also a low scoring item. One participant that disagreed with this statement commented that many ETDs did not have descriptions. This issue will be explored further in Section 5.3.3. It should be noted that this participant is the same participant that commented on the lack of citation feature, and their average response for the Satisfaction section was 4, showing that this participant was not satisfied with the system.

5.3 Qualitative Analysis

The analysis of the qualitative data was done using thematic analysis [4]. Thematic analysis is the process of reading through the qualitative data gathered and identifying patterns in the data. The patterns are then grouped into different themes, which can be analysed. The open-ended questions of the questionnaire were analysed and the following themes were identified:

5.3.1 Theme 1: Public reading lists. The ability to create public reading lists was regularly mentioned under "most enjoyed features", with around half the participants (15) mentioning that feature explicitly. The reason for the public reading lists being the most enjoyable feature varied amongst the participants. Four participants explained that the public reading lists would save them time because related content is recommended. Again, this was an aim of this system. Since participants mentioned that the system saves them time explicitly, it emphasises that users want a system that makes them more efficient at performing their required tasks and appreciate that this system provides them with the tools to do so. Some participants found the public reading lists enjoyable for the specific suggestion of related resources. One participant thought the feature would help when performing group research projects. A final notable comment was from a user who enjoyed the public reading lists because they believe it is important to share resources with one another.

There were, however, some suggestions for changes to lists that users would make:

(1) Two users wanted to rename their already existing lists. Renaming reading lists was not a possibility in the system. The only way to change the name of the list is to create a new one.
(2) A user suggested making it easier to remove an ETD from a list. Users can only remove ETDs from a list on the User List management page.
(3) As already detailed in Section 5.2.2, one participant tested the system on a narrow screen, so could not see the ETDs on their lists without scrolling down the page. The system would need to be optimised for narrow screens to cater for this.
(4) One participant wanted the ability to share a list with particular users and not just make it available to all system users. The participant wanted to share lists with "friends" on the platform.

5.3.2 Theme 2: Private reading lists. Half of the participants (14) mentioned the private reading lists are their most enjoyable feature. Participants gave several different reasons for it being their favourite feature. The main reason amongst participants (6 of the 14) was that the private reading lists provided a way to organise their research. One participant explained how their current method to save their research is on a Microsoft Word document. Another participant uses multiple browser tabs. Both of which are certainly not efficient. From the responses, most participants currently struggle to organise their research efficiently, and the private reading lists provided them with a way to do so. This system aimed to allow better research organisation by introducing reading lists. It is clear from both quantitative and qualitative data that private reading lists are an effective way to organise research. Several participants liked that reading lists could be toggled between public and private because some lists they may not want to share with other system users.

Two participants liked how it was possible to bookmark items. They found it was an efficient way to quickly save relevant ETDs without creating a reading list to save it to.

Like the public reading lists, participants wanted the ability to rename private reading lists after they were created but could not do so. One participant wanted to rank the ETDs by relevance within the list to know the most important quickly. ETDs are only able to be shown in order of date added to the list.

5.3.3 Theme 3: Search Results. There were several suggestions and changes users would make that involved the search results of the system. Firstly, a few users wanted to add ETDs to a list or bookmark an ETD from the search results page. Currently, the system only supports these features when viewing the details of a particular ETD. Three users mentioned that one of their most-used features on other academic search engines, like Google Scholar, is seeing

the citations or saving the citation. These users would like to see a similar feature on this system. One participant explained how they frequently use the citation feature on Google Scholar and could not use this system without that feature being added.

There were several suggestions pertaining to features or improvements that the current NDLTD limits. A few participants wanted an improvement in filtering options, while another thought the ETD descriptions were inconsistent. The inconsistencies in the metadata supplied to NDLTD, unfortunately, limits the possibility to solve these issues.

5.3.4 Theme 4: System Design. Six participants made comments on the design of the system. Participants responded positively to the system's sleek design, with five participants commenting that they enjoyed the design of the system under the general comments. The design was a focus of the system, which users noticed and appreciated. Other users pointed out the responsiveness of the system. A further five participants mentioned how the system was easy to use and easy to understand. As mentioned in Section 2.1, digital libraries should be simple to learn and easy to use. Participants mentioning the system's ease of use emphasises explicitly that they felt the system was easy to use and simple to learn.

Two participants enjoyed the responsiveness of the system. Both mentioned that they appreciated the fast loading speeds of the system. Although this was not found to be a specific user need for a digital library in Section 2, a responsive system positively affects the user experience when using a system. A responsive system improves efficiency when trying to perform research.

One participant thought the design of the landing page should be improved slightly. The participant did not like the white space below the background image. This, fortunately, is a minor issue and can be improved with ease.

6 CONCLUSIONS

This research project aimed to improve Global ETD Search's [2] user services to allow better research organisation, find important material more efficiently and expose users to more resources than they would with a basic search. The research project aimed to achieve the above results by enabling users to organise content into reading lists.

The objectives of this study were to investigate whether public reading lists provide a useful recommendation feature to help users find relevant content and determine whether private reading lists provide a better user experience than the current bookmarking tools users have at their disposal.

A web-based application was designed and developed to investigate the research objectives. The system was built using the search engine currently used by Global ETD Search (an Apache Solr index), which searches NDLTD and gives users the ability to create a profile and create personal reading lists. Users can create public or private reading lists containing any ETD available on NDLTD. Reading lists provide users with a way of organising their research in any way they choose. Private reading lists are only visible to the user who created them, while public reading lists can be viewed and accessed by all system users. These features allow users to organise their research into different categories and expose them to more potentially relevant content.

Thirty participants were gathered to test the system to provide data to answer the research questions. 62% of participants consisted of students in their fourth year of study (Honours) or higher, while the rest was made up of students in their third year or Bachelor graduates.

The results from the research provide a clear answer to the research questions. The participants found the system useful and easy to use. The average response was 8.36 for the 10-point Likert items in the questionnaire, highlighting the usability and user experience of the system.

The results make it overwhelmingly clear that the public reading lists provide a useful recommendation feature to help users find relevant content. Many participants commented on the public reading lists as their favourite feature and thought it was a great way to find relevant resources. By suggesting relevant content, researchers save time and are exposed to more information.

It is also abundantly clear that private reading lists provide a better user experience than other bookmarking tools. This feature was also popular among users, with several mentioning that this feature would have been beneficial during their thesis research. Participants were using inefficient ways to organise and save their research, and the private reading lists provided them with a way of doing so efficiently.

7 FUTURE WORK

There are several ways this system could be improved or added to in the future to improve the user experience. It was identified in the literature that users wanted the ability to rank the most important resources within a particular category. A participant in the study commented that they wanted to rank the ETDs on their reading lists. This is undoubtedly a feature that should be added to the reading lists.

Two participants wanted to rename their lists after creating them, which was not supported. Editable list names would be a simple feature to add and was an oversight during the system development phase of the project. The system does not provide a feature to generate or show citations. Two participants commented that that feature is their most-used feature on popular academic search engines such as Google Scholar. This feature should certainly be added in future development.

To improve usability further, users should have the ability to bookmark and add ETDs to different lists from the search results page. Currently, users have to select a result before adding a ETD to a reading list.

ACKNOWLEDGEMENTS

I want to extend my gratitude to Dr Hussein Suleman for his support and guidance throughout this project. Dr Suleman also provided all the ETD metadata from NDLTD that was used by the system developed in this paper. The success of this project would not have been possible without him. I would also like to thank all the students that participated in this study.

[2] http://search.ndltd.org

REFERENCES

[1] Maristella Agosti, Franco Crivellari, Giorgio Maria Di Nunzio, and Silvia Gabrielli. 2010. Understanding User Requirements and Preferences for a Digital Library Web Portal. *Int. J. Digit. Libr.* 11, 4 (Dec. 2010), 225–238. https://doi.org/10.1007/s00799-011-0075-7

[2] Maristella Agosti and Nicola Orio. 2012. User Requirements for Effective Access to Digital Archives of Manuscripts. *Journal of Multimedia* 7 (04 2012). https://doi.org/10.4304/jmm.7.2.217-222

[3] Bootstrap. 2021. Build fast, responsive sites with Bootstrap. Retrieved September 18, 2021 from https://getbootstrap.com/docs/5.0/getting-started/introduction/

[4] Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology* 3, 2 (2006), 77–101. https://doi.org/10.1191/1478088706qp063oa arXiv:https://www.tandfonline.com/doi/pdf/10.1191/1478088706qp063oa

[5] George Buchanan, Sally Cunningham, Ann Blandford, Jon Rimmer, and Claire Warwick. 2005. Information Seeking by Humanities Scholars. *Research and Advanced Technology for Digital Libraries: 9th European Conference* 3652, 218–229. https://doi.org/10.1007/11551362_20

[6] Vannevar Bush. 1945. As We May Think. *The Atlantic Monthly* 176, 1 (July 1945), 101–108. https://www.theatlantic.com/magazine/archive/1945/07/as-we-may-think/303881/

[7] The Apache Software Foundation. 2021. Solr. Retrieved September 16, 2021 from https://solr.apache.org/

[8] Edward Fox, Hussein Suleman, Remesh Gaur, and D Madalli. 2003. Design Architecture: An Introduction and Overview, Design and Usability of Digital Libraries: Case Studies in the Asia Pacific. *Information Science Publishing* (2003), 22–37.

[9] Susan Jamieson. 2004. Likert scales: How to (ab) use them? *Medical education* 38, 12 (2004), 1217–1218.

[10] E Kani-Zabihi, G Ghinea, and S Chen. 2006. Digital libraries: what do users want? Digital libraries: what do users want? Digital libraries: what do users want? Digital libraries: what do users want? Digital Libraries: what do users want? *Online Information Review* 30, 4 (2006), 395–412.

[11] Norbert Lossau. 2004. Search engine technology and digital libraries-libraries need to discover the academic internet. *D-Lib magazine* 6 (2004).

[12] Arnold M Lund. 2001. Measuring usability with the use questionnaire. *Usability interface* 8, 2 (2001), 3–6.

[13] NDLTD. 2021. Global ETD Search. Retrieved September 9, 2021 from http://search.ndltd.org/

[14] Michael Seadle and Elke Greifeneder. 2007. Defining a digital library. *Library Hi Tech* 25 (06 2007), 169–173. https://doi.org/10.1108/07378830710754938

[15] Hussein Suleman. 2011. Interoperability in digital libraries. In *E-Publishing and digital libraries: Legal and organizational issues*. IGI Global, 31–47.

[16] Hussein Suleman and Edward Fox. 2001. The Open Archives Initiative. *Journal of Library Administration* 35, 1-2 (2001), 125–145. https://doi.org/10.1300/J111v35n01_08 arXiv:https://doi.org/10.1300/J111v35n01$_0$8

[17] Mark S. Sweetnam, Maristella Agosti, Nicola Orio, Chiara Ponchia, Christina M. Steiner, Eva-Catherine Hillemann, Micheál Ó Siochrú, and Séamus Lawless. 2012. User Needs for Enhanced Engagement with Cultural Heritage Collections. In *Theory and Practice of Digital Libraries*, Panayiotis Zaphiris, George Buchanan, Edie Rasmussen, and Fernando Loizides (Eds.). Springer Berlin Heidelberg, Berlin, Heidelberg, 64–75.

[18] John V.Lombardi. 2000. Academic Libraries in a Digital Age. *D-Lib Magazine* 6, 10 (2000), 1–7.

A EXPERIMENTAL DESIGN

A.1 Research Measures

Table 3: Questionnaire Items with results for each item

ITEM	$\bar{x}$	M	σ
USEFULNESS			
1. It helps me be more effective	8.03	8	1.59
2. It helps me be more productive	8.03	8	1.50
3. The private user lists are useful	8.83	9	1.20
4. The public user lists are useful	8.79	9	1.59
5. It gives me more control over the activities in my life	6.52	7	1.66
6. It makes the things I want to accomplish easier to get done	7.79	8	1.61
7. It saves me time when I use it	8.62	9	1.29
8. It meets my needs	8.24	9	1.46
9. It does everything I would expect it to do	7.93	9	2.09
EASE OF USE			
10. It is easy to use	8.76	9	1.50
11. It is simple to use	8.62	9	1.68
12. It is user-friendly	8.21	8	1.74
13. It requires the fewest steps possible to accomplish what I want to do with it	8.59	9	1.90
14. It is flexible	8.03	9	2.08
15. Using it is effortless	8.21	9	1.72
16. I can use it without written instructions	8.10	9	2.21
17. I don't notice any inconsistencies as I use it	8.41	9	2.47
18. Both occasional and regular users would like it	8.24	9	1.81
19. I can recover from mistakes quickly and easily	8.41	9	2.03
20. I can use it successfully every time	8.90	9	1.35
EASE OF LEARNING			
21. I learned to use it quickly	9.34	10	1.08
22. I easily remember how to use it	9.62	10	0.73
23. It is easy to learn to use it	9.21	10	1.29
24. I quickly became skillful with it	9.14	10	1.19
SATISFACTION			
25. I am satisfied with it	8.72	9	1.51
26. I would recommend it to a friend	8.62	9	1.90
27. It is fun to use	7.59	8	1.97
28. It works the way I want it to work	8.24	9	1.70
29. It is wonderful	7.90	8	1.80
30. I feel I need to have it	7.24	8	2.42
31. It is pleasant to use	8.21	9	1.54

A.2 Instruction Set

Below is the instruction set given to the test participants to follow below answering the questionnaire shown in A.1:

This system allows users to add resources to different reading lists (or user lists) and share them with other users. The below instructions are slightly repetitive but aim to give you a good idea of how the system operates.

(1) Navigate to http://20.87.26.56:8080/ResearchWorkbench
(2) Create a user profile.

Now imagine you are performing research on anything to do with computers.

(3) Search "computer" in the search field and select one of the top 5 results
(4) Click one of the user lists and skim through the titles shown.
(5) Add at least 3 of the ETDs to a list of your own. You may choose whether you would like it to be public or private. Bookmark some of the items as well.

Now imagine you are performing research on neural networks.

(6) Select Menu and go back to the Search page.
(7) Search "neural networks" and select one of the top 5 results.
(8) Select one of the user lists and skim through the titles shown.
(9) Add 2-3 of the items to a new user list of your own and bookmark some of the items you come across by making use of the bookmarking feature.
(10) View the items you have bookmarked so far by navigating via the Menu.

Finally, imagine you are performing research on digital libraries.

(11) Navigate to the search page and search "digital libraries".
(12) Select one of the top results. If the paper isn't contained in any other user lists, choose another search result.
(13) Select one of the user lists and skim through the titles shown. Bookmark some more items if you like.
(14) Navigate to your User List page via the Menu. Here, you are able to see the lists you have created, and the items you have added to each list

Optional: Feel free to make use of the reading list feature to make your own lists and manage them.