UNIVERSITÀ DEGLI STUDI DI TRENTO

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# Context

## in learning, organizing and sharing information

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# Abstract

*In the digital era, users face a new challenge to study, organize and find information they need in a time-efficient and effective manner. Recent studies have shown that success in doing such tasks depends more on human memory than semantically filtering and re-organizing digital information. As demonstrated by commercial and prototypical Web tools, context seems to play an important role in helping users memorize cues in various user scenarios. While these results are encouraging, there is not yet sufficient understanding of which type of context is useful for which situations. In this thesis, we explore the impact and the role context plays under three different perspectives. First, we examine how allowing users to add their impressions and interpretations of digital learning materials via multimedia annotations influences their learning. Secondly, we collect and analyze the types of context users add and use to organize and retrieve their personal bookmarks. Then lastly, we investigate how a customized set of user contextual tags can aid a targeted set of users to help search and find information easier and faster in a community.*

**Keywords**

Multi-modal learning, Personalized learning, Contextual metadata, Personal information management, Collaborative tagging, Community search, Human-computer interaction

# Contents

**1 Introduction** **1**
1.1 The Context . . . . . . . . . . . . . . . . . . . . . . . . . 1
1.2 The Problem . . . . . . . . . . . . . . . . . . . . . . . . 3
1.3 The Solution . . . . . . . . . . . . . . . . . . . . . . . . 4
1.4 Innovative Aspects . . . . . . . . . . . . . . . . . . . . . 5
1.5 Structure of the Thesis . . . . . . . . . . . . . . . . . . . 5

**2 State of the Art** **7**
2.1 Human memory and its link to context . . . . . . . . . . . 7
2.1.1 Memory creation for learning . . . . . . . . . . . . 8
2.1.2 Memory retention for information search and retrieval 9
2.2 Definition of Context . . . . . . . . . . . . . . . . . . . . 11
2.3 Context in learning digital contents . . . . . . . . . . . . . 13
2.3.1 Annotations and their role in learning . . . . . . . . 14
2.3.2 Electronic annotations . . . . . . . . . . . . . . . . 15
2.4 Context in organizing and re-finding web contents . . . . . 19
2.4.1 Web re-visitation and re-finding techniques . . . . . 19
2.4.2 Role of context in re-finding . . . . . . . . . . . . . 23
2.4.3 Types of context . . . . . . . . . . . . . . . . . . . 25
2.4.4 Application of context in PIM and Web tools . . . 29
2.5 Context as metadata tags for information search . . . . . . 34
2.5.1 Social tagging for resource sharing . . . . . . . . . . 34

2.5.2 Folksonomy vs Ontology tags . . . . . . . . . . . . 36
2.5.3 Tags as search metadata . . . . . . . . . . . . . . . 39

**3 The Problem** **44**

**4 Q-Book: context in learning digital contents** **47**
4.1 Intro and detailed problem description . . . . . . . . . . . . 47
4.2 Q-book architecture and implementation . . . . . . . . . . . 50
4.2.1 Q-book Interface . . . . . . . . . . . . . . . . . . . . 51
4.2.2 Q-book: Supported e-book format . . . . . . . . . . . 52
4.2.3 Q-book: Implementation . . . . . . . . . . . . . . . . 53
4.3 Q book experiment and its results . . . . . . . . . . . . . . . 54
4.3.1 Methodology . . . . . . . . . . . . . . . . . . . . . . 54
4.3.2 Results Analysis . . . . . . . . . . . . . . . . . . . . 58
4.4 Related work . . . . . . . . . . . . . . . . . . . . . . . . . 65

**5 MemoryLane: context in organizing and retrieving bookmarks** **69**
5.1 Intro and detailed problem definition . . . . . . . . . . . . . 69
5.2 MemoryLane - tool description . . . . . . . . . . . . . . . . 70
5.2.1 User interfaces . . . . . . . . . . . . . . . . . . . . . 71
5.2.2 Architecture and implementation . . . . . . . . . . . 75
5.3 Memorylane experiment and its results . . . . . . . . . . . . 77
5.3.1 Methodology . . . . . . . . . . . . . . . . . . . . . . 77
5.3.2 Results analysis . . . . . . . . . . . . . . . . . . . . . 79
5.4 Related work . . . . . . . . . . . . . . . . . . . . . . . . . 94

**6 Learnweb: context in searching shared materials** **104**
6.1 Intro and detailed problem definition . . . . . . . . . . . . . 104
6.2 Metadata useful for search: teachers' perspective . . . . . . 106

6.2.1 Teachers' search pattern and decision-making strategy 106
6.2.2 Categorization of resources to facilitate search . . . 107
6.2.3 Comparison to Learning Object Metadata (LOM) . 108
6.3 Prototype: redesigning and implement the new interface to facilitate search . . . . . . . . . . . . . . . . . . . . . . . . . 111
6.3.1 Interface: Eliciting desired types of metadata . . . 112
6.3.2 Interface: Visualization of contextual metadata for search . . . . . . . . . . . . . . . . . . . . . . . . 113
6.3.3 Implementation . . . . . . . . . . . . . . . . . . . . 116
6.4 Learnweb experiment and its results . . . . . . . . . . . . . . 117
6.4.1 Methodology . . . . . . . . . . . . . . . . . . . . . 118
6.4.2 Datasets . . . . . . . . . . . . . . . . . . . . . . . . 120
6.4.3 Result analysis . . . . . . . . . . . . . . . . . . . . 121
6.5 Related work . . . . . . . . . . . . . . . . . . . . . . . . . . 130

**7 Conclusion** **132**

**Bibliography** **136**

# List of Tables


2.1 Definitions of Context and its Scope . . . . . . . . . . . . . 13
2.2 Different Categorization Schemes of Tags by Various Researchers . . . . . . . . . . . . . . . . . . . . . . . . . . . 34
2.3 Context-based Tools . . . . . . . . . . . . . . . . . . . . . 43

4.1 Student group composition . . . . . . . . . . . . . . . . . . 57
4.2 Questionnaire Results per Dimension . . . . . . . . . . . . 60
4.3 T-test results of test group and control group (The max test score is 10. Students who score below 6 are considered having failed) . . . . . . . . . . . . . . . . . . . . . . . 61
4.4 Test scores and number of annotations of test group . . . 63
4.5 Pearson Correlation Coefficient per Annotation Type . . . 65

5.1 MemoryLane: Elements of Bookmark Dialog . . . . . . . 100
5.2 Mapping of Tag Classification by Bischoff et al. to that of MemoryLane [63] & Data Extraction and Selection . . . . 101
5.3 MemoryLane: Implementation Details . . . . . . . . . . . 101
5.4 Stage I: Online Survey Questions . . . . . . . . . . . . . . 102
5.5 Stage II: Premeditated Questions Given to 6 Participants 102
5.6 Online Survey: Perception of Importance per Type of Information for Recall . . . . . . . . . . . . . . . . . . . . . 102
5.7 Usage of Contextual Cues per Category of Collected Bookmarks . . . . . . . . . . . . . . . . . . . . . . . . . . . 103

5.8 Retrieval Success Rate per Quality of Semantic Information Recalled . . . . . . . . . . . . . . . . . . . . . . . . 103
5.9 Comparison of MemoryLane and Chrome Bookmarking Tool in Retrieval Time and Success Rate . . . . . . . . . . . . 103
5.10 Comparative ranks of metadata types by perception, by actual usage (including results from [17]) and as retrieval cue 103

6.1 Categorization of resource suggested by teachers from YELL/TELL community on Learnweb . . . . . . . . . . . . . . . . . . . 108
6.2 Comparison of LOM and Categorization of resource suggested by teachers from YELL/TELL community . . . . . 110
6.3 Metadata support on old interface Vs. new interface . . . 112
6.4 Instructions for Task 1: Search and tag resources from the Web . . . . . . . . . . . . . . . . . . . . . . . . . . 120
6.5 Instructions for Task 2: Search and tag resources shared by others . . . . . . . . . . . . . . . . . . . . . . . . . . 120
6.6 Instructions for Task 3: Search and tag your own resources 121
6.7 Instructions for Task 4: Tagging resources provided in a test group . . . . . . . . . . . . . . . . . . . . . . . . . . 121
6.8 User action logs of new interfaces . . . . . . . . . . . . . . 122
6.9 User action logs collected during and after pilot . . . . . . 122
6.10 User action logs collected for tags and comments . . . . . 123
6.11 User metadata added for new and existing resources . . . 123
6.12 Post-pilot User Log Profile . . . . . . . . . . . . . . . . . 124
6.13 Ranks of metadata added by users Vs. those used for search 127
6.14 Tags and comment logs collected post-pilot . . . . . . . . 129
6.15 Comparison of ratios per user . . . . . . . . . . . . . . . . 129

# List of Figures


2.1 Moon reader pro - Interface . . . . . . . . . . . . . . . . . . 17

4.1 Brain-study Interface [94] . . . . . . . . . . . . . . . . . . . . 47
4.2 Apple iBook Interface with rotating 3D image . . . . . . . 48
4.3 Q-book: Main interface . . . . . . . . . . . . . . . . . . . . . 52
4.4 Q-book: Video annotation of selected text . . . . . . . . . . 53
4.5 Test scores of Test Group (with the tool) . . . . . . . . . . . 60
4.6 Test scores of Control Group . . . . . . . . . . . . . . . . . . 61
4.7 Scattered graph of # of annotations (X axis) and test scores(Y axis) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 62
4.8 Percentage of annotations per type . . . . . . . . . . . . . 64
4.9 Annotation Studio Interface . . . . . . . . . . . . . . . . . . 67

5.1 MemoryLane: Concept . . . . . . . . . . . . . . . . . . . . . 71
5.2 MemoryLane: User Interface of Bookmark Dialog . . . . . 72
5.3 MemoryLane: User Interface of Keyword Search . . . . . . 72
5.4 MemoryLane: User Interface of Category Navigation . . . 73
5.5 MemoryLane: User Interface of Location Navigation . . . . 74
5.6 MemoryLane: User Interface of Image Navigation . . . . . 74
5.7 MemoryLane: Architecture . . . . . . . . . . . . . . . . . . . 76
5.8 Bookmark Collection: Number of Bookmarks per Metadata Type . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 81
5.9 Numer of Bookmarks with Goal per Category . . . . . . . 82

5.10 Numer of Bookmarks with Emotion per Category . . . . . 83
5.11 Numer of Bookmarks with Location per Category . . . . . 84
5.12 MemoryLane: Usage of Semantic and Contextual Cues Used for Retrieval . . . . . . . . . . . . . . . . . . . . . . . . . 88
5.13 Usage of Contextual Cues Used for Retrieval per Gender . 90
5.14 Performance in Time for Successful Retrievals . . . . . . . 92

6.1 The search and decision process of selecting teaching materials 107
6.2 The base schema of Learning Object Metadata . . . . . . . 109
6.3 Percentage of usage of different LOM data elements in GLOBE [105] . . . . . . . . . . . . . . . . . . . . . . . . . . . 111
6.4 The comparison of the old and new interface for adding metadata (tags) to a new resource . . . . . . . . . . . . . . 113
6.5 Adding metadata to existing resources shared by others . . 114
6.6 Old interface of search result . . . . . . . . . . . . . . . . . 115
6.7 New interface of search result . . . . . . . . . . . . . . . . 116
6.8 Metadata filters on new search interface . . . . . . . . . . . 117
6.9 Category navigation interface . . . . . . . . . . . . . . . . 118
6.10 Metadata Ratio per Resource . . . . . . . . . . . . . . . . 125
6.11 Contextual metadata type (in %) Post-pilot Vs. Pilot . . . 126
6.12 Metadata filter search by type . . . . . . . . . . . . . . . . 127

# Chapter 1

# Introduction

The personal computers, the Web and the Internet have transformed our lives in the most drastic ways in a blink of an eye. Even within a single generation, we are constantly asked to streamline our daily lives with the latest "technologies" both at work and home: there are digital books one can view anywhere on multiple devices, search engines that can find anything from anywhere in the world and social platforms that allow us to connect with anybody from all the walks from our lives or even find new people who share the similar interests. While such technologies have offered us a number of benefits (i.e. portability, accessibility, connectivity, etc), one may ponder how well these technologies support users in performing their key activities once carried out with print materials such as learning, organizing and searching information. The best way to answer the question would be to turn the attention first to ourselves and understand how we process information in our natural computers - a.k.a our brains.

## 1.1 The Context

According to various prominent researchers in the cognitive science [108, 27], our brains create and retain information in multi-dimensional ways: each information acquired is encoded along with contextual information in which such acquisition takes place and this context is indexed in such a way that the main information acquired can be effectively retrieved by contextual cues at a later time. Some studies [25, 131] have hinted that the success of retrieving information may hinge on our memory, rather than the semantic filtering or organizing that most tools offer. Context has been shown to play an important role in helping users to retrieve memory in various scenarios and thus in fact has been applied to varying degrees in many tools of today.

In learning, context can be expressed through text annotations users scribble on the margins of print materials. Such act of making annotations is a method by which users build personal connections with the given information, which in return results in active learning and longer memory retention as claimed in [76, 23]. A great number of annotation tools exist for digital materials. Users are allowed to highlight or add notes to Web pages or electronic books and these annotations can be shared with others and be accessed through multiple devices any time or at any place. Recent technologies also make it possible to add multimedia contents to digital materials that can render learning experiences richer.

The impact of context extends to information retrieval. One of the most challenging aspects of "keeping up with the Web" is to manage the information we have found useful in order to refind them with minimal efforts when needed. Users have been repeatedly observed to revisit information seen before on the Web [128, 131, 73] and apply various refinding techniques such as using history, bookmarking, url auto-completion or even searching again [103, 65, 10]. While bookmarking is still the most common way of preserving information found on the Web, the actual usage of bookmarks as the re-finding method has remained low [103, 65, 10]. Refinding requires finding a specific piece of information in a large pile of ever-expanding number of sites. The natural decay in human memory over time renders it even more difficult as users tend to forget crucial hints that can lead them back to where they were [131, 39, 104]. To remedy this problem, context has been offered as the additional retrieval cue in numerous information search and retrieval systems in the recent years [42, 6, 45, 36, 129, 142, 68, 55, 30].

The context is not always exclusively personal as one might assume. A group of users who share the same interests or professional goals can have a collective context that can have impact on their information needs. The emergence of the "Social" Web has made it trivial for people to share their digital resources with others. Thanks to this phenomenon, the problem of indexing and organization online resources became even greater in scale. "Social tagging" became the go-to solution by which users could add any number of keywords to their resources as they would like, making it possible to search shared information via multiple paths. Though free-form tagging gives users unlimited freedom and flexibility, using such tags for search has been somewhat proven challenging since they come with no structure or relations to use them as index. There have been efforts to organize these tags in semantically meaningful way to use them for search though ontology [22, 21, 52]. However, some recent studies interestingly showed that some of these tags were contextual in nature (i.e. not directly related to the content of the resources) that can be used for search and hence need to be encouraged [17, 47, 119].

## 1.2 The Problem

As we discussed so far, context plays an important role in cementing or retrieving memory and thus has been applied in various forms and depth to improve key activities we perform with digital resources. There are tools that can support users in making annotations across devices, those that use contextual information such as location or time to help users organize their personal digital resources, and lastly those that allow users to index their resources using their own words (tags), which in return are used for the good of community to improve collective search experiences. Nevertheless, there seems to be lack of empirical evidence on what types of context should be used, how they are perceived by the users, how they should be supported or to what extent or under which circumstances using such context is actually useful. Specifically, we are interested in finding out how context influences - positively or negatively - learning for academic purposes, searching and refinding information both for personal and community-based interests.

## 1.3 The Solution

To investigate the role and impact context plays in three different scenarios - learning, refinding and searching information with digital materials, we have developed three different prototypical tools. Each of the tool was designed and developed based on the research on the relevant areas to address the questions posed in the problem. The first prototype, Q-Book, was developed to investigate the impact of contextual multimedia annotations have on learning outcomes when users are given the free choice to build the personal connections with the text. User experiment with 36 high school students, divided into test and control group for comparison, was carried out. The second prototype, MemoryLane, addresses the problem of using context as retrieval cues for personal bookmarks. The tool allowed users to add various types of context such as location, goal (task), people as well as emotion when they are bookmarking. Furthermore, the tool indexed the bookmarks by these contextual metadata so that users could search or filter bookmarks based on what they remember in the long run. User survey with 120 people and an in-depth experiment with 10 people were carried out. We collected 160 bookmarks and analyze data to provide insights into the types context users used to organize and retrieve their bookmarks. Lastly, we re-designed online resource-sharing platform, LearnWeb, to provide re-vamped user interfaces to allow users to add contextual metadata to shared resources. The requirements were empirically gathered through user interviews and observations and we implemented such findings as new functions. An experiment with 40 users were carried out as pilot and we analyzed the data to find out the types of contextual metadata most appreciated and actually used by the community users in search.

## 1.4 Innovative Aspects

Although there have been diverse studies on the impact of context in various areas in computing, our work is unique in having provided a comprehensive study on the role and impact of context in dealing with digital contents under various scenarios. To our best knowledge, this is the first study that developed prototypical tools to investigate the role and impact of different types of context have on the performance of key activities users carry out. Our experiment results, albeit preliminary, could be used as a design guide for improving existing online learning tools and information search in both personal and community-wide scope.

## 1.5 Structure of the Thesis

This thesis is organized as follows: Chapter 2 provides the literature review with the focus on the role of context in human memory and how it has been applied to support learning, refinding and searching information. In Chapter 3, we lay out the problem we will address in this thesis. Next three chapters discuss each experiment that was carried out. Chapter 4 provides the details of user experiment undertaken with Q-book and its result analysis. The experimentation with MemoryLane bookmarking tool is explained in Chapter 5. The new interfaces to support contextual metadata search in teachers' community and the experiment results are discussed in Chapter 6. Lastly, we revisit the key findings from our experiments and provide conclusion in Chapter 7.

# Chapter 2

# State of the Art

Since the advent of the affordable personal computers, a great part of our daily lives has transitioned to performing daily activities with digital materials. The subsequent arrival of Internet saw the explosion of user services offered on the Web, turning every aspect of our lives into that of digital. Nowadays, it is virtually inconceivable to imagine a life without doing stuff online, be that social, academic, or work activities.

All the services on the Web are essentially created to enable us to perform daily tasks in a more efficient and effective way, attempting to emulate the work our brains are doing behind the scene. Especially, the need to provide appropriate support for key activities we carry out in the digital era - learning, searching and re-finding information - is paramount. In this section, we provide the literature review on how our brains learn, retain and search information with the focus on the role of context and then further investigate how the context has been applied to online learning, searching and re-finding information in personal and community-based scenarios.

## 2.1 Human memory and its link to context

One could argue that computer systems are designed to mimic the functions our brains perform. Human brains execute vital functions for our survival, ranging from physiological functions such as motor control to abstract ones like perception and thought. We rely heavily on the intricate workings of our brains, especially on its information-processing capabilities that allow us to learn new things and retain them as memories for search and retrieval at a later time. According to [5], the human brain still supersedes computer systems thanks to its memory capacity because our brains do not work by doing a string of complex calculations to solve a problem - as we understand what computers do - but rather map the problem to the reservoir of existing ones in memory to find solution. This brings up an intriguing problem of better understanding how new memories are created and how to retain them better for future use and applying it in digital information era in which we thrive in.

### 2.1.1 Memory creation for learning

Learning is essentially creating new experiences (memories) via information passed through synapses to neurons in our brains. The number of synapses that are linked to the particular neuron(s) where the new experience is stored determines how easily it can be retrieved for re-use. The effective learning does not happen just by seeing, hearing or touching but more a combination of all sensory inputs plus the person's pre-existing experiences that can be linked to the new experience [28].

This multi-modal process of learning is not a new revelation. Even as early as back in 1971, Allan Paivio argued that human brain represents information in more than one way, that is in verbal and visual form [108]. This theory was coined as "Dual Coding Theory", which has set the tone for multi-modal learning. Subsequently he published a research paper on the impact of Dual coding theory on education where he postulated that the associative processes of verbal and imagery play a crucial role in comprehension and learning [27].

In other words, we learn better if we have more synapses that connect to the new concepts we are learning: we not only learn by verbal cues (e.g. words) but also by other cues received from our sensory organs such as seeing or feeling that are present concurrently. The positive results of multi-modal learning are not eye-opening if we consider the multi-sensory environment we are constantly exposed to.

Notwithstanding the promising effects of multi-modal learning, multi-sensory stimuli do not always produce the desired effect. If learners fail to make association of the new concept to the existing ones (e.g. failure to connect the given image to the word), it brings adverse results in recalling [115]. All the previous experiences of each person may vary and therefore learning outcomes could be different when people are given the same information to be learned. This set of unique personal experiences constitute the personal "context" by which each person can create his or her mental representation of the new knowledge that comes linked to the previous one(s).

In digital era, the effective memory creation for learning new knowledge may depend on how well users are supported in establishing this personal "relationship" with the digital contents. Probably the best way to do this is to allow users to choose their own relevant information and have its context mapped to the new information presented for learning.

### 2.1.2 Memory retention for information search and retrieval

In the previous section, we provided insight into the creation of the memory and its relation to learning: the more synapses are created to the memory cell, the more effective learning occurs. However, using the brain space to create a new memory block and not to be able to retrieve it would be pointless. Effective learning is tightly related to the ability to retrieve it at a later time. In fact, the new synapses created to link to the memory cell are to be used for subsequent retrievals. Recent studies surprisingly pointed out practicing retrievals enhance learning better than other encoding techniques [67].

Then how do we retrieve memory? In order to understand how memories are retrieved, we first need to examine the types of memories and how they are triggered. Tulving postulated that memories are made up of two different but not disparate types: the first is the *semantic* memory while the other is *episodic* memory [135]. Semantic memory is the memory "necessary for the use of language" [135]. In other words, semantic memory deals with the mental representations of the knowledge perceived and thought. Suppose we meet a new person, the person's name and the topics of conversation would belong to this category. On the other hand, episodic memory deals with the autobiographical events and temporal-spatial relations among the events [135]. Going back to the analogy above, the purpose of the meeting, the person's clothes, the smell of his or her perfume, the weather and place where the meeting happened will be stored alongside the semantic information.

Episodic memory at a glance may not seem as important or relevant to the semantic knowledge being acquired. However, it has been shown to play a significant role as an effective retrieval cue. Encoding specificity principle [136] states that memory retrieval is improved when the same information is available at encoding is also available at the point of retrieval. In other words, these two seemingly disparate types of memory - semantic and episodic - are intertwined at the point of encoding thus making it possible to retrieve semantic information if episodic information is available. This point of view is reflected in a paradigm called *Context-dependent memory*, which argues that context - temporal, spatial or meaningful in nature - is stored along with target information and hence be used as effective retrieval cues [53].

## 2.2 Definition of Context

We have laid the ground argument that context is paramount to creating and retaining memory but, before we go into the details of how context may influence positively some of key activities we perform, it is necessary to first provide the various definitions of context and which definitions have been applied to this research work. Context is multidisciplinary in nature and can be generally thought to mean the surrounding situations in which a person gains new experience or carries out an activity. However, it is far from that simple. During past decades, prolific definitions and categorization schemes of context have been offered by various scholars [3, 35, 46, 89, 117]. It is not in the scope of this research to cover them all. Instead, we will focus on a few relevant ones in the context of information and computing systems to set the stage for the research work discussed in this thesis. At the very first workshop on Mobile Computing Systems and Applications in 1994, Schilit et al [117] defined the context as "where you are, who you are with, and what resources are nearby". This definition describes context as an collection of external factors regardless of who the actor (you) is. Context, on the other hand, may mean different things depending on the main involved entity or actor. For example, [46] divides context into four distinct categories based on who the actor/entity is.

- User context - contexts describing a user's situation
- Document context - contexts describing a document's situation
- Software context - contexts describing a software's situation
- Network context - contexts describing a network's situation

In this research work, we would be focusing on the user interaction with the digital contents; therefore the definition of context would remain within that of aforesaid "user context" and "document context". When it comes to the interaction between computer systems and users, these two types of contexts are often intertwined depending on the purpose of the interaction, albeit different weights given to one another. For instance, when a user needs to retrieve information seen previously over a prolonged time period, he or she may not recall the context describing the web page (e.g. keywords) but remember the surrounding internal and external factors of the given episode such as “why” or “where”, giving more significance to the user context defined above. However, when a user is dealing with a new digital material to study or to share it with others, the document context may take precedence to describe the document at hand via subjective or objective annotations.

As context can be of numerous types, each type of context can contain several categories. Probably the most commonly applied is the one proposed by Abowd et al. [3]. In their work, they divided context into components of an episode (what, where, when, who and why) and defined that any information out of these categories that can used to characterize the situation is the context of the given system. This categorization scheme has been adopted for the organizing and refinding scenario because the schema considers context inherently episodic that meets the our needs. The second categorization scheme by [89] offers an interesting aspect of context. They claim the human cognition of the context should be considered and become a part of context categories. Each individual or a community may maintain a unique view of the objects which affects the objective contexts defined previously. For learning and searching scenarios of this research, we highlight the role of context in augmenting the metadata of the given contents through personalization / customization per the needs of a community. The second categorization offers the extension of context for our first and last experiments.

Context-aware systems are defined as the systems that use context to render relevant information or services based on its relevancy to the user's task [35]. Staying true to this definition, we have designed three prototypical tools starting from the user's task to choose the right type of context that deemed most relevant instead of choosing the context first then try to apply it to the tools. Since three experiments presented in this research work serve their own distinctive purposes, the context used in each scenario includes different features of context-awareness.

Table 2.1 describes the scope of context used for each scenario and how they were presented in the prototypical tools.

Table 2.1: Definitions of Context and its Scope

| **Scenario** | **Context Type** | **Context Category** | **Purpose** | **Tool service** |
|---|---|---|---|---|
| Learning digital contents | Document context | Cognitive [89] | Personalization, Creativity, Richer experience to enhance memory | Multimedia annotations |
| Organizing and refinding | User context | Episodic [3] | Personalized metadata to encapsulate episodes | Contextual metadata tags |
| Searching and sharing | Document context | Cognitive [89] | Tailored metadata for communal interests | Cognitive-driven metadata for teaching materials |

## 2.3 Context in learning digital contents

As mentioned in section 2.1.1, learning is not a straightforward process of simply memorizing the given piece of new information but a complicated one that involves one's past experiences and contextual input from the surroundings. Most typically learning entails studying written information on a piece of paper in an academic setting like in a school but the transition from paper-based to digital contents allowed us to access the materials anytime and anywhere thanks to the Internet and the Web. In this section, we discuss how this transition has affected our way of learning from written materials and how new tools have been developed to support users in the transition. In particular, we focus on the role of annotations in learning as a way of building personal (contextual) relationships with the given content and the current state of the available annotation tools.

### 2.3.1 Annotations and their role in learning

All of us have, at one point or another in the course of our lives, scribbled in the margins of books or highlighted text that was meaningful or important. Formally this set of activities is called "text annotation" which dates as far back as around 1000AD when it became a prominent activity in Talmudic commentaries and Arabic rhetoric treaties [140]. Unarguably text annotation has a number of significant benefits. Harvard Library recommends annotations as one of the six reading habits to develop during the first year because they are the essential mechanism by which one can learn to read critically [76]. Studies have shown that annotations have a big impact on learning personally or in groups at large. Brown and Smiley have demonstrated that students who make annotations study text better [23]. The benefits of annotations also extends to collaborative learning when shared with others [84].

Unlike how most people perceive, annotation is not limited to highlighting and adding notes. A more broader range of pre-reading, while-reading and post-reading activities are involved in annotating text. Annotating text brings readers to have an active conversation with the text: annotation requires readers to build personal relationship with the given information and thus helps to reach a deeper level engagement. According to Porter-O'Donnell, the annotations are the "viable record of the thoughts that emerge while making sense of the reading" [111]. In a sense, the effectiveness of annotations stems from the fact that these are highly subjected to the interpretations and views of the person who is interacting with the text. Simply considering annotations as a way of writing down the definition of a term or highlighting keywords would not allow the full potential of annotations in creating strong contextual connections to readers or in storing the new knowledge in memory.

### 2.3.2 Electronic annotations

We have so far discussed how annotations make profound positive impact on learning. The advent and growth of digitalized contents and books are bringing changes to the way these text annotations are made. Numerous tools have been proposed and made available both as standalone and web-based applications, which allow users to highlight text, append notes and comments and sharing their annotations with others.

The quest for meeting the need for annotation tools on digital contents started as early as in 1998. Schilit introduced a prototypical tool called XLibris, a tablet-like device where users can scribble, highlight, circle words on digital documents, using a pen [118]. He focused on providing a tool for users to perform active reading on the computational device which was as close as possible to reading a paper-based document. What was very ahead of time was that the tool automatically extracted annotations and created a "notebook" for users to easily view and search documents based on their annotations.

Schilit's innovative idea may not have seen its heyday at his time but nowadays the most of contents we read and consume are in digital format, thanks to the Web technologies and the availability and affordability of the Internet. Numerous text annotation tools are available commercially to support readers online including portable devices such as tablets and smartphones. The supported content format are also diverse. Pdf, HTML Web pages, e-books are some of most common examples. Adobe reader first introduced annotation tool for its PDF reader where users could highlight or append post-it like notes to the text. More elaborate tools have been developed for Web pages as more and more people turned to the Web as the source of information for study and work.

Diigo [1] is a web annotation / sharing tool which has gained wide popularity among the researchers and schools alike. Initially developed as an online bookmarking tool, diigo has gone through several revamping on its functions to emerge as a powerful annotation tool. Installation is also made easy as users can simply add it onto their favorite web browsers such as Chrome, Microsoft Internet Explorer, firefox and Safari. Once installed, users can bookmark, highlight, add notes to, crop and capture screenshots of any parts of the web pages, which are subsequently archived for later retrieval. Annotations can be shared with other users for collaboration as well. Web page is not the only type of content that can be annotated and shared online. Tools such as A.nnotate [2] allows users to upload documents in pdf or word format and share it with multiple others who can collaboratively annotate the text. A.nnotate offers the common highlighting and adding notes as key features but it also makes annotation possible on images found on documents. There are also annotation tools developed for e-books. E-books have garnered much attention and popularity because of their being more economical, flexible and accessible. Moon Reader [3] is one of such examples. It is rated as the best e-reader on Android and offers multicolor highlighting and adding notes. All saved annotations are retrievable, searchable and sharable with other users. Figure 2.1 shows the snapshot of its interface with annotation functions.

E-books are not only for pleasure reading. Back in 2012, Digital Book World published an article called “Ten Bold Predictions for E-books and Digital publishing”. In the article, it claimed that education administrators and governments who oversee education and the educational publishers are in great favor for e-textbooks even though students were still hesitant to

[1] www.diigo.com
[2] http://a.nnotate.com
[3] https://www.moondownload.com

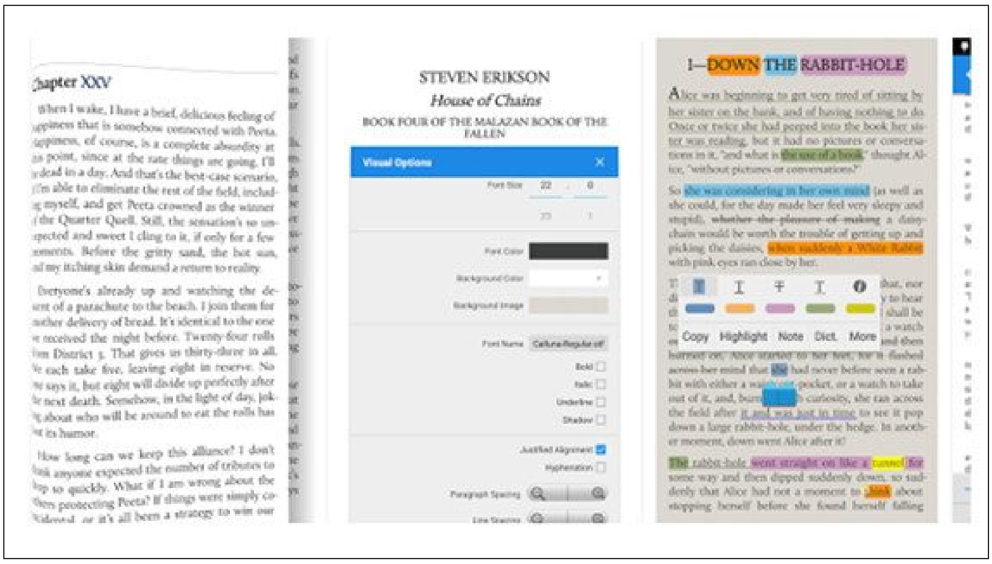

Figure 2.1: Moon reader pro - Interface

using them [51]. In fact, nowadays, most publishing companies offer e-textbooks and some higher education institutions have taken it up as part of their educational method. For example, at Indiana University, more than half of the students at its seven campuses have started their semester with at least one e-textbook loaded in their educational management system's account [100]. They conducted a two-year study of students using e-textbooks and found that students reacted favorably to using e-textbooks compared to paper-based textbooks [32]. Even though in the past years, other studies have claimed that students still prefer paperback textbooks [32, 143, 88], the most recent extensive 4-year study of e-textbooks spearheaded by Educause [4] shows that the use of textbooks has increased, particularly among the young students and that the major barriers to using e-textbooks such as student preference for print and unfamiliarity with e-textbooks show signs of being alleviated [34].

They conducted a large-scale pilot with over 5000 students in 393 under-

[4]Educause: a non-profit U.S. organization whose mission is to promote intelligent use of information technology in education

graduate and graduate programs in 2012. Digital materials were provided by McGraw-Hill publishing company and Courseload provided e-textbook platform for the pilot. One of the main finding from the pilot was that less than one third of the students found e-textbooks more effective than paper-based books even though almost all students (96%) used anotation tools such as highlights and notes while using their e-textbooks [50]. Despite the rather negative perception of e-textbooks as an effective studying medium, the annotation tools seem to affect positively the academic performance. In [33], students who made annotations outperformed those using paper textbooks even though they considered e-textbooks less useful. This result demonstrates that, in order for e-textbooks to be effective, users should be provided with tools well equipped with functions to support studying with digital contents.

As highlighted previously, annotation acts like a bridge between the reader and the text and thus instrumental to effective learning. So far, the annotation tools provided for e-books, including those intended for students, are simply highlighters or support adding notes (e.g. e-textbook platforms by Barnes & Noble, McGrow-Hill, and Pearson publishing houses) even though there are a wide range of annotation activities one can perform as indicated in [111]. Furthermore, annotations do not exclusively need to be restrained to "textual" ones. One of the most obvious advantages of contents in digital format is that the page can contain any format of media, be that an image, video or hyperlinks to other texts, which was not possible with traditional print books. To go beyond being concerned with how to render e-book identical or similar to paper-based books, there is a need for looking into ways to harness the benefits only digitalized contents can provide to students. As briefly touched on in previous section 2.1.1, multi-sensory input can help improve learning. Considering such fact, e-textbooks could provide features to give students freedom to choose and add multimedia annotations as a way to enrich personal and contextual relationship with the text they are studying.

## 2.4 Context in organizing and re-finding web contents

The Web has evolved from being a central, static repository of information to being a dynamic all-purpose toolkit that meets the demands of all sorts of tasks, ranging from finding information to buying products and services or staying updated with news of our interests. While most people consider the Web a vital and credible source, owing to its "easy accessibility, currency, interactivity, and the broad repertoire of information" [10], the sheer size and the complexity of the Web can render organizing and re-finding - retrieving web resources already seen before - challenging. In this section, we present literature review on users' re-visitation behavior and re-finding techniques and how context may be used to alleviate the difficulty of re-finding information on the Web.

### 2.4.1 Web re-visitation and re-finding techniques

One of the most commonly observed user behavior on the Web is that users often revisit information already seen before at various time intervals. Revisiting a website requires re-finding efforts from users' side, which can turn out to be a rather frustrating experience. Thanks to the advance in technology and browser tools, users have espoused techniques to maneuver skillfully in the labyrinth of the Web to their destination. The earliest study was done by Tauscher and Greenburg in 1995, for which they gathered Web usage data from 23 users over the period of 6 weeks. Through the analysis, they discovered that 58% of web pages visited by the participants were revisits [128]. Moreover, their result analysis showed that most page revisits involve pages visited just before, with hyperlinks and the back button as the most popular mechanisms for revisitation [128].

However, a more recent study conducted in 2007 [103] reported a declining use of the back button: according to their analysis, only 14.3% of revisits were carried out by pressing the back button, due to "major changes in browsing strategies" such the use of multiple windows as well as multiple tabs within a single window [103]. The study also provides a classification of revisits based on time and user action: short-term, mid-term and long-term. 72.6% of all revisits were short-term (within an hour), with the back button being the most preferred method, while URL-entry and bookmark selection were the choices for mid-term revisits (within a day). For long-term revisits (after a week or longer), users mainly applied two different strategies: they search the target information again using search engines or they try to find their way back, "re-tracing", from known paths such as search result pages [103].

Similarly, Adar et al. investigated Web revisitation patterns, but on a much larger scale. Not only they observed how people revisit Web pages, but also the types of Web pages they revisit. They analyzed the logs collected from 612,000 users over 5 weeks and identified four different groups of revisitation patterns based on factors like "usage, content, structure, and intent" [7]. According to their analysis, the rapid (short term) revisits exhibit the hub-and-spoke style navigation as in shopping and references sites. The medium group (mid-term) pages were visited hourly or daily and consisted of search engines, popular homepages or those that act as communication portals whereas the slow group (long-term) included pages pertaining to personal interests and sporadic needs for information seen before [7].

Further studies conducted by Kumar et al. showed that regular visits (short to mid-term) made up 31% of the page-views and consisted mainly of revisiting the portals that act as the "entry point" to various types of information. They also postulated that sites delivering content – such as news, multimedia and portals – amounted to 52%, communication 35.5% and search 9% [73].

Based on the results from these studies, we can conclude that re-visitation is a vital part of users' Web activity. Re-visitation does not seem to involve only routine behavior or repetitions of the same tasks, but rather is diversified according to the types of information content and temporal frequency of the need for revisit. The World Wide Web has become a toolkit for users to search, find, book and purchase a multitude of products and services such as hotel rooms, flight itineraries and Christmas presents. However, in contrast to a real-life toolkit, which is of a manageable size, the Web is evolving at a pace users cannot easily cope with and this renders re-finding the same information a challenging, if not outright frustrating, task.

Users interestingly have come up with different types of coping mechanisms for re-finding tasks on the Web. Jones et al. observed how people approached the problem of retrieving the target information and discovered that two methods directly supported by the browser tools (bookmarking and history functions) were least used by the participants [65]. Obendorf et al. arrived at the same conclusion as just 16% of long-term revisits were done via history or bookmarking tools [103]. This is quite in contrast to the fact that most users do create bookmarks when they discover information they find useful or interesting [137]. Surveys done in 1996 and in 2005 both showed that a very high percentage (over 80% [110] and 92.4% [10]) of the respondents kept a list of bookmarks in their primary browser.

The main reason for not using bookmarks stems from the difficulty in locating the information once the collection of bookmarks becomes large and complex. [4] discovered that there is a linear relationship between the number of bookmarks and the elapsed time, meaning that the size of bookmark collection increased over time. In fact, according to a recent survey among 236 experienced web users, 79.2% of respondents had more than 50 bookmarks, with an average of 220 bookmarks and 29.7 folders per user [10]. Bookmarks are typically organized in hierarchical structure but the inherent obscurity, web pages being hidden from the naked eyes, can hamper retrieval efforts. This is caused by folder names that not necessarily fully reflect the content they include, as they assume a one-to-many relationship (i.e. one folder can have many web pages). Using tags may alleviate this problem by allowing multiple keywords to be associated with single web page. Nevertheless, users still seem to experience frustration when revisiting information using tags, as revealed in a study carried out by [26]. They discovered that folders and tags yielded similar retrieval performance and that some users claimed using multiple categorizations like tags "could cause confusion, redundancy, and inefficiency"[26].

Given the results of these studies, it is of no surprise that users tend not to use bookmarks when they need to re-find information seen before. In fact, many users would prefer initiating a new search to re-find their target information to looking for it within their bookmark collection [121]: strikingly, the usage of search engines to re-find the information increased in accordance with the amount of time elapsed since the discovery of information [7]. Indeed, Teevan et al. analyzed 13,060 Yahoo query logs of 114 users over a course of a year and found that 33% of them were repeat queries [131].

Searching for information seen before is not an easy task, however. Search engines are optimized for discovery of new information by shuffling search results frequently, which in return thwarts re-finding old information [103]. A study by Teevan, conducted in 2008, consolidates this finding: through an in-depth study on how people recall, recognize and reuse search results, she discovered that people had a hard time re-finding information and showed low satisfaction with the quality of the results, while spending more time searching [130]. Page revisits are rarely achieved with just one query [73] and the accuracy of queries diminishes over time [131], which hampers re-search efforts even further. Putting this in perspective, researchers in Finland concluded: "It can be almost impossible to remember the exact query that was used when a specific piece of information was found" [10].

More recently, Pu and Jiang compared the performance of information finding and information refinding in an experiment with nine users. The results indicated that users performed more trial searches and modified search terms more often while refinding than they did while searching for new information [113]. Additionally, the performance of refinding was found lower than that of finding when the search topics were work-related or not familiar to users [113].

This calls for Web tools to refocus on difficulties faced during long-term refinding tasks. Though it constitutes a small part of page revisits, these long-term revisits are considered "very important" and the failure of refinding them poses as "severe problem" to users [103]. Currently available tools such as Re:Search [129] are helpful as they exploit previously visited Web pages, search queries or user activities as contextual cues to lighten the cognitive burden of refinding. However, they are more suitable for short to medium-term refinding, given that all Web history or search queries would need to be cached, unless there would be an 'oracle' that could reliably predict whether a page would be revisited or not [109].

### 2.4.2 Role of context in re-finding

Thanks to the advances in search engines such as Google, finding information on the Web has become rather trivial through query-based interface and linear result lists [48]. Nevertheless, re-finding specific information seen before has remained a challenge as it demands both "recognition" and "recall" in our brains [25], turning a "re-finding" problem into a "memory" problem. In fact search engines produce results based on how detailed and accurate search queries are, which makes it difficult for users to re-find information when they no longer remember sufficient details to construct effective re-finding queries. A study done in Japan revealed that re-finding success diminished rapidly after a fortnight due to memory loss [104].

However, not all details are forgotten equally. In our human brains, semantic information is encoded along with surrounding contextual information, which actively participates in the retrieval process. This contextual information forms what's called the "episodic memory", a term coined by the prominent psychologist, Endel Tulving, back in 1972. He claimed that episodic memory is the memory of autobiographical events, which captures the "story" of each slice of the personal time-line, whereas the "semantic memory" is directed at the pieces of knowledge perceived and thought [135]. In other words, human memory works in dual processes, whereby episodic and semantic memory are combined and stored. A year later, in 1973, Tulving and Thomson postulated that what is stored can most effectively be retrieved by how it is encoded: what is stored is not just about what we perceive, but also what we see, hear, think and feel, thus forming an "episode" of personal experience not separate from the semantic knowledge [136]. For example, we may have forgotten the name of a person (semantic memory), but we can surely remember other things about this person, like the style of clothing, what the weather was when you met, activities that you have done together and things you have spoken about (episodic memory). As a matter of fact, several studies have shown that the same applies to searching and retrieving digital information.

According to [70], combining "content" (i.e. keywords) and "context" (i.e. time, location and weather) cues resulted in the best performance after 6 months when users were asked to retrieve some items from their own digital archives. The experiment results also emphasized the importance of context as retrieval cue over time as recalled content cues tended to degrade in accuracy as time went by. Furthermore, simply asking users questions about context cues such as events or emotions seem to enhance the recall of content cues to retrieve the target information [104].

The positive impact of context in information retrieval, as demonstrated in the studies mentioned above, is not a new discovery. Context has been used as an integral tool in information search and retrieval as well as other various fields including linguistics, mobile and pervasive computing and automatic image analysis [98]. As context plays a crucial role in retrieving memory in human brains, it also helps to provide expedient delivery of content relevant to the information needs [46] in information retrieval systems. Despite its apparently significant role in aiding users to re-find information [104, 70], the dynamics of context in such scenario has not been extensively studied: in fact, context comes in various forms and the difference these different types of context make in terms of re-finding is yet to be understood.

### 2.4.3 Types of context

Context is a very multifaceted term and its meaning can vary to a large degree. In this chapter, we focus solely on the aspect of context in terms of its role in **episodic memory of information** seen by users on their electronic devices as discussed in 2.2. Still even in this narrow point of view, context covers a wide spectrum of experiences. Putting the users in the center, context could be divided into external and internal context [112, 54], or into physical and logical context [60].

When applied to information systems, both types of context are often, but not always, saved in the form of automatically generated data (e.g.

timestamp for time, ip address for geographical location) or explicitly provided information (e.g. email subjects that specify a user's current task or a reference to the weather/temperature).

#### External (Physical) Context

External context denotes the environmental factors that are present when users perform their activities. *Location*, *time*, *light*, *sound*, *movement*, *touch*, *temperature* and *air-pressure* are some of the examples from this category [54].

- **Location**: the geographical location is by far the most used context, to the extent that it is not easy to find information search services that do not exploit user's location in the era of pervasive computing. When we apply the concept of location to web resources, however, it could refer to two different things: the current location of the user or the location context addressed by the web content. In our user experiment, we observed that users alternate between these two types of interpretations, depending on the nature of the content and their intention. This will be thoroughly discussed in the subsequent sections. Typically, location is automatically extracted from the IP addresses or the GPS signal, depending on its availability. In addition, users are often encouraged to "verify" the accuracy of such data.

- **Time**: the second type of external content mostly used is the temporal context. Temporal context can be expressed in two ways: a date-time or "categorical scales" [107]. The latter term refers to ways of specifying blocks of time intervals, such as working hours, personal events, and so on. In terms of episodic memory, we tend to remember better the temporal context in series of personal events, rather than the exact date or time. As an example, consider the case of Sarah. She attends a seminar on a Wednesday, the 11th of November and is given several websites that are of interest. She hurriedly copies the urls into her browser or writes them down on a notepad. After 3 weeks, she recalls that she found some interesting websites at the seminar but cannot recall enough to find them again by searching and she has misplaced her notepad. Sarah may have forgotten all about the content of those websites, the day of the week, or the exact date of the seminar, but she probably still remembers that she found those websites during that seminar (a meaningful block of time) after a long time-elapse. Even though it is trivial to get the timestamp to indicate a specific time and date, it is difficult to automatically discern the time blocks that are meaningful to each user without explicit user-input, such as events in calendar.

- **Others**: though used rarely, other types of external context, including temperature, light, audio and motion, are also gaining attention by information system scientists. For instance, [106] designed an ambient-intelligent nurse call system, which uses various devices to evaluate patients' needs based on such context information. Temperature sensors notified nurses if there is a spike in patients' fever and light sensors dim the light if it is considered too bright for the patient. A dedicated badge keeps track of patients and nurses' motion and current locations [106]. With the advent of smart sensors, much of such context can be collected without user's explicit involvement. Nevertheless, it is still to be seen how and if this type of context can be useful for information retrieval on PIM (Personal Information Management) systems or Web tools.

**Internal (Logical) Context**

The internal context is comprised of factors that are at work inside the user's mind. Accordingly to Oppermann, *users' goals*, *tasks*, *work context*, *business processes*, *communication*, and *emotional state* are some of such factors [107]. In other words, the internal context forms the "logical" context and is usually specified by the user or induced from users' interactions with the information system. Unlike external context, internal context has been recognized as substantial and implemented only in recent years.

A pioneer project that makes use of internal context was the Watson Project [24]. The Watson project proactively extracts contextual information about a user's current task by analyzing the document that the user is working on and uses that information to filter relevant content for users' search. Using internal context is, of late, a hot topic among the researchers in the field of context-aware systems. As recently argued by [41], such systems need to move away from harvesting the "easy" contextual information – such as "who", "when" and "where" – and focus on the types of internal context that are difficult to capture (e.g. users' intentions) and that are expected to deliver truly personal and meaningful information.

In spite of its importance, internal context is difficult for systems to capture automatically. Tasks and goals are probably the most popular types of context that systems attempt to capture. Even though some hints can be directly observed from users' interaction with the system, the observations are often far from accurate or complete. For example, Tom is a student studying tourism. He needs to write his term paper on the best vacation places in Europe. He visits the Google search engine and types in queries like “best vacation places in Europe”. The system will likely assume that Tom is looking for a holiday destination for himself, rather than that he is trying to write his term paper. Suggesting tour companies, airplane companies or hotel sites in this case would be of little help.

- **Goals**: each of the user’s actions is triggered by an underlying “purpose” that is internal to him or her. This purpose, or the “why”, can be called the *goal* of his or her action. It is not a trivial job to “guess” a user’s goals accurately, as various interactions with the system may not be unambiguously mapped to a specific underlying goal. Nevertheless, the goal constitutes an important and valuable context for information retrieval, as revealed in several studies on user recall [49, 39]. Understanding users’ goals is esteemed to be essential in Web search, in order to satisfy the user’s information needs. [116] from Yahoo postulated in 2004 that goal-sensitivity would be “one of the crucial factors in future search user interfaces”. In the domain of Web search, user goals are often divided into three categories: navigational, informational and resource goals. Users have a *navigational* goal when they use queries to arrive at a single website that they already know. An *informational* goal, on the other hand, is assumed when users are looking for more information regarding a certain topic, without having any specific source in mind. Finally, when users are not looking for information but for resources such as songs, images or documents, they are said to have a *resource* goal [116].

- **Tasks**: unlike goals, tasks are more directly tied to user interactions with the systems, usually called “activities”. Typing in words on a word processor can be considered a task and, similarly, listening to music is also a task. In a nutshell, tasks represent “what users are currently doing”, whereas goals represent “why are users doing what they are doing”. Tasks are rarely used for Web refinding in current tools. YouPivot marks user activities (tasks) on the Web and uses them as cues to look for resources that were accessed while those activities were taking place (i.e. a user was watching a YouTube video when he or she saw the Web page about new vegetarian recipes) [55]. Refinder [30] is another example of a tool that uses user activities as retrieval cues. However, Refinder explicitly asks users to provide the activities, which was found to be cumbersome by the participants.

- **Emotional state**: we often react to the information we see and read, especially when it is of personal interest. The form of reaction may be a physical action, but sometimes it is accompanied by an emotional reaction. Life is full of unique events that are stored in our brain as memories. Such memories are not only made up of facts (i.e. what happened, where did it happen and who were present) but also of various emotional states during such moments. A study conducted in Japan, during which participants were asked to recall the news they had previously read on-line, showed that asking questions about emotions that were evoked by the news had a positive influence on recall [104]. Emotion itself does not necessarily improve the recall of the details nor is effective uniformly for all aspects of experiences. Close observation on the memory benefits of emotions showed that negative emotions seemed to enhance memory more than positive ones [71]. Emotions are largely neglected in the field of information retrieval, but they are widely expressed in social media and communication applications in the form of *emoticons*. As revealed in a study with 92 participants, people cited as the major reasons for the use of emoticons that they "aid for personal expression" and "reduce ambiguity" [69]. The benefits of emoticons are overall positive, because they make the content more enjoyable and interactive as well as increase the perceived richness and usefulness of the content [61].

- **Others**: internal context such as work context, business processes and communication are scenario-specific and thus not seen to be useful for general-purpose systems, although they could potentially be exploited for business or work-specific applications. For instance, IBM developed a bookmarking tool, called Dogear, designed for internal employees to store and share Web pages. To fit into the "work context", the tool offered some customized features like navigating the bookmark collections of colleagues who share similar tags and collaboratively adding comments to bookmarks [92].

### 2.4.4 Application of context in PIM and Web tools

So far, we have reviewed the types of context and how each type is being applied in information systems. Equally, context plays an important role in the field of PIM systems, as revealed in several studies on what people remember about their personal information after time-elapse. [49] asked people to tell stories about their electronic documents to understand what what aspects people actively remember and recall. They collected 60 of such stories and the findings showed that time, storage location and purpose of the documents were commonly recalled, in particular the purpose being the most relevant and easily remembered both for recent and old documents.

A study conducted by [18] resulted in a similar yet slightly different outcome: users remembered not only storage location and time but also format, keywords and associated events. Interestingly, time and keywords were often remembered incompletely or incorrectly. Purpose of the documents was excluded from the experiment, because it was used as the prompter for the recall. Nevertheless, we can deduce that users remembered the purpose as they could use it to recall other attributes of the target document.

More recently, [70] directed a pilot study to examine the types of context recalled by users and how useful they are for retrieval. Their study considered a more diverse range of context types compared to previous studies [49, 18]: they recorded all the events during a 6-week period and segmented context into time of events (date-time, season, the day of the week), geographical location of the user, file type, file source and weather. The retrieval test results showed that much of the narrative or textual content failed to be recalled but context information such as geographical location and file types were recalled after 6 months [70]. Moreover, neither textual nor contextual information by itself was useful in retrieval, but the combination of both resulted in the best performance [70].

The proof of context being useful for retrieval is not limited to personal electronic documents. [39] performed a study of 150 emails, in which they scrutinized how people refind target information. According to their study, people remembered most frequently the general topic of email, the purpose of the email, the sender of the email and temporal information. However, time elapse seemed to have an adverse impact on the recall of certain types of context as people tended to forget the sender of the email. The most enduring type of context that was remembered was the purpose of the email – this is in line with the finding by [49] on electronic documents.

Predictably, users exhibit similar tendencies in recalling the information they see on the Web. A recent study conducted in Japan demonstrated that users are prone to forget accurate keywords over time, but this can be significantly improved by asking context-related questions such as attributes of characters or events that appear in the content and emotions that were evoked by the content [104].

Summarizing the input from the aforementioned studies, it can be safely concluded that it is imperative to take a critical look at how current tools support users to ease the cognitive burden of remembering exactly what they are looking for. Certainly over the past decade, several innovative tools have been proposed that purportedly can help users to retrieve information using context.

Context in PIM (Personal Information Management) tools was first applied back in 1996 in the form of date-time. Users were able to locate their digital document by remembering roughly when they created, found, or stored it. This *temporal context* has persistently been applied as an important re-finding cue in various PIM tools to this day, offering not only date-time but also more meaningful time-blocks such as events. Users' interactions were also significant as a means to implicitly discern users' current tasks or goals.

Context was initially exploited in PIM systems, but the sophistication and size of information available on the Web has brought up the need to focus on context exclusively for refinding information in very large information spaces, such as the Web, as well. These efforts so far have been mainly exerted in improving the Web history tools or the search results in order to facilitate the refinding the same exact information. In this section, we review some well-known context-based tools in chronological order and discuss the types of context employed and the evolution of such tools over time.

LifeStreams (1996) was probably the first alternative to the traditional semantic-centric hierarchical organization of resources. Freeman and Gelernter envisioned a system in which personal digital resources were organized in user-centric events rather than in directories. LifeStreams automatically collects all types of digital resources into a time-based stream and is capable of slicing it into "substreams" based on user-specific queries (e.g. "All emails I have not responded to"). Web pages also become a part of the lifestream as a form of URL documents and Lifestream keeps track of all bookmarks silently [42].

Three years later, Adar and Karger proposed HayStack (1999), a PIM system that captures users' interaction with digital resources as metadata. While LifeStreams focused heavily on the temporal aspect of user interaction, Haystack offered more rooms for other aspects such as author, file type and relationship among resources through agents [6].

A similar system,introduced by Gemmell et al., is MyLifeBits (2002), a system that stores all types of personal resources, including documents, images, sounds, videos and web pages [45]. Notable about this system is that it allows users to group both homogeneous or heterogeneous resources into unique personal stories, which definitely would help in retrieval when semantic memory fades over time. As far as visualization is concerned, it offers a graphical timeline view by which users can browse to a specific time or time-range to find what they are looking for. In contrast to HayStack, MyLifeBits is more flexible in terms of the range of permitted annotations and visualizations, as it does not follow a predetermined ontological structure [45].

Dumais et al. put forward a system called Stuff I've Seen (SIS, 2003) that uses rich contextual cues to facilitate information re-use [36]. SIS offered time, author, thumbnails and previews as contextual filters that users could exploit to narrow down further to their target information. According to the results of their evaluation with 234 people over 6-week period, time and people turned out to be most important retrieval cues and that people used fewer of the other available search tools after using SIS [36].

The unprecedented boom of Web and Internet technology starting from the early 2000s also brought changes in how we search for information. More and more resources were made available to the public and Web browsers became more sophisticated to support such changes. This influenced the direction of research in improving refinding as well: as more people were relying on the Web to discover information, context-based research shifted its focus towards improving the search engine results and the web history tools.

Teevan et al. observed how users resort to search engines to refind information and yet face a lot of difficulties due to the frequent changes in the search results and the inaccurate recall of original search queries. Based on these observations, she proposed Re:Search (2007), which uses the previously given search queries and search results as a snapshot of the user context. Repeated queries are identified by indexing past search queries and the most recent search results of the matching past query are displayed for users to quickly locate what they saw before [129].

Other tools have focused on using the Web history to aid users in getting back quickly to the information seen before. The first of such examples is CWH (Contextual Web History, 2009), developed by Won et al. CWH uses contextual cues such as time of visit and visual appearances to help track information visited before. Their evaluation did not show any significant improvement in retrieval speed but the success rate of retrieval was better than that of the Firefox history tool [142]. Kawase et al. came up with PivotBar (2011) that aimed to improve dynamic bookmarks [127, 43] by using the browser context (i.e. the page being viewed currently) [68]. PivotBar keeps its own contextual prediction library that ranks and propagates previously visited pages based on user behavior, on which recommendations can be made to users when they are visiting a certain Web page.

By contrast, YouPivot (2011), proposed by Hailpern et al., brings a richer context into web history search. Users can pick a contextually related activity (e.g. watching a YouTube video) to pivot and view web pages visited in the time-frame before and after the pivoted activity [55]. YouPivot also provides a special time-annotation method called "TimeMarks", using which users can mark a specific activity or time as to-be-remembered. According to the pilot study, users reported a preference to use YouPivot and showed that the tool resulted in improved retrieval performance of visited pages [55]. The enrichment of context was also recently considered for PIM systems.

The most recent context-based tool that we discuss is ReFinder (2013), a system that "leverages human's natural recall characteristics" [30]. The system takes a "context memory snapshot", which includes time, place and concurrent activity, and allows users to query web pages and digital documents based on context cues. As with YouPivot, its evaluation study showed positive results in retrieval performance compared to other available tools [30]. Table 2.3 provides a summary of the context-based tools discussed in this section, along with the types of context they take into account.

The results from the user experiments using these tools are encouraging and give more credibility into the crucial role context plays in information search and retrieval. Nevertheless, there is still much room for improvement: most tools have used a narrow selection (e.g. date-time) of available user context (see 2.4.3) although several studies show that a various types of context such as emotion or purpose can aid in refinding [18, 39, 49, 70, 104]. Restricting the types of context regardless of the resource types, user preferences or scenarios can also hamper the synergy context can offer in information retrieval. A more systemic and thorough comparison of available tools is discussed in section 5.4.

Table 2.2: Different Categorization Schemes of Tags by Various Researchers

| **Golder [47]** | **Xu et al. [145]** | **Sen [119]** | **Heckner [57]** | | **Bischoff [17]** |
|---|---|---|---|---|---|
| What or who it is about | Content-based | Factual | Subject-related | Content-related | Topic |
| What it is<br>Who owns it | Attributes | | | Resource-related | Type<br>Author/Owner |
| Replaced Refinding categories | Context-based | | Non-subject related, personal | Time-task related; context | Time |
| | | | | | Location |
| Task organization | Organizational | Personal | | | Usage context |
| Self-reference | | | | | Self-reference |
| Qualities /Characteristics | Subjective | Subjective | | Affective | Opinion /Qualities |

## 2.5 Context as metadata tags for information search

As seen in previous sections, context can be an effective tool for personal learning, organizing and refinding information. However, since the emergence of the "social" Internet, more and more people now actively share their digital resources with others and collectively perform search activities. In this section, we provide literature review on the use or the potential of context as search metadata in community-based resource sharing scenarios.

### 2.5.1 Social tagging for resource sharing

Thanks to the Web, keeping track of useful information found online has been made possible but the revolution did not end there. Having a reservoir of personally curated and organized information accessible anywhere and anytime extended its possibility to have it available to others as well. Furthermore, the rise of social network allows users to form easily communities based on interests and social backgrounds. As more and more people began to share digital materials with others, the need for finding a way to help them organize their resources was made apparent. To address this problem, the concept of "social tagging" was introduced and it is used in various bookmarking systems (i.e. Bibsonomy, delicious, Pinterest) as well as media sharing sites (i.e. Youtube, Flickr), social blogs and even commercial sites.

Tagging was initially introduced as the alternative solution to the problem of organizing resources in hierarchical folder structure. There are a number of distinct benefits of using tags instead of folders. Tagging allows multiple categorizations of a single resources [16, 44], as opposed to the folder-based scheme, making it possible to search the resource via multiple paths. There is also a claim tagging requires less cognitive efforts [79]; however, such benefits are still yet to be verified as other researchers argue tagging bring about numerous "problems such as homonyms, synonyms, multilinguality and typos" due to its unstructural nature that "hampers search and retrieval" [22].

The underlying motivations for users' tagging has been a hot topic in recent research and several paradigms have been offered to explain the seemingly diverse types of tags found across systems. Marlow et al. depicted tags as "links" that connect resources to users in their conceptual model of social tagging systems. Motivation plays a significant role in determining the nature of the tags that emerge in social tagging systems and can be largely divided into two types: personal (organizational) and collaborative (sociable) [83]. While personal motivation concerns tags being used for organization and later retrieval, sociable tags are intended for one's position in the community such as contribution, attention-attraction and self-presentation [83].

Which type of motivation is more prominent can be said to be under debate. Some researchers argue that it depends on how the system is designed to support such tagging behavior. According to [148], the high degree of freedom given to users to tag others' resources promote more social tags. Zoller maintains that users are aware that tagging resources on social platforms is not only an act driven by self-interest but a social or collaborative act by which the entire community is impacted upon [148]. This "collaborative model" is also assumed by several studies such as [75, 85]. On the contrary, there is a plenty of literature [9, 137, 77] that argues the opposite: that users are driven by personal motivations even in collaborative settings. According to Rader and Wash, the need for personal organization outweighs that of collaborative goals [137]. The study carried out by Lipczak and Milios corroborates their argument: they studied the impact of the resource title on the decision process of the tag choice and found out that users' tagging decisions were most influenced by personal gains and convenience than by collaborative aspect [77]. The same behavior was observed by Ames and Naamann. They analyzed user annotations in mobile and online media and concluded that the need to get one's resources organized and findable was a major motivation for tagging even in content sharing communities [9].

These two rather seemingly conflicting study results show that users are faced with two different motivations when tagging shared resources and guided by both in their decision. As if to reflect these different aspects of user motivations, tags have been found to fall into distinct types across social tagging systems and vary according to different types of Web content. There are a number of ways of diving the tags into different types but first of all, we review the two types of tags that are most commonly used in social tagging platforms in the next section.

### 2.5.2 Folksonomy vs Ontology tags

Folksonomy, by definition, is a composite term of "folk" and "taxonomy" and a "kind of user creation of metadata" [144]. In social tagging systems, folksonomy is used as the synonym for user-defined tags that are used for indexing and retrieval. Thanks to its ease-of-use and high degree of personalization, folksonomy tags are used in numerous resource sharing platforms and applications. Folksonomy addresses the well-known problem of indexing data with content-descriptive data and fosters user involvement and web collaboration [138]. The first type of Web tools that harnessed folksonomy as the indexing scheme was that of bookmarking. The most well known ones are Diigo and delicious.

Delicious [5] was the first tool to offer the tag-based indexing system [86]. Once users are registered, they can use their own tags to organize saved Web pages and share their bookmarks with other users. Tags are classified non-hierarchically, meaning establishing relations among tags is not possible. However, users may try to group similar tags as a "stack" and share it with a group for collaborative work. Diigo [6] is also a social bookmarking service based on tags. However, it is different from delicious

[5] www.delicious.com
[6] www.diigo.com

because it offers a set of "recommended" tags for each saved page. The recommended tags are based on the web content and users can either choose to use them or add their own tags. Users can also group certain web pages using the "outliner" which acts like a tree-structure folder in a classical sense that can be private or shared with others for collaboration.

Despite its wide application and acceptance, folksonomy tags do not come without price. Due to its having no structure and no controlled vocabulary, such tags can create problems for search and retrieval. In fact, a study carried out by Al-Khalifa and Davis demonstrated that as large as 32% of the tags were of no practical use for others and had no relations to the actual content of the saved resources [8]. Since the debut of the *Semantic Web*, the problem caused by the ambiguity of folksonomy tags was augmented as they could not be used to classify information and draw relations to others. Ontology was hailed as a solution to this problem as it can add structure to and forming a model for knowledge, providing a "formal conceptualization of a particular domain" [38]. Applying ontology to tags of shared online resources was coined as "Social Semantic Bookmarking" [22]. Social semantic bookmarking allows adding tags extended by semantic definitions and descriptions which can be interlinked and progressively evolve though the collaboration [21]. There are a number of exemplary systems that use ontology to organize shared online resources. Here we briefly introduce some of the tools in this regard.

Bibsonomy is probably the first tool that allowed users to add semantic relations among tags. It is a bookmarking and publication reference-sharing tool developed by Knowledge and Data Engineering Group in Kassel, Germany. Not only users can share bookmarks as with other social bookmarking tool but also they can share bibtex entries at the same time [52]. Bookmarks shared by others can be re-tagged with personal tags but co-editing of tags is not allowed. Users can organize their tags using broader - narrower relations for better navigation while the system takes care of related - similar relations automatically [21].

Braun et al. [22] proposed SOBOLEO, a social semantic bookmarking tool that attempts to alleviate (linguistic) limitations of folksonomy. SOBOLEO uses SKOS [7] standard on which a shared ontology is built

[7]Simple Knowledge Organization System (SKOS) - W3C recommendation to represent any type

among users. When a new bookmark is saved, users are offered to choose among the concepts (i.e. tags) drawn from the shared ontology in the target domain or create their own concepts. SOBOLEO supports and permits users to set hierarchical relation as well as parallel relation among the concepts, making it easier to search and retrieve saved resources [22].

Semantic Turkey is a semantic extension for Mozilla Firefox browser implemented with OWL [8] by Griesi et al. [52]. The notable feature of this tool is that the knowledge data (WHAT) is distinctively treated from the knowledge source (WHERE), which allows "innovative navigation of both the actured information and of the pages where it has been collected" [52]. Semantic Turkey uses several ontological layers to separate its system-defined ontology from user-defined ontology: the system uses automatically generated concepts from the annotated and/or the whole web page content to build the base ontology and users can edit or add relations simply by dragging and dropping annotable text from the web page. Direct editing of ontology is also supported [52].

Ontology-based tagging, however, seems not to have gathered much popularity despite its benefits. Many of social tagging systems such as Flickr, Youtube, Pinterest or Instagram still resort to folksonomy-based tagging. Because of its need for expertise, it is difficult for general users to make use of it to annotate their web resources. As Weller observes, asking users to use existing ontology is the "least promising approach" since it "takes away the freedom and convenience" [138]. Furthermore, content-related tags, thus applicable for ontology, make up only a part of tags users use. Instead, users are shown to use a variety of types of tags when annotating their online resources [17, 47, 119]. Interestingly, contextual tags also make a part of these types and are found in various social tagging platforms. In the next section, we review the types of these contextual tags and how they are being used for search of shared resources.

of structured vocabulary. It is a part of Semantic Web Family standards built on RDF and RDFS (Wikipedia)

[8]Web Ontology Language (OWL) - a family of knowledge representation languages for authoring ontologies or knowledge bases (Wikipedia)

### 2.5.3 Tags as search metadata

As proliferation of social tags took place, researchers pondered the possibility of leveraging tags in improving information search and retrieval. Before the tags, search engines simply processed the given search query regardless of the user or the circumstances. As Paul Heymann puts it, the search engines had access to only "page content, link structure and query (or click-through log data)" [59] to produce search results. Tags, essentially user-provided metadata of digital resources, could potentially add flavors to the otherwise-dry search results, paving a way to provide tailored search experiences.

Noll and Meinel were one of the first who proposed using tags to improve Web search. They used bookmarked pages with their tags to re-rank search results returned by search engines. They exploited the fact that users were willing to bookmark and tag pages that are most important or relevant to their information needs. Once a page is bookmarked by the user, the system automatically stores tags based on search query. Bookmarked page is then queried from social bookmarking system to gain more tags (metadata) about the page. Such combined metadata is used to provide personalized search results. Their experiment using public bookmarking service of delicious showed that personalized search results were considered better in 63.5% of the 104 search queries [102]. Similarly, an experiment done by Yanbe et al. showed that Web search can be enhanced by using popularity statistics and tags from social bookmarking service as metadata. They compared the standard link-based page ranking with that of social bookmarking service, delicious. They claim that using popularity ranks of bookmarks can assure better quality of search results and tags can extend search capabilities by enabling temporal and sentimental search, which is not possible with current search engines [146].

As shown in these studies, tags provide unique benefits because they serve as "document descriptors for other users' search queries" in users' own language [57]. However, not all tags are of the same type and thus equally useful for search [17, 59, 126]. Quite a number of categorization schemes have been proposed by various researchers in recent years. The first studies that examined the different types of tags were of [47], [145] and [119]. [47] identified seven different types of tags that serve different functions, while [145] and [119] provided a broader categorization. Heckner et al. offered a more detailed hierarchical view of functional tags, dividing them into subject-related and non-subject related tags with their own sub-branches [57]. Lastly bischoff et al. came up with the most fine-grained categorization, adding on *time* and *location* to accommodate tags found in systems other than delicious [17]. The summary of different categorization schemes is provided in Table 2.2.

Typically the subject-related (content-based) tags are considered more important than the non-subjective (organizational, personal and contextual) ones, since better search is strongly associated with building semantic taxonomy from the tags [37, 144]. Several researchers, however, have shown that non-subjective - including contextual - tags can also be used for effective search but it depends on various factors: the type of resource, users' search scope and users' perception of the purpose of the tagging systems.

Bischoff et al. conducted an extensive study on the potential of different types of tags for improving search [17]. They examined tagging behavior of users on social tagging systems that serve different purposes: Delicious for Web pages, Last.fm for music, and Flickr for images. They study results showed that different types of tags were deemed useful for search for different types of resources. Interestingly, users provided different ranks of usefulness for search in personal and shared resources, indicating usefulness depended on the search scope. When searching in shared resources, topic, usage context, author/owner and resource type were the top useful tags for Web pages while time and location were considered important for pictures. Opinions/quality were found to be surprisingly useful for songs, which shows that users seem to assume agreement on subjective opinions of others for certain media types.

Sen et al., on the other hand, studied how users tag MovieLends, a movie recommendation system, for personal and shared movies. Their results showed that users differentiated the types of tags useful for search, depending on whether or not the movie was shared with others. Interestingly, subjective tags - opinions and qualities - played a key role in decision making for selecting a movie among given search results, which emphasizes the role of non-content related tags in effective search of shared resources. They also argued that tags solely used for personal organization of resources are not useful for searching others' resources and vice versa as the usefulness of tags depend on the search scope: all types of tags are potentially useful for search but they need to be separated for personal and shared resources. The search scope also varies according to the users' perception of the purpose of tagging systems, according to Heckner et al. [57]. They examined the usage of tags in different systems (flickr, youtube, delicious and connote) that serve different purposes. They found out that users considered tags useful for search for flickr and youtube but not so for delicious and connotea. Interviews with the participants revealed that users considered delicious and connotea as systems for organizing and searching their own personal resources while youtube and flickr for sharing resources with others.

So far, we have shown that tags can be in fact useful for search but they come in many different types and their usefulness for search depend on several factors. Typically contextual tags - those not related to content - are considered not useful and discarded. But the studies mentioned above [119, 17, 57] point that contextual tags can be and are useful if chosen appropriately according to resource types and users' search needs. Understanding users' motivations behind tagging, whether or not resources are shared and subsequently how the systems are designed to support such needs would be the key challenge. Unfortunately a great number of users are not aware of the potential role tags can play in information search and retrieval. According to a study carried out by Kim and Rieh [72], most users are still confused with the purpose of tags and believed that they were for their system rather than for the users themselves. Tag recommendation functions are a way of encouraging users to use the types of tags deemed most useful for search. Systems that recommend tags are quite common. Most of them follow the approach to recommend tags based on the content using natural language processing, machine learning and ontology. Some of the examples of such techniques are seen in [141], [62], and [11]. However, recommending tags solely based on the content are highly restrictive since the number of key terms extractable is rather limited. To solve this problem, recommending tags based on the collaborative tagging behavior of the whole community was proposed and applied in AutoTag [95] and Tagassist [124].

All these aforementioned techniques are focused on providing content-based tag recommendations even though, as we have seen previously, users make use of non-content based tags that can be effective metadata for personal or community search. Using or recommending such personal or contextual tags as metadata for search is still rarely or not seen at all either in research or in commercial tagging platforms. The importance of contextual metadata in improving personalized search has been recognized for Web search. According to Bennett et al., there is a growing focus on how user's interests, intentions and context can improve search and recommendations [12] but these cannot be easily gleaned from explicit search queries. On the other hand, tags found across various platforms provide insight into various implicit, personal and contextual information (see Table 2.2), which can certainly be used to provide richer search experiences if carefully encouraged and applied.

Table 2.3: Context-based Tools

| Tool | Type | Context | Highlights | Lowlights |
|---|---|---|---|---|
| LifeStreams [42] | PIM | Time, User-defined query | All resources are automatically organized into a time-based stream, which can be sliced into user-query-based sub-streams | Requires users to remember a specific time or query; limited types of context; all resources are uniformly presented along one time-line, provides no extra clues as to what they are about without having to manually view each |
| HayStack [6] | PIM | Time, Author, File type, Relationship among resources | Allows rich metadata of resources through agents | Context is limited to the properties of the document rather than the user's episodic experience; Requires efforts to remember the metadata of target document such as author, file type and date-time of saving the file |
| MyLifeBits [45] | PIM | Time, Author, File type, Relationship among resources, user text annotation | Allows homogeneous and heterogeneous grouping of resources into user-defined stories, flexible range of permitted annotations | Similar to HayStack, context refers to the properties of the document. User-story based grouping of resources can be useful but it requires a lot of manual efforts |
| Stuff I've Seen [36] | PIM | Time, Author, Thumbnails of documents | Offers filtering by various contexts and textual or graphical visualization with 2 flavors, thumbnails and previews. | Offers very limited context; Focuses mainly on properties of documents that can be forgotten over long term |
| Re:Search [129] | Web Search | Past search query and results | Records previous searches and matches them with current search to quickly provide the last previous search results for faster refinding | Relies only on the textual search query; Requires users to remember past search queries; Requires large storage |
| CWH [142] | Web History | Time of visit, Screenshot of Web page | Provides graphical visualization of screenshots and search by time or text | Requires users to remember the time of visit and details of the content |
| PivotBar [68] | Web History | Current browser context, content of Web pages seen before | Prediction library keeps previous browser context and propagates previously seen pages that match the current browser context | Offers limited context based on textual content of Web pages; Requires large storage |
| YouPivot [55] | Web History | User Web activities, Time | Allows users to refind Web pages based on web activities, offers time-marks for important moments | Offers limited context; Requires users to know in advance when they are going to start viewing Web pages that they need to revisit later |
| Refinder [30] | PIM | Time, Concurrent Activity, Place | Supports contextual annotations to digital resources and search by context | Requires a lot of efforts to input activity and place manually; Offers only contextual search detached from the content of the resources |

# Chapter 3

# The Problem

In previous section 2.1, we have provided literature review on how our brains create, retain and retrieve memory. How memory is encoded and organized seems to be the catalyst for various key functions brains play in learning and searching or retrieving information. The particular aspect of how human memory is encoded and retrieved is the involvement of *context* in the process. Context has been shown by extensive research to play a key role in learning and retrieving information when used properly. Context not only can improve personal learning [134] but ensure the timely delivery and relevant of content in search [46]. Since the dawn of the digital era, much, if not all, of our daily activities that used to be performed by hand or on papers have moved onto using digital tools and documents. Context, given its impact on information acquisition and retrieval, has been applied in various computing areas. According to Dey, there are three categories of features that makes a system "context-aware" - presentation of information and services to a user, automatic execution of a service for a user and tagging of context to information to support later retrieval [35]. In fact, we have reviewed some of such tools and applications to support contextual elements in learning, organizing and searching information in the State of Art, Chapter 2:

- Systems that support annotations by which users can highlight or make comments on digital documents
- Systems that support organizing and retrieving personal resources using some of the context types such as time and location

- Systems that allow folksonomy tags - users' own metadata - to categorize digital resources that can be shared with others, which in turn are used for targeted or exploratory search in community.

Nevertheless, there seems to be lack of clear consensus on what types of context should be used, how they should be supported or if using such context is actually useful. Specifically we are interested in finding out the role and impact of context in performing key activities such as learning in academic ambience and searching and refinding information for personal and community-based interests. In this thesis, we aim to provide a tentative prognosis for following research questions based on experiments conducted with three different prototypical tools.

1. **Learning digital materials** - what role do contextual (personally meaningful) annotations play in learning digital materials? Annotations bring the readers closer to the text they are reading by helping to establish personal relationship with the text thus in the long run, aid in comprehension and retention of the material. Numerous annotation systems are available not only for general Web pages but also electronic books but they are limited to highlighting or adding notes. In the first part of this thesis, we take a close look at the impact annotations potentially have when users are given the free choice to build the connection with the text using various forms of multimedia materials. To this end, we performed a pilot testing with a prototypical tool called Q-book in a real school setting. The more detailed motivation and the subset of pertinent research questions are provided in Chapter 4.

2. **Organizing and re-finding bookmarks** - which types of contextual information do users use to organize and re-find their bookmarks and under which circumstances are they most useful? In the second part of this thesis, we dive into the impact of context in organizing and refinding information on the Web. Specifically we focus on the most commonly used method of preserving Web pages found useful - bookmarks. In Section 2.1.2, we provided some background knowledge on how context can be instrumental to information retrieval and further discussed the different

types of context (see Section 2.4.3) and how those types have been applied in various computing areas. As far as bookmarking tools are concerned, using context in its various types are not yet realized to their full potential. Most tools offer time and location as additional context cues for retrieval but there has not been an extensive study including all different types of context available to gauze their usefulness. To answer this research question, we conducted a user experiment, albeit in a small scale, to provide qualitative analysis using a prototypical tool, MemoryLane. Further detailed problem description is provided in Chapter 5.

3. **Searching shared materials in community** - what role does contextual meta-data play in searching and retrieving shared digital contents among users in a homogeneous community? Since the Web became "social", we have seen the proliferation of online services catered to the needs of sharing information among users. Metadata to help organize and retrieve such materials became a key issue in the online social scene and that gave rise to the birth of popular folksonomy tags, user-defined keywords, to index the resources. Some studies have shown that these user-based tags fall into distinct categories and some of those are contextual (see Section 2.5). In the last part of this thesis, we extend the research question into the online community. In particular, we want to examine the role of contextual tags may play in the search of shared digital materials. We have conducted a user experiment with a group of professional language teachers on an educational platform called LearnWeb to answer the question. First, thorough investigation of the types of metadata most appreciated and useful for searching teaching materials was carried out. And second we have designed new interfaces according to the findings and implemented the new user interfaces. The motivation and detailed problem description can be read in Chapter 6.

# Chapter 4

# Q-Book: context in learning digital contents

## 4.1 Intro and detailed problem description

There has been a heated debate around whether multi-media aided learning is more effective than traditional text-only based learning. Supported by the "Dual coding" theory [27], various applications have attempted to put the theory into practice. One successful case is the "Word sketch" (currently changed to "Brain study"), an application developed in 2009 for hand-held devices by Weaversmind Inc., which patented the idea of teaching foreign languages by annotating words with drawings and sounds [66] (see Figure 4.1).

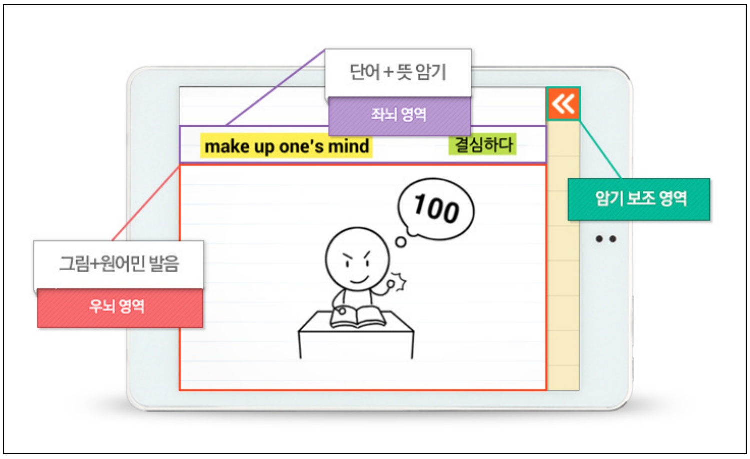


Figure 4.1: Brain-study Interface [94]

The application saw a great success among the students and adults alike and was adopted officially by public and private schools in South Korea. Using multimedia to help aid learning is nothing novice in the education field. E-textbooks have long included supplementary images in text. Nevetheless, the new computer technology has revamped the variety and interactivity of such multimedia that can be added to main text. A far cry from static images, current e-books contain videos and audio clips as a part of its package. For example, iBooks by Apple Inc. [1] provide e-textbooks that offer the state-of-art multimedia technologies including photo galleries, 3D images, video and audio as seen in Figure 4.2.

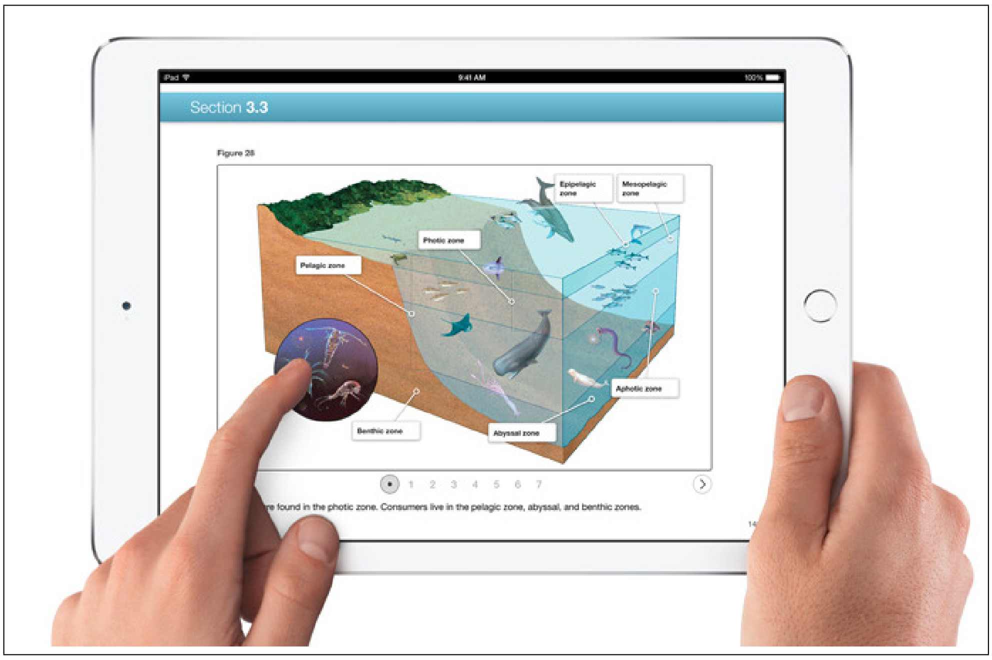


Figure 4.2: Apple iBook Interface with rotating 3D image

The positive benefits of multimedia aids is not surprising if we consider the multisensory environment we live in and are constantly exposed to, pursuant to an article written by two psychologists, Ladan Shams and Aaron R. Seitz, of University of California. They emphasized that multisensory stimuli facilitate unisensory learning when given during encoding of the given information as well as accommodate different learning styles [120].

[1] https://www.apple.com/education/ibooks-textbooks/

Without doubt, as examplified by its successful applications in educational tools and materials, multisensory stimuli yield great contribution to learning. However, one must be cautious because providing additional multimedia aids not always bring positive outcomes in learning. As Stephen K. Reed, a professor at the University of San Diego, USA, puts it, if one fails to make the association between the image and word, for instance, it is harder to remember it at a later time than it would without the image [115]. His opinion may be backed by the studies which show the importance of "linking" pieces of information and how we can apply it in the era of e-books. In a Curriculum Enhancement report by NCAC, National Center on accessing the General Curriculum, Strangman and Hall postulated that students needed to "integrate new materials into their existing knowledge base to construct new understanding" while adapting existing conceptions and beliefs as needed [125].

How can we then apply background knowledge and its activation in e-books? It is not possible to estimate one's background information by current technology; however, this powerful method of "linking" to one's experience could be partially simulated by combining existing technologies to support users' choosing their own relevant materials to the text by a form of multimedia-aided annotations. In previous section 2.3, we have pointed out how text annotations are instrumental to better learning by allowing readers to add their personal context to the text. We have also reviewed how the transition from print books to e-books have resulted in various tools that provide electronic annotations but they lack support for various types of annotation activities that go beyond highlighting and adding sticky notes. Already numerous e-books provide multimedia contents but they are pre-determined solely by the authors: readers only become the "consumers" of such multimedia contents, which may or may not be relevant or necessary in some cases. This could be the cause of users finding such contents not so useful. A study carried out with 91 students on their preference for e-textbooks or print textbooks, showed that students did not make use of the visual or interactive elements provided in their e-books to their potential [143].

In this chapter, we provide details of user experiment carried out with a prototypical tool, Q-book. Q-book aims to promote effective learning through personalized interactions in context with the contents by choosing their own supplementary multimedia aids to annotate the text. Furthermore, Q-book also provides the entirety of the recommended text annotation activities by [111] and exploits the benefits of multimodal learning mentioned in section 2.1.1 and 2.3. Specifically, we are interested in finding out the answers for the following research questions:

1. Do personalized (contextual) annotations have any impact on learning outcomes?

2. Given the free choice, what media type of annotations are mostly used by students?

3. Do different types of annotations have any implications for learning outcomes?

## 4.2 Q-book architecture and implementation

Q-book is a Web platform developed for e-book readers that provides easy-to-use multimedia annotation functions to enhance personal learning and also supports collaborative learning by sharing annotations with others. It is specifically designed for "learning" context whereby the readers of the e-books aim to study closely and learn from text to retain knowledge in a relatively long-term, most typically students in class who are expected to study for exams or write papers. Teachers can also use Q-book to oversee the learning process and to evaluate students' work. The functions that are provided by Q-book are as follows:

- **Text annotation encompassing annotation activities from pre-reading to post-reading**: Q-book allows users to get involved with the book actively by providing key concepts, key entities, keywords and automatically-generated chapter abstract when user selects a chapter to study. This information can help users quickly to get an idea of the content they are about to read and be prepared. Users can also check out textual or visual cues of the given key concepts, key entities and keywords in order to maximize background information before reading. While reading, on the other hand, users are enabled to add multimedia annotations, adding notes, marking key phrases or even asking questions about selected text. As the post-reading activity, users can not only create a summary of chapter in their own words using the key phrases they have highlighted but also answer the questions they asked or other students or teachers have asked.

- **Multimedia annotation linkable to any text and retrieval at any time post-reading**: Q-book provides automatic search results of related textual and visual materials such as images or videos for the selected text during reading. Users can browse and select to annotate the material they themselves find most relevant or interesting. This freedom allows personalized preferences and differences. Saved multimedia can be accessed at anytime during or after reading in annotation pane found on the right side of the page.
- **Shared annotations with others**: Q-book embraces the benefits of social sharing. Users can view any annotations shared by others studying the same book, be that a link to related news article or a video or even a summary or questions. Moreover, Q-book allows users to "borrow" annotations from others, driving learning-from-peer to a more solid and permanent personal learning.

### 4.2.1 Q-book Interface

Q-book allows users to maintain a personal library, to which they can add E-books in EPUB format [2]. When the user clicks on a book to read, the main interface displays the chapter of choice and on the side, automatically-extracted concepts, keywords and chapter abstract are provided. Users can also opt to listen to the chapter abstract by clicking on the "listen" button. When the user starts reading the chapter, he or she can highlight any part of the text to add various types of annotations including the most common highlights in different colors, notes, videos, images or other Web contents as links. Asking questions about selected text is also possible and can be viewed and answered by clicking on the "question" tab. Once reading of

[2] http://idpf.org/epub

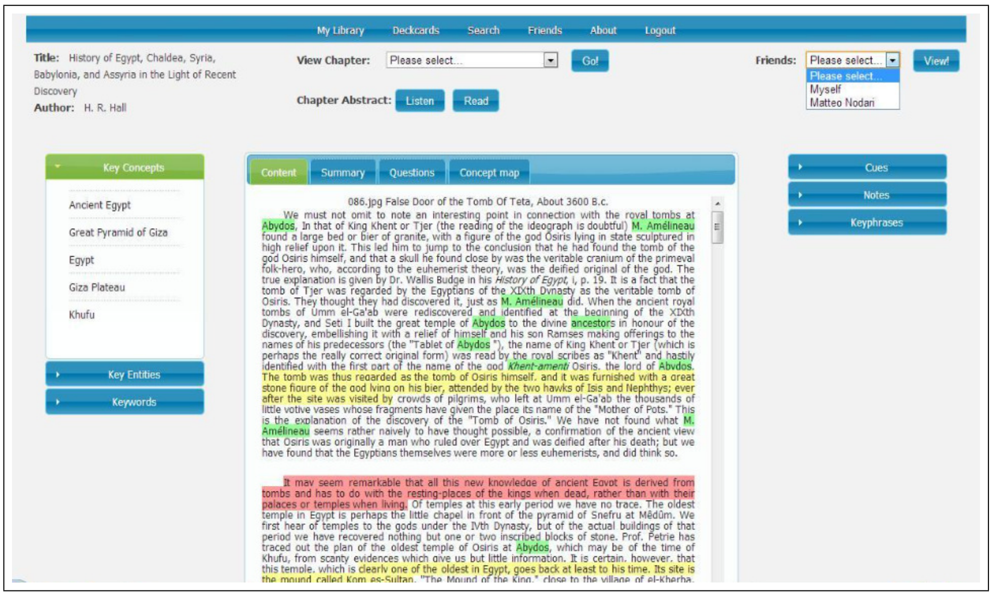


Figure 4.3: Q-book: Main interface

the chapter is complete, users can click on the "summary" tab to write their own summary to make the learning more concrete. Figure 4.3 illustrates the main interface.

Q-book's uniqueness lies in the functions that provide multimedia annotations directly linked to selected text. When user highlights text, a contextual menu pops up, from which users can choose to add "visual" or "textual" cues. Selecting visual will open a popup displaying all videos or images relevant to the selected text. Figure 4.4 shows an example of video annotations. Once added, these multimedia annotations are displayed on the right-side of the main interface and viewable anytime. They can be also shared with other users.

### 4.2.2 Q-book: Supported e-book format

Q-book exclusively supports EPUB format [3] . EPUB was first founded in 1999 to promote industry-wide adoption of publishing standard while working on to resolve interoperability issue of various reading systems. While there are numerous formats used for e-books such as PDF, MOBI,

[3]EPUB is XML-based e-book format and a technical standard for e-books created by the International Digital Publishing Forum (IDPF)

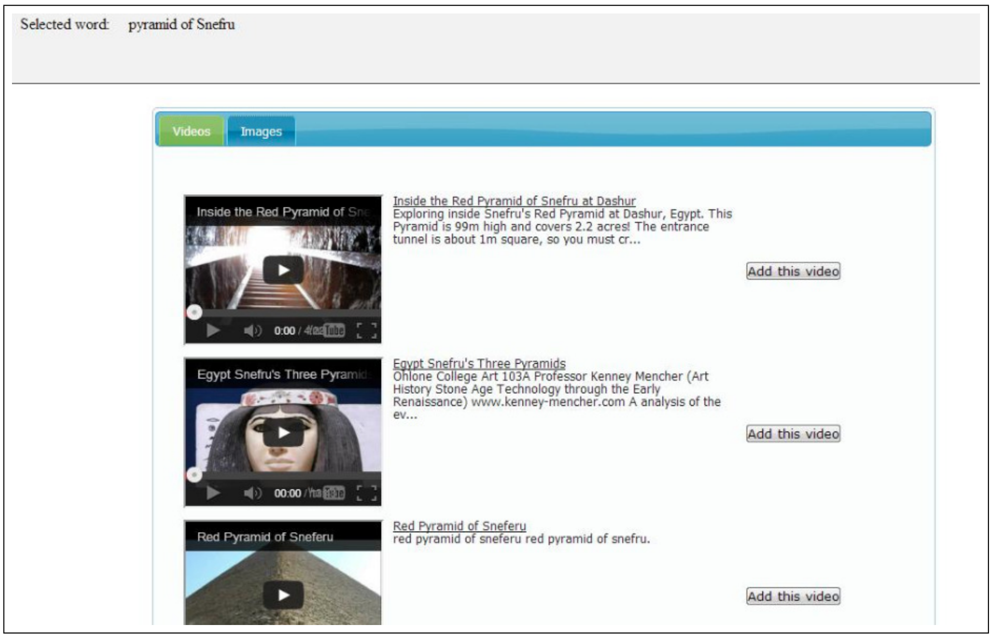


Figure 4.4: Q-book: Video annotation of selected text

AZW, IBA, etc; EPUB is so far the most widely accepted and used format (apart from PDF) thanks to its vendor-independence. EPUB is XML-based, which makes it easy for developers work with on most platforms. E-books created in EPUB format can readjust the content sizes based on the reading devices and supports multimedia contents. As Q-book offers various types of annotations, more than highlighting and adding notes that are available with PDF documents, EPUB format was selected so that implementing additional features, different layouts and custom interface design were made possible.

### 4.2.3 Q-book: Implementation

Q-book is an Web application that follows the MVC (Model-View-Controller) model, which allows the separation of representation of information from users' interactions. Architecture-wise, it is divided into 3 different layers: presentation, logic and data layers that perform different set of functions. The user interface was implemented using JSP (Java Server Pages) and CSS. The logic layer handles extracting necessary contents from the uploaded e-books and also persisting data into database. Finally data layer deals with data from logic layer and also from external services.

Several libraries and external APIs were used to develop Q-book. The most fundamental ingredient was the library for handling epub files. We chose epublib [4] to read and write epub files programmatically or from the command line. To perform customized search, we used Google Custom Search API [5] and Youtube Data API [6]. Text-to-speech API [7] was employed to transform the summary into a mp3 file containing the text read by a synthesized voice. For text summarization, Classifier4J [8] was used. On the other hand, Alchemy API [9] was used to extract keywords, concepts and entities.

## 4.3 Q book experiment and its results

The prototypical tool, Q-book, introduced in previous section was taken up as a part of a state-sponsored research project called "E-schooling". With collaboration with companies such as Telecom Italia and Eriksson publishing house, Q-book was re-developed using different technologies like php instead of jsp, while preserving all the main functions. A User experiment in an Italian high school was carried out to find tentative answers posed in Section 4.1. In this section, we provide the overview of the methodology and experiment results. The role of the author of this thesis was to oversee and participate as a developer in the re-development of the same tool using different technologies (Java platform to Javascript and from MySQL to Mongo DB) as well as the planning, design and execution of the user experiment of the tool.

### 4.3.1 Methodology

The objective of the user experiment was two-fold. One was to understand the use patterns of multimedia annotations and the other to gain insight

[4] http://www.siegmann.nl/epublib
[5] https://developers.google.com/custom-search/
[6] https://developers.google.com/youtube/v3/
[7] http://www.voicerss.org/
[8] http://classifier4j.sourceforge.net/
[9] https://en.wikipedia.org/wiki/AlchemyAPI

into the impact of using such on learning in a real classroom setting. Apart from the data gathered from students' usage of annotations during and after school, a separate survey was carried out to measure the qualitative measure of usability and user satisfaction.

#### Pedagogical approaches

E-schooling application can be used to achieve several types of pedagogical objectives. This experiment, in particular, focused on the following two types of approaches.

- **Active learning** - the key approach of the experiment was to encourage students to actively participate in reading the learning material through building personal relationship with the content. The e-schooling tool enabled students to create their own personal multi-media annotations to the text, make comments or ask questions. Students were given home assignments to search for more information and make annotations to the selected digital text according to their preferences.

- **Collaborative learning** - though active learning focuses on the "individual" involvement, it can also be collectively used to enhance the learning for others though sharing their reflections and digital materials, which was not easy with traditional paperback textbooks. Using the e-schooling tool, students were given the possibility to view each others' multi-media annotations to learn from each other.

#### Participants

Garda Scuola [10] located in Arco, a province of Trento, participated in the experiment. The school provided necessary Internet access and was equipped with a computer lab. The teachers were open to using new technologies in classrooms and demonstrated eagerness towards using the proposed tool in class. Nevertheless, only one teacher participated in the experiment due to the second academic semester already being on the way, making it difficult to change teaching materials. Below we provide more details about the role the teacher and students played in the experiment.

- **Teacher**: although not directly involved in the assessment of the experiment, class teacher was responsible for creating teaching materials in e-book format, giving out assignments and carrying out the necessary tests before and after the experiment.

- **Learning Material**: teaching materials authored by the teacher was in EPUB format. Materials were created with E-schooling authoring tool supplied to teachers

[10] www.gardascuola.it

where they could create e-books in power-point like interfaces that compiled as e-books upon completion. Two separate e-books were created by the teacher to be used as learning materials in classrooms. Both e-books covered concepts of economy: the first book was about the demand and supply while the second about the demand elasticity. E-books contained text, images, videos and quizzes. The e-books were then distributed to students in the e-schooling platform.

- **Students**: the participating students were of the first grade of high school, aged between 14 and 15 years old. Their computer literacy was deemed to be sufficient though not experts. The students were divided into two groups: testing group who used the prototypical tool and the other control group who used the print textbook. Both groups were taught by the same teacher during the experiment. The testing group used the e-books created by the teachers whereas the control group were shown the powerpoint slides during the lectures. The content of the teaching material was the same for both groups.

#### Testing period

The experiment roughly lasted for two months. The first two weeks were spent in preparing e-books and taking pre-assessment test. Once e-books were ready, students in the test group studied with our prototypical tool for 4 weeks (two lectures per week lasting 40 minutes each) in computer lab located in school. The last 2 weeks were spent in completing questionnaire and taking post-assessment test.

#### Testing hypothesis and group composition

As briefly mentioned above, the participating students were divided into two groups (two classes of the same grade) so that we could compare the test results. One group (test group) was asked to use e-book created by the teacher and the annotation tool while the other group (control group) proceeded with the traditional paperback textbooks without any digital tools. Table 4.1 shows the composition of these two groups of students. Independent same T-test [11] was performed to ensure there was no significant difference on the previous test scores between two groups. The results of T-test (T=0.827, p=0.415) was not significant, meaning the two groups were of similar learning performance on test. In summary, the testing hypothesis of this experiment were:

[11] T-test assesses if the means of two groups are statistically different. To test the significance in difference, the risk level is set to 0.05. If the test results show p is lower than 0.05, then the difference between two groups is significant

1. *Students in test group will show greater learning achievement than those in control group*

2. *Students with higher number of annotations will show greater learning achievement than those with fewer annotations (within the test group)*

Table 4.1: Student group composition

| | **Test Group** | **Control Group** |
|---|---|---|
| # of students | 18 | 18 |
| T-test result | Not significant at p¡0.05 (T=0.827, p=0.415) | |

Greater learning achievement was measured in three different ways as shown below:

- Increase in students' positive attitude towards learning
- Higher difference in scores between pre-test and post-test on group level (test group Vs. control group)
- Positive correlation between number of annotations and test performance on individual level (Pearson correlation method)

**Procedures**

The experiment consisted of several procedures from the beginning to the end. Before the experiment took place, students were given a class session in which students were taught how to use the tool with the e-book. A detailed demonstration of each available function within the tool was provided and students were given two weeks to familiarize themselves with the new tool. Then students were asked to perform several tasks which are described in details below.

- Pre-test: Class teacher gave participating students of both groups a pre-assessment test of the materials they will be learning to evaluate students' prior knowledge about the topic. The test results were used to evaluate the improvement in learning by comparing them with post-test results of the same material once lectures were completed.
- Lectures: students in test group carried out their studies in and out of the class using the e-book and the tool whereas those in control group studied with print textbooks.
- Home assignments: students in test group were given free-style home assignments to read the material and make annotations at home.

- Post-test: students of both groups were given a post-assessment test of the materials learned to evaluate their learning achievements.
- Questionnaire: class teacher and the students in test group were asked to fill out a questionnaire at the end of the experiment.
- Data collection: data was collected to be analyzed at the end of the experiment. The data included scores of pre-test and post-test of both control and test groups, completed questionnaires and e-schooling tool log data (annotations, log-in sessions, types of annotations per each students of the test group)

### 4.3.2 Results Analysis

Participants were given pre-test and post-test for analysis of leaning achievement and a separate questionnaire to measure usability and satisfaction after the experiment was concluded. This section provides the detailed result and its analysis in both qualitative and quantitative aspects. The key findings from the results are summarized below:

1. **Overall students were very enthusiastic and satisfied with using the tool to study**. The most popular function was to add videos and images to text. Students also seemed more engaged during the lectures as per feedback from the class teacher.
2. Test scores showed that **there was no statistically significant difference in learning outcomes between the test and control group**. Interestingly enough, the standard deviation of test scores decreased after the experiment, showing a more even score distribution among the students. Moreover, a moderate correlation could be observed between the number of annotations and test results albeit the test scores of some students remained unaffected by annotation activities or the lack thereof. In general, students with high score in previous test carried on to making a larger number of annotations and vice versa. This conceivably suggests that student's scholastic aptitude and desire for high performance takes precedence over methods of learning.
3. **Quality of annotation seems to play a role in learning achievement**. Students who spent more time searching and selecting related

content to the text seems to have scored better in post-test than those who did not. More specifically, unrelated comments or mere highlighting and underlying text showed weaker or even negative correlation to the test scores. Quality of annotation could be improved via more vigorous pre-reading and post reading activities, typically as a form of home assignments or other forms of motivation schemes such as reward for best annotations in class. Exclusive usage of the annotation tool in lectures worked against better learning achievement, i.e. possible distraction in class and hindered students for actively searching and selecting their own favorite content.

4. **Image annotations were the most popular ones used by the students during the experiment**, followed by comments and highlights. Students showed their preference for videos during the questionnaire but the number of video annotations was very few. This can be attributed to the fact that videos take time for viewing and it was not possible to do so during lectures. Comments and highlights were commonly used but they did not show to have great impact on learning outcomes.

#### Qualitative - usability

The questionnaire was made up of 17 questions for the tool. Students evaluated each aspect of the tool on a scale ranging from 1 to 5 with 5 being most satisfied. Table 4.2 shows the results of questionnaire. Overall, the results were shown to be positive. Notably, the overall user satisfaction and usefulness of multimedia annotation and sharing of annotations resulted in 4.4 out of maximum 5.0. However, the learning satisfaction and willingness for future use scored lower at 3.5 and 3.7 respectively, showing that students were not as convinced of positive learning effects of the tool even though they overwhelmingly found learning experience more interesting than with traditional print textbooks. Participants provided other valuable information through open-ended questions. Most of the participants had no prior experience with similar tools. Half of the students indicated that they would prefer to have such tools on tablet or smartphone devices and a majority answered that their favorite function was to add videos and

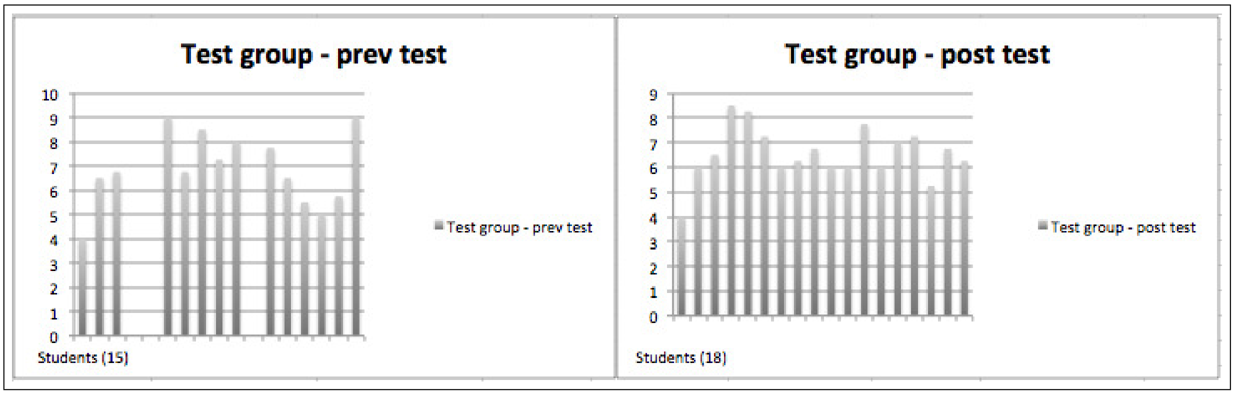


Figure 4.5: Test scores of Test Group (with the tool)

images of their choice to digital text.

Table 4.2: Questionnaire Results per Dimension

| **Dimension** | **Score out of 5.0 max** |
|---|---|
| Overall user satisfaction | 4.4 |
| Ease-of-use & Aesthetics | 4.0 |
| Usefulness of multimedia annotations and sharing | 4.4 |
| Learning satisfaction | 3.5 |
| Willingness for future use | 3.7 |

#### Quantitative - effectiveness

Quantitative measurement of learning achievement was done through analyzing the test scores of participating students. students were given pre-test and post-test on learning materials. According to the initial plan, both test and control group students were supposed to be given a pre-assessment test of the same materials they were about to learn to evaluate their improvement in learning. However, there was an unforeseen problem of students in control group not having been given the pre-test. Therefore, we collected the test scores of previous tests both groups took as an alternative. The readers of this report should keep in mind that the analysis below is only "tentative" due to this fact. Following Figures 4.5 and 4.6 show the test scores of test group (those who used the annotation tool and e-textbook) and of control group (those who used print textbooks).

There was no significant difference in test scores between the test and control group before and after the experiment according to T-test results

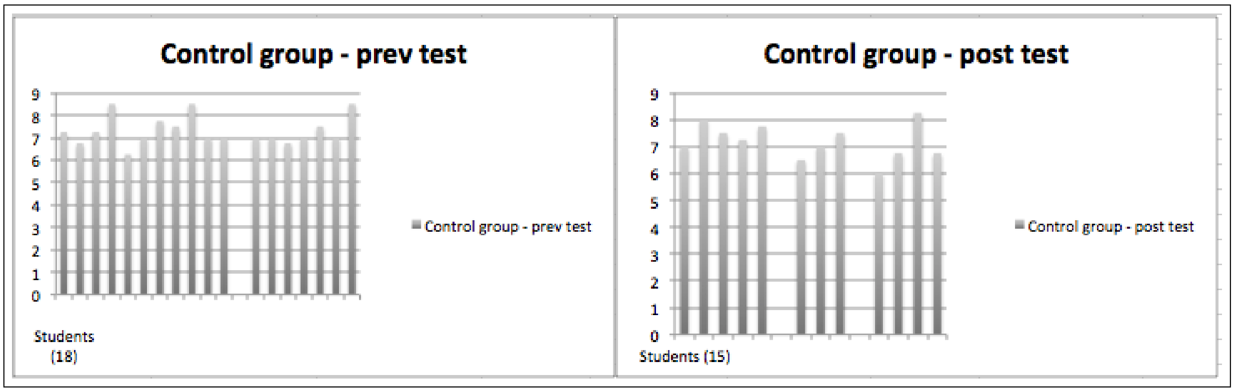


Figure 4.6: Test scores of Control Group

(see Table 4.3). Notwithstanding, the test results gave us a number of noteworthy observations.

- Post-test scores of test group are slightly more evenly distributed than those of previous test: standard deviation of post-test (SD=1.065) is smaller than that of previous test (SD=1.5014). This indicates that the test scores are more closely clustered around the class average than previously. Given the fact that the control group showed no such change (SD=0.6391 and SD=0.6329), we might carefully consider the possibility of sharing annotations having impact in learning performance of the class as a whole.

- The number of failed students in test group decreased from that of previous test: 2 students failed the post-test after using the tool whereas there were 4 students who failed the previous test in the same class.

Table 4.3: T-test results of test group and control group (The max test score is 10. Students who score below 6 are considered having failed)

| | **Previous test** | | **Post test** | |
|---|---|---|---|---|
| **Group** | *Test* | *Control* | *Test* | *Control* |
| # of students | 15 | 18 | 18 | 15 |
| Standard Deviation | 1.5014 | 0.6391 | 1.065 | 0.6329 |
| # of failed | 4 | 0 | 2 | 0 |
| T-test results | **Not significant (T=0.83, p=0.41)** | | **Not significant (T=1.89, p=0.07)** | |

#### Number of annotations Vs. Test scores

The other aspect of the quantitative analysis was to discern if there was any correlation between the number of annotations and test scores. The corre-

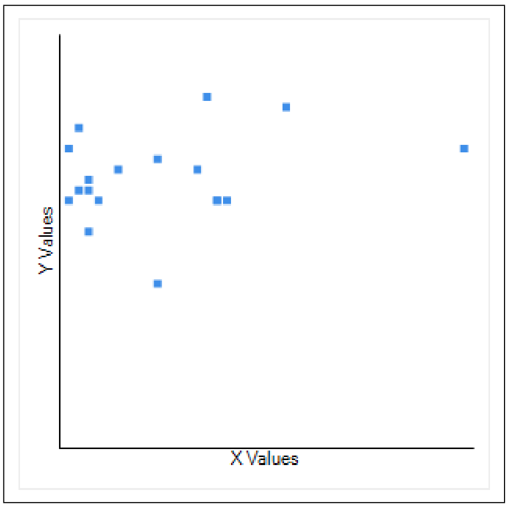


Figure 4.7: Scattered graph of # of annotations (X axis) and test scores(Y axis)

lation was measured using Pearson correlation coefficient [12]. Our analysis showed a correlation coefficient of 0.2671. Although there is a positive correlation (more annotations, higher test score), the correlation is relatively weak. The outliers might have caused this as shown in Figure 4.7. The outliers indicate points that lie far outside from the cluster of other points. In our analysis, the outliers may have come from three scenarios:

- Students scored low in test despite having made many annotations
- Students scored relatively high in test despite having made no or few annotations
- Students scored even lower than previous test despite having made many annotations

Table 4.4 shows the number of annotations and test scores of the test group. Students indicated with an asterisk (*) are the outliers mentioned previously. Once these are removed (student 1, 6, 12, 16), the Pearson correlation coefficient increased from a weak 0.2671 to moderate 0.5216, which means there is a tendency for high number of annotations to go with high test scores.

As far as the types of annotations are concerned, there was a high number of image annotations compared to other types. As figure 4.8 shows, students preferred highlights and images the most, followed by comments

[12] Pearson correlation coefficient varies from -1 to 1. The closer resulting coefficient to the value of 1 (both positive and negative) means strong correlation between variable X and Y.

Table 4.4: Test scores and number of annotations of test group

| **Student** | **Prev. test** | **# of Annotations made** | **Post test** |
|---|---|---|---|
| 1* | 4 | 9 | 4 |
| 2 | 6.5 | 3 | 6 |
| 3 | 6.75 | 2 | 6.5 |
| 4 | absent | 14 | 8.5 |
| 5 | 8.5 | 22 | 8.25 |
| 6* | 9 | 40 | 7.25 |
| 7 | 6.75 | 15 | 6 |
| 8 | 8.5 | 2 | 6.25 |
| 9 | 7.25 | 5 | 6.75 |
| 10 | 8 | 15 | 6 |
| 11 | absent | 16 | 6 |
| 12* | 7.75 | 1 | 7.75 |
| 13 | 6.5 | 0 | 6 |
| 14 | 5.5 | 9 | 7 |
| 15* | 5 | 0 | 7.25 |
| 16 | 5.75 | 2 | 5.25 |
| 17 | 9 | 13 | 6.75 |
| 18 | absent | 1 | 6.25 |

and Web pages. The usage of the video was not observed even though the questionnaire (see Section 4.3.2 results showed that students were most interested in using image and video annotations. The possible reason for not using videos could be the lack of time to view videos during lectures. Students made annotations only during lectures in this experiment even though they were encouraged to use it for home assignments.

#### Possible effects of variables and interpretations

The quantitative analysis showed that using the annotation tool did not result in significant improvement in test scores when compared to control group who used print textbooks with no digital tool. Similar findings were reported in several studies like [143, 97, 122]. Nevertheless, a positive correlation, though not significant enough, between the number of annotations and test scores was demonstrated. This result agrees, to much lesser degree, with [32] in which it was claimed students who made annotations using e-textbooks outperformed those who used print textbooks.

There were several variables in the experiment that may have had impact on the results. Below we provide some of those we believe were most important.

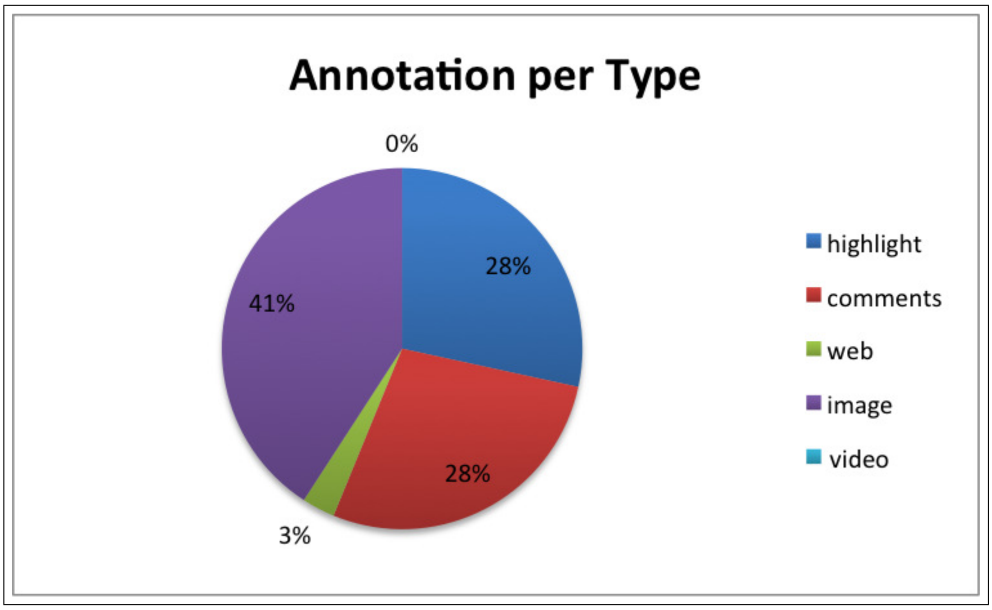


Figure 4.8: Percentage of annotations per type

- **Exclusive usage during lectures**: according to the logging time sessions, students used the tool exclusively during lectures. This could have undermined the potential benefits of using the tool in terms of learning outcomes. The tool was designed to be used also after school as a means for students to build their personalized relationship with the given material through spending time searching for and adding on annotations. However, this did not take place despite the home assignments given during the experiment. Annotations made during the lecture may have acted as distraction and of bad quality as students are pressed for time.

- **Quality of annotations**: almost all annotations were made during the class. Therefore, most of the annotations were of scant quality in terms of how they truly represented and supplemented the main content. A majority of comments made by students were not related to the learning material but more of general chat with fellow students. Pearson correlation test shown in Table 4.5 demonstrates that mere highlighting text or comments yielded much lower correlation coefficient that that of images. Quality of annotation seems to be correlated with the test performance, more so than the number of annotations made by each student. Students who made meaningful and related annotations to the text scored relatively high in post-test meanwhile some students scored low even though they have made quite a few annotations.

- **Unfamiliarity with the tool**: Due to the short period of the testing, students may not have fully grasped the functions of the tool to realize its full potential. Even though the multimedia annotations was the key subject for this experiment, there were numerous other functions such as automatic summary, key concepts and key entities and asking questions. The tool also offered automatic generation of all annotations made by the students in pdf format, intended to be used as the "study cards" before the exam but none of these functions seems to have been utilized during the experiment.

Table 4.5: Pearson Correlation Coefficient per Annotation Type

| Type | Image | Comment | Highlight | All |
|---|---|---|---|---|
| Correlation | 0.4648 | 0.1431 | -0.0644 | 0.2671 |

## 4.4 Related work

Quite a few studies have examined the effectiveness of learning with e-textbooks in the recent years. Some of such examples are [122], [143], [97], and [33]. Shepperd et al. compared the performance of students studying Psychology in terms of the total time spent studying and the final course grade. The results showed that there was no significant difference in the learning outcomes although it was shown that students spent slightly more time studying the print textbooks than the e-text [122]. Similarly 2 years later, Woody et al. involved 91 university level psychology students in their experiment to find out if using e-textbooks had any impact on academic performance. Even though students overwhelmingly stated they preferred print textbooks, they found no significant difference in the learning outcomes between the 2 mediums [143]. A study by [97] reported the same results in 2011.

All studies mentioned above, however, focused on simply measuring the performance without the regard to the tool using e-text involved during the experiments. It is not very clear if students were also given a tool to aid their studies with e-textbooks and if having such a tool had any impact on the outcome. Interestingly, a very recent study carried out by Dennis in 2015 reported that his experiment showed the students who used e-textbooks performed better and specifically those who used annotations outperformed the others who used print textbooks [33]. Our experiment did not show the same results as there was found to be no significant difference in learning performance between the test and the control group although there seems to be a tangible correlation between the number and quality of annotations and the exam scores (see Section 4.3.2). To our best knowledge, however, our study is the only one that offered some insights into the quality and types of annotations students prefer and use when given a free choice to annotate text with multimedia.

As far as our prototypical tool that supports multimedia annotations is concerned, we found just one similar tool, Annotation Studio [13], created by the HyperStudio of Massachusetts Institute of Technology. The tool was developed to address the lack of multimedia annotation tool for electronic learning materials used in classrooms. Annotation studio helps students to discover how "literary texts can be opened up through the exploration of sources, influences, editions and adaptations" [64].

Annotation studio consists of two components. The first is the user-facing web application written in Ruby on Rails, Backbone.js to handle documents and the second is RESTful web API written in Node.js and MangoDB to handle users' annotations for storage and retrieval [40]. The user interface is showcased in Figure 4.9. Once the user logs in, they can select from given HTML documents and highlight a text to add textual or multimedia annotations, which can be shared with other users who are studying the same document. Test with annotation is highlighted and the annotation can be viewed in-line on mouse-hover. Multimedia annotations such as image, video or audio can be added via direct URL input.

The quantitative assessment of using this tool on learning outcome is not available. They performed user surveys, observations and interviews during the Fall 2012 and Spring 2013 semesters to find out qualitative assessment of user satisfaction and usability. The results showed that students were more engaged with the text and the tool helped them do their writing assignments [40].

Though this tool satisfies the necessity of an annotation tool for e-text that harnesses the benefits of both annotation and multimedia, there are still some advantages our proposed tool offer in comparison. First of all, this tool does not support the widely used e-textbook format such as EPUB our tool supports. All learning materials (MS-DOC, HTML, pdf sup-

[13] https://www.annotationstudio.org/

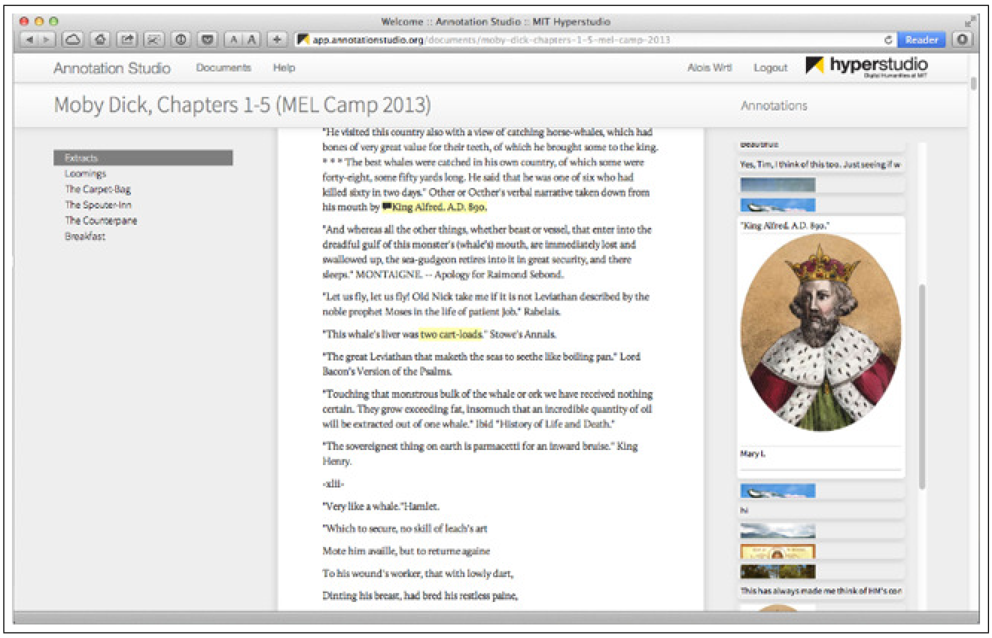


Figure 4.9: Annotation Studio Interface

ported) need to be converted to HTML format and mostly created and uploaded by the teachers themselves. Moreover, the annotation activities students can perform is limited to simply adding annotations. Our tool, on the other hand, offered various types of learning aids such as automatic summary, keywords and concepts, asking questions, study cards generated from annotations etc. Furthermore, adding multimedia annotations to Annotation studio is cumbersome as the user needs to add the URL into the source directly, meaning they would probably need to open another browser to search for materials and copy the URL. In our tool, multimedia annotation search and select functions are embedded, making it easy for users to simply view and select without having to leave the window. Lastly, our tool displayed annotations per their types. Videos, images and comments were grouped separately and users could view them by their type.

Though multimedia annotation is not supported, there is another similar collaborative annotation tool developed by Harvard University that is catching popularity in recent years. The tool is called Perusall [14] and is intended to foster students to prepare for class lectures via annotating e-

[14] https://perusall.com/

textbooks before the lectures. According to their experiments carried out with undergraduate students enrolled in an introductory physics course for the period of two academic semesters, students who used their tool for pre-reading assignments spend more time reading and performed better on in-class exams than the students who did not use the tool [93]. Differently from the Annotation Studio, Perusall supports PDFs and EPUBs as well as textbooks published by various publishing houses - list of publishers available on their commercial website - and students can access them either short-term or long-term according to their needs.

# Chapter 5

# MemoryLane: context in organizing and retrieving bookmarks

## 5.1 Intro and detailed problem definition

As previously argued in section 2.4.2, the underlying difficulty in refinding information after a longer period is not so much the method of organization, but memory loss. In other words, over time people forget accurate or complete (semantic) information – such as keywords, folder names or tags – to refind what they need. Current bookmarking tools that rely on semantic information come to little aid in such situations, as there are no other alternative cues to navigate around the bookmark collection. Based on studies by prominent psychologists [136, 135], we could argue that these bookmarking tools are somewhat detached from the way how information is retrieved in human brains, where semantic and episodic information work together to represent blocks of memory.

While context is being progressively considered paramount to effective information retrieval in fields like PIM (Personal Information Management), search and history tools (see Section 2.4.4), its importance is barely acknowledged in bookmarking tools. Furthermore, the types of context used in various existing tools are not only limited, but also arbitrarily selected, without sound empirical grounds. In this experiment, we aim to answer the following research questions in a tentative pursuit of discovering the positive impact contextual cues, as well as which contextual cues, can bring to improving organization and retrieval of bookmarks, especially as the antidote to semantic memory loss.

1. Which type of context information do users perceive as important about the Web pages they visit?
2. Which type of context information do users use for their bookmarks and are there any differences in the types for different type of Web content?
3. Which type of context information do users use to retrieve their bookmarks and are there any discernible reasons for doing so?
4. Does using context information improve quantitatively or qualitatively the performance of retrieval? If it does, in what dimensions?

## 5.2 MemoryLane - tool description

For this experimentation, we developed a context-based bookmarking tool, MemoryLane, initially proposed by Hwang and Ronchetti in 2016 [63]. Memory lane aims to provide a more efficient bookmaking management and retrieval method by optimizing the synergy between the semantic and contextual cues. As conceptualized in Figure 5.1, each bookmarking event is treated as a personal "episode" that constitute its own 5W1H: the *what* refers to the semantic aspect of the Web page whereas the *why, where, when, who and how* to the contextual aspect of the event.

MemoryLane makes context-specific tags available, using which users can organize and retrieve bookmarks in an intuitive and graphical interface. Unlike other available context-based tools, MemoryLane makes available both semantic and contextual retrieval cues, which can be effectively used to trace back via multiple pathways by anything users remember over long term.

Not limiting context to an arbitrarily chosen subset, MemoryLane offers a wide range of context, which is largely, though not entirely, based on the study conducted by Bischoff et al. that provided insights into what type of contextual information was being used as tags in Web pages, music and images [17]. Table 5.2 shows the mapping of tag classification by bischoff et

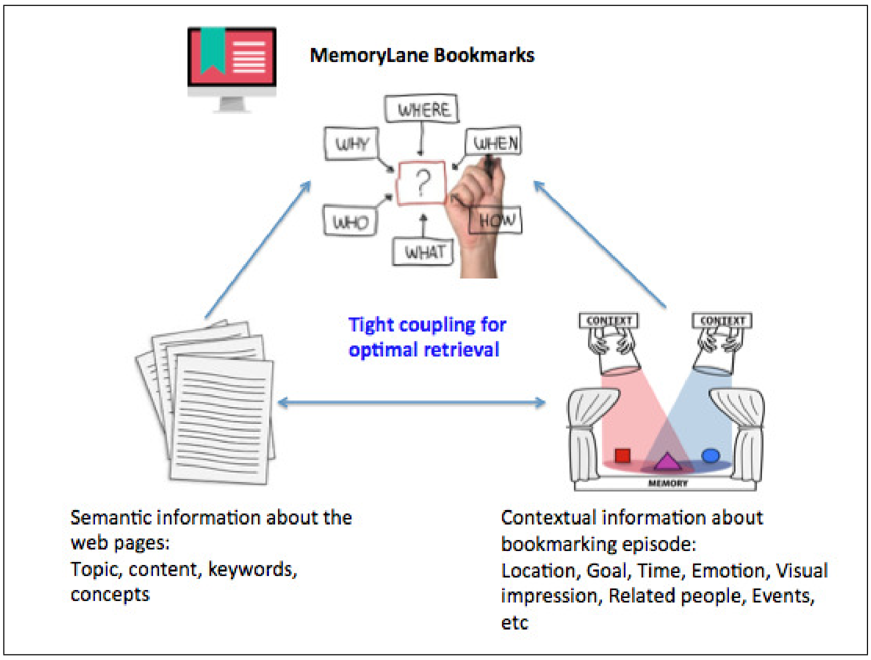


Figure 5.1: MemoryLane: Concept

al. [17] to that of MemoryLane along with how each tag data is extracted and selected by the tool.

### 5.2.1 User interfaces

MemoryLane offers two different user interfaces - one for saving and another for searching bookmarks. Both interfaces are graphical and provide user-friendly and intuitive functions.

#### Bookmark Saving

When a user clicks on the MemoryLane extension icon located top-right of the browser, he or she is shown a bookmark dialog. Each bookmark is comprised of its "semantic" and "contextual" parts as shown in Figure 5.2. The semantic part deals with elements related to the content of the Web page, whereas the contextual part attempts to capture the user's episodic context. By providing both semantic and contextual cues that can be associated with a bookmark, MemoryLane aims to maximize the likelihood of users' finding a viable path back to the source of information,


Figure 5.2: MemoryLane: User Interface of Bookmark Dialog

as demonstrated by the study done by Kelly and Chen, in which they showed people recalled best when both content-based and contextual cues were provided [70]. Users are given freedom as to which type of context they choose to use. Table 5.1 provides the details of the key elements and how they are used. Once users fill out the fields they find relevant and useful, they can click on the "Save Bookmark" button to save it. Users can also directly go to the Homepage or log out from this dialog.

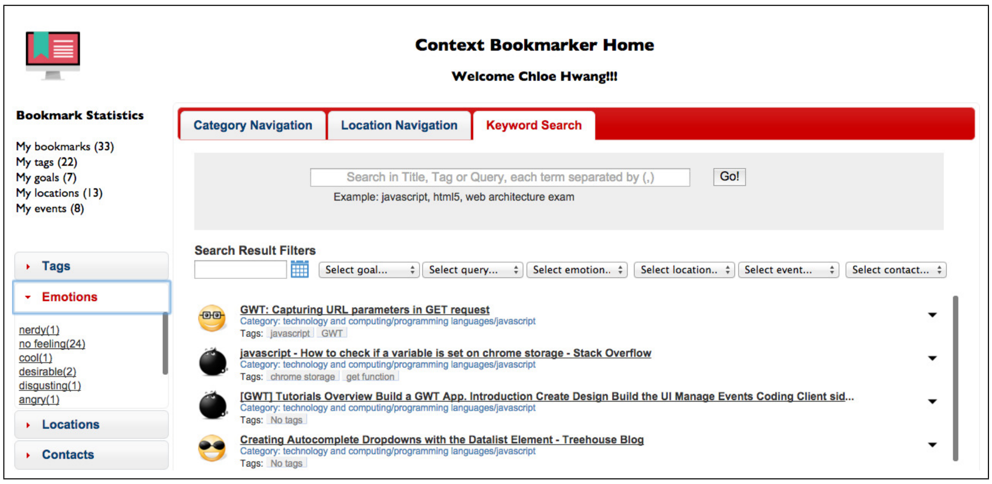


Figure 5.3: MemoryLane: User Interface of Keyword Search

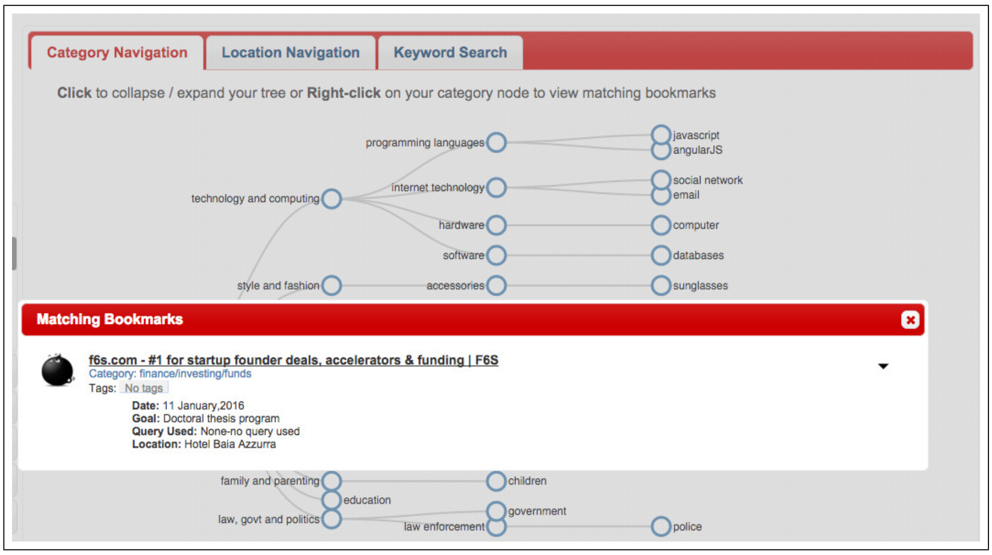


Figure 5.4: MemoryLane: User Interface of Category Navigation

### Bookmark Search

MemoryLane provides powerful and browsing-oriented search by any fragment of contextual or semantic cues in both textual and graphical dimensions. Users can search for bookmarks by entering complete or partial titles, tags, or search queries, or simply browse bookmarks by single or multiple filters (date, goal, search query, emotion, location, event or people) provided in the interface, as shown in Figure 5.3.

Each bookmark is displayed with its emoticon, title, category and tags with the possibility to expand the list view by clicking on the down-arrow icon to show more details such as goal, people and event. Users are also given the possibility to browse by a single contextual factor, which is supported in 3 additional graphical interfaces: Category navigation (Figure 5.4), Location navigation (Figure 5.5), and Image navigation (Figure 5.6).

- ***Category Navigation***: thanks to the auto-generated category for each bookmark, users are given a comprehensive and graphical taxonomy tree of categories which they can browse in order find their their bookmarks. The category tree can be collapsed or expanded by a click and right-clicking on any node opens up a dialog containing bookmarks belonging to that particular category as showcased in Figure 5.4.

- ***Location Navigation***: geographical locations associated with bookmarks are visualized as place markers on a Google map. Right-clicking on a marker opens a dialog that displays all the bookmarks belonging to that location. Figure 5.5 demonstrates

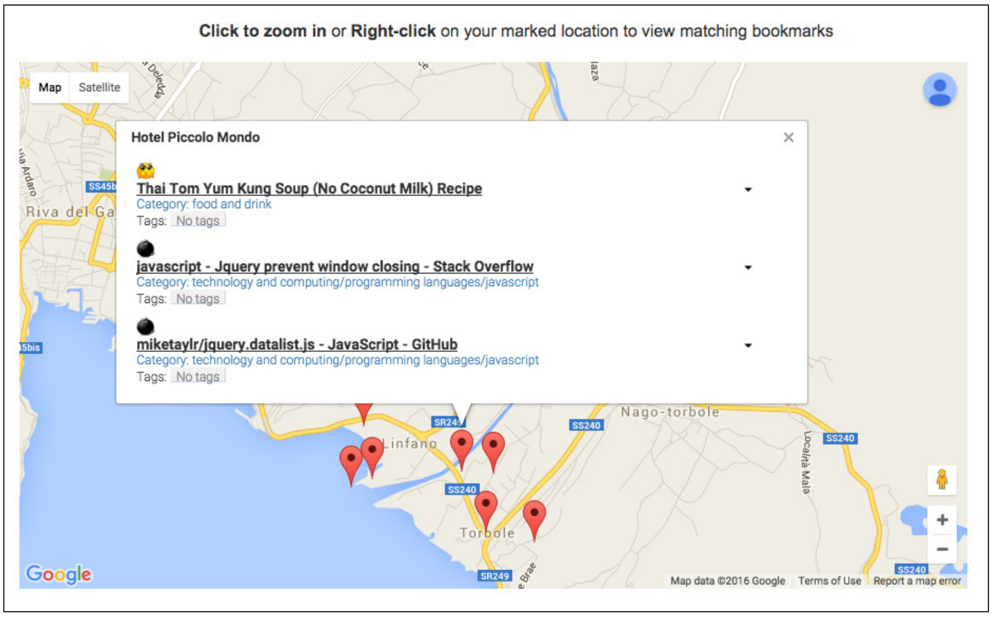


Figure 5.5: MemoryLane: User Interface of Location Navigation

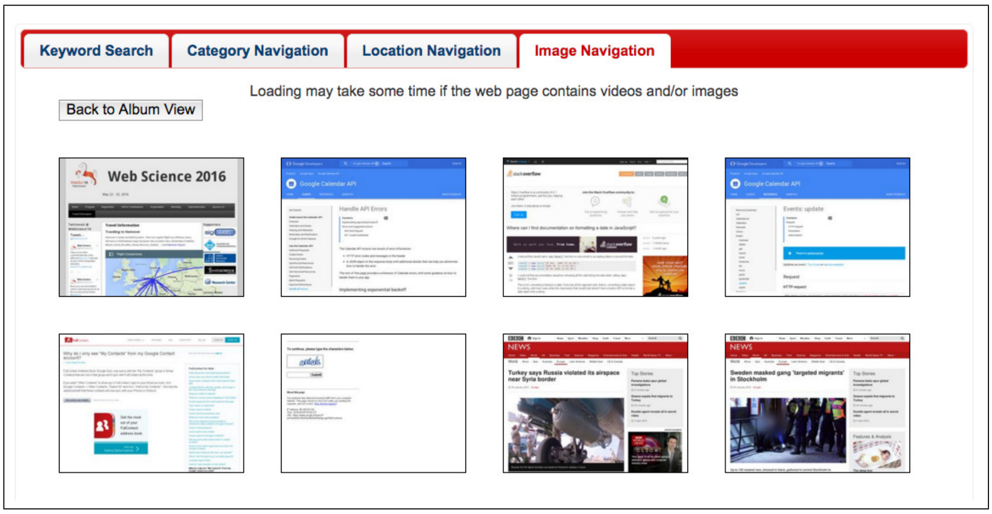


Figure 5.6: MemoryLane: User Interface of Image Navigation

an example. This feature not only offers a unique way of bookmark-browsing but also gives a sense of geographical distribution of places that are represented by information most interesting and useful to the users.

- ***Image Navigation***: last but not least, users can browse their bookmarks by their "visual" impression as shown in Figure 5.6. MemoryLane captures the screenshot of each bookmarked Web page automatically, o enable users to find their bookmarks even when they have forgotten all semantic or contextual cues.

As discussed above, MemoryLane offers several visualized interfaces for selected metadata, chosen based on its navigability. Users are found to prefer navigation to direct search [15, 132]. Therefore, we hope to observe how users exploit various navigational interfaces for their bookmark retrieval.

### 5.2.2 Architecture and implementation

MemoryLane is a Chrome extension built using HTML5 and JavaScript that users can add onto their browser. They can bookmark Web pages by clicking on the tool icon. MySQL is used for storing bookmark data and a back-end application server handles all data requests via custom-made REST service APIs over HTTP. The architecture of the system is as shown in figure 5.7.

The Google Identity Platform API [1] was selected for the user log-in process, because it offers secure authentication and access to various services such as Google contacts and calendar. Various Google and external APIs (Google Calendar API [2], Google Contacts API [3], Google Places API [4], and Alchemy API [5]) were used to present personally relevant context to the users. Table 5.3 shows the details of the implementation of each bookmark element. MemoryLane's homepage described in Section 5.2.1 is a Web page built with Javascript and HTML5. Google Maps API [6] was used to display locations on the map and category visualization was rendered using D3 - Data-Driven Document library [7].

[1] https://developers.google.com/identity/
[2] https://developers.google.com/google-apps/calendar/
[3] https://developers.google.com/google-apps/contacts/v3/
[4] https://developers.google.com/places/
[5] https://www.ibm.com/watson/alchemy-api.html
[6] https://developers.google.com/maps/
[7] https://d3js.org/

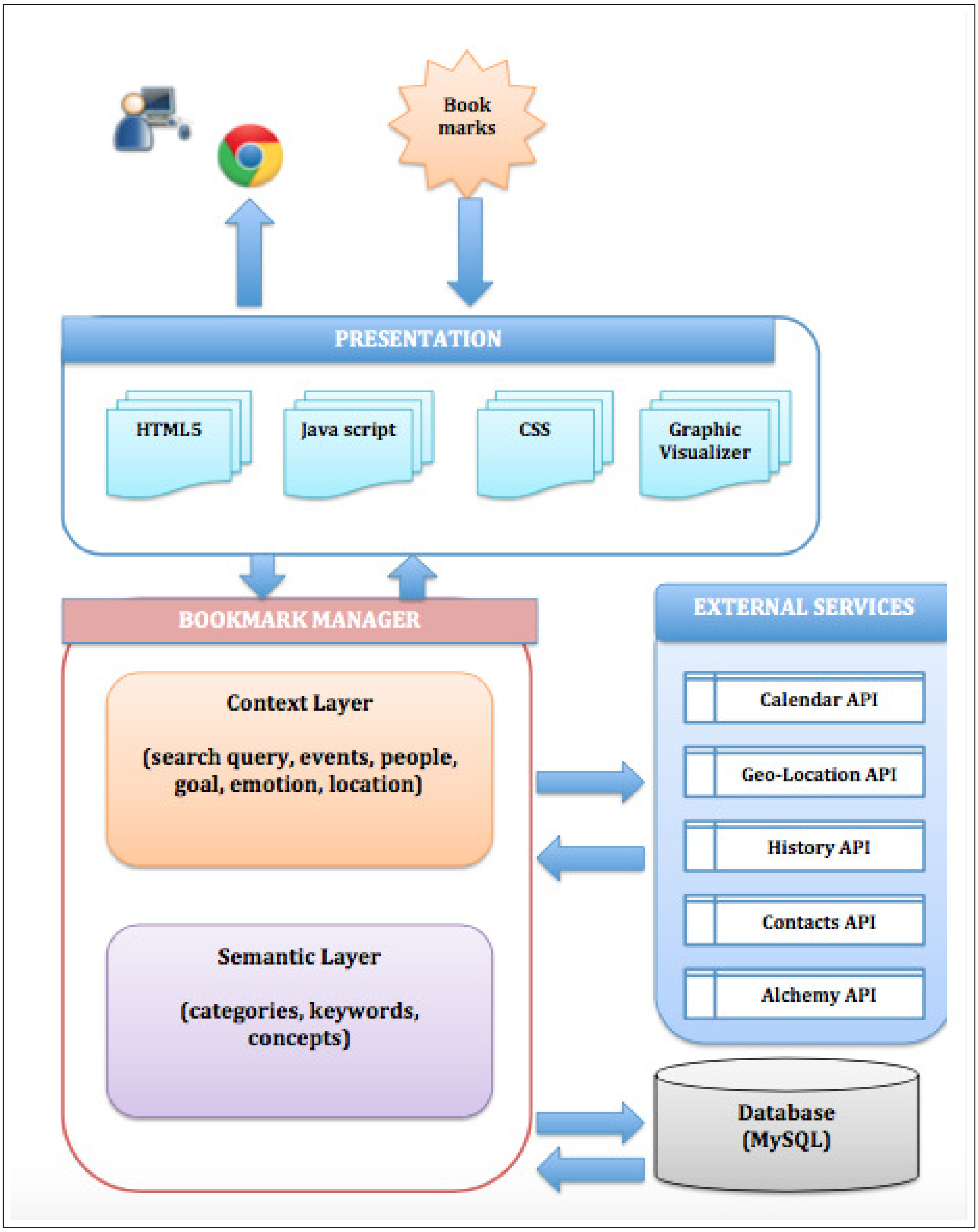


Figure 5.7: MemoryLane: Architecture

## 5.3 Memorylane experiment and its results

In this section, we provide the details of the user experiments that have been carried out in three different stages to discern how, when and in which way contextual information could be used to improve the organization and retrieval of bookmarked Web pages. Specifically, the study is focused on discerning how important people perceive context to be for information retrieval, how people actually use context in their bookmarks, and finally how people use context to retrieve their bookmarks.

### 5.3.1 Methodology

Three different stages of user experimentation were carried out to gain understanding of the perceived and actual role of contextual cues in the organization and retrieval of bookmarks. The detailed methodology of each phase is described in detail in subsequent sections.

#### Stage I: Online Survey

An online survey was carried out to gain understanding of how users are making use of existing bookmarks. Specifically we wanted to discover the preferred method of bookmark organization and the difficulties faced in the retrieval. Moreover, participants were asked to provide the reason for difficulty in refinding their bookmarks and what other types of information they believed they would remember about web pages after a time-elapse. A total of 120 users participated in the survey, divided into two age groups, as shown below, to discern the differences in results (if any) between the group of students and young professionals on the one hand and the group of middle and advanced professionals on the other hand.

- Group A: aged between 30 to 49 (36 responses)
- Group B: aged between 18 to 29 (84 responses)

All participants were experienced Web users, though not all were in IT-related fields. The list of questions is provided in Table 5.4.

#### Stage II: Bookmarking with MemoryLane

The second part of the experimentation was performed with 10 users bookmarking Web pages with MemoryLane tool over a period of 4 weeks. The focus of this phase was to find out what type of contextual cues users actually associate with their bookmarks when they were given the free choice. Before the experiment, users were provided with a detailed user guide on how to install MemoryLane and use the tool. A total of 160 bookmarks were saved at the end of the experiment. The participants were advanced Web users, aged between 25 to 35, from the department of Computer Science at University of Trento, Italy. All participants were given freedom to bookmark any Web page they wanted, but 6 of them were given an additional list of 10 premeditated questions for which they bookmarked Web pages as answers, in order to take part in the third part of the experiment. The given set of questions covered areas ranging from work-related to personal ones, as demonstrated in Table 5.5.

#### Stage III: Comparative Bookmark Retrieval

The last phase of the experimentation was performed with 6 selected participants, 3 females and 3 males aged between 25 to 35, who were advanced Web users. During Stage II, they were asked 10 specific questions (see table 5.5) for which they bookmarked two different answers per question: each user bookmarked a total of 20 unique pages, of which 10 were done with MemoryLane and the rest with the default bookmarking tool in Google Chrome browser. This controlled user testing was intended to measure quantitatively the performance of bookmark retrieval with MemoryLane in comparison with another tool after a time-elapse of 3 weeks. The comparison tool was not specified but all participants chose to use the Chrome browser tool, because that is what they normally use. During the third part of the experiment, users were asked to perform specific tasks as shown below.

- Users were asked to retrieve the answers they had bookmarked 3 weeks earlier for each question. Questions were asked in a random sequence.
- When each question was presented, users were asked to tell the moderator what they recalled about the answer.
- Then users were asked to retrieve their bookmarks using both MemoryLane and Chrome browser tool. The moderator recorded time of both attempts and also how users retrieved their bookmarks using MemoryLane.

The experiment was carried out as individual interview-session for each participant and each session lasted about 40 minutes on average. After the session, users were also asked to provide free-form qualitative feedback on the usability of MemoryLane.

### 5.3.2 Results analysis

In this section, we attempt to answer our research questions posed in section 5.1 by reporting the results from the experiment with a focus on the role and impact of contextual cues in the organization and retrieval of bookmarks. The results and our analysis are divided into three parts according to the stages. The key findings and their implications are discussed at the end of this section.

#### Online Survey Results

The results of our survey with 120 participants confirmed many of the findings from previous studies. Bookmarking was still the primary technique used by most users across the age groups, though the percentage seems to have declined since those of previous studies. An overwhelming number of users preferred to organize their bookmarks in folders rather than tags, though the younger group was slightly more open to using tags. The older group kept a larger bookmark collection than the younger one and they experienced difficulties finding their bookmarks significantly more often than the counter group, due to "memory problem". Users overall perceived context as important, albeit with differences among types of context. The following list details each finding along with some insights into the contextual information users considered important.

- **Bookmarking is still the primary refinding method**: the majority of both group A (age 30-49) and group B (age 18-29) used bookmarking as their primary method of keeping useful or interesting information found on the Web: specifically, 77.8% of group A and 63.7% of group B relied solely on bookmarks and they normally used the default bookmarking tool available on their favorite browsers. This confirmed the finding by earlier studies that most users use the bookmarking tools found in their browsers; however, the figures are lower than 80% [110] and 92.4% [10], notably smaller in the younger age group. Interestingly, a higher number of the younger group B (19%) said that "they do nothing" than the older group (10.8%). When asked why, both groups replied that they were confident they would refind information using search engines or auto-completion of url in browser. The remaining alternative refinding techniques were writing down urls, keeping tabs open or downloading the Web pages into a local folder.

- **Folders are preferred over tags**: both groups showed a strong preference for folders over tags (61.8% and 65.9% respectively), which seems to support the claim that folders are better than tags for organizing resources [16]. Only 5.9% of the group A said they organized bookmarks only with tags, whereas 13.4% of group B said so. The younger group appears to be more open to the concept of tagging; however, they also kept fewer bookmarks than the older group with just 33.2% keeping more than 50 bookmarks in their collection.

- **Users face difficulty in refinding because they cannot remember**: While group A said that 41.2% had difficulty finding their bookmarks, group B said only 25% experienced such difficulty. This gap may be explained by the fact that the younger group were more confident in refinding information using search engines and auto-completion of url or it could simply mean that they retain memory longer than the older group. As far as the cause is concerned, both groups had difficulty most due to "memory problem" - they forgot the name of folders or tags they used with 60% of Group A and 54.8% of Group B. Still, about 30% of group A and 47.6% of Group B said that they remembered the name of folders or tags but they got lost because there were too many bookmarks in the folder or by the same tag to sift through. This finding re-affirms the proposition that long-term revisitation is rather a "memory problem" as we discussed in section 2.4.1.

- **Users rely on search engines when they cannot find what they are looking for**: 77% of participants from both group A and B said that they try to refind using search engines when they get lost in their bookmark collection. They added that they usually try to recall the keywords and perform several searches until they locate what they are looking for. This is in agreement with study results by several researchers, as discussed in section 2.4.1.

- **Users perceive different types of context with varying importance**: participants were asked about the information they believe they would remember after a significant time-elapse. They were given a list of options to choose from and the results are shown in Table 5.6 - since multiple choices were allowed, the total percentage does not tally to 100%. Both groups said that topic (65.7% and 72.6% respectively) and goal (62.9% and 65.5% respectively) were the things they would remember the most. How they found the Web page (i.e. search query they used, shared by a friend or a random encounter) was also considered important by both groups (31.6% and 33.3% respectively), followed by the expected time of revisit, emotions, location and time. This perceived importance of different types of context is compared, in the next stages of this study.

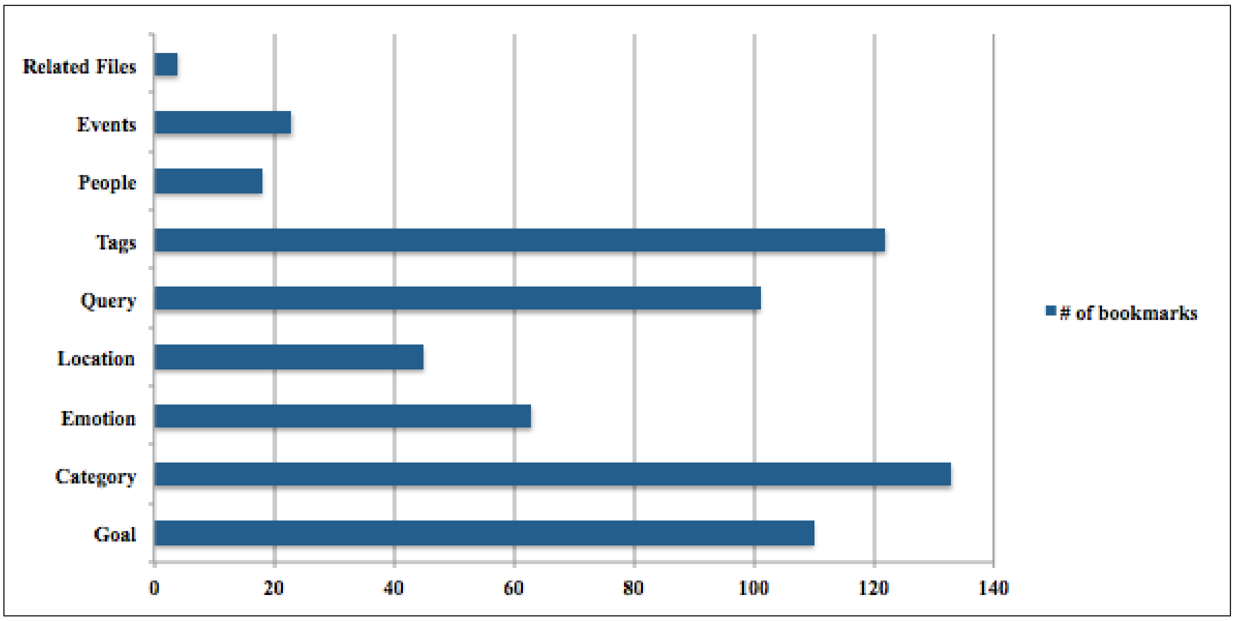


Figure 5.8: Bookmark Collection: Number of Bookmarks per Metadata Type
* Note: Time (date-time) is not included in the figure because it was automatically added to all bookmarks

**Bookmark Collection Analysis**

A total of 160 bookmarks were collected over a period of a month using the MemoryLane tool. Below outlines the analysis of bookmarks and findings. Interestingly, users used different sets of contextual information based on the content being bookmarked, while semantic information was used rather consistently, regardless of the type of content. Figure 5.8 shows the number of bookmarks that users added for each type of contextual and semantic cues. Furthermore, the type of contextual cues used for different category of bookmarks were also discernible, as demonstrated in Table 5.7, and explained in more details below.

- **Frequently used bookmark metadata**: Category, search query and tags were added frequently, but this could have been caused by the tool providing such information automatically to users. Among the information needed to be inserted or selected manually, the goal was most frequently used, followed by emotion and location. These results are similar to what was perceived as "memorable" by the users shown in Table 5.6, however with some differences. Notably, emotion and location were used more frequently than what users had considered. Time, which is used in most available context-based systems, was used least; reminders of predicted future revisits were used for some work or study related bookmarks. Similarly, people and

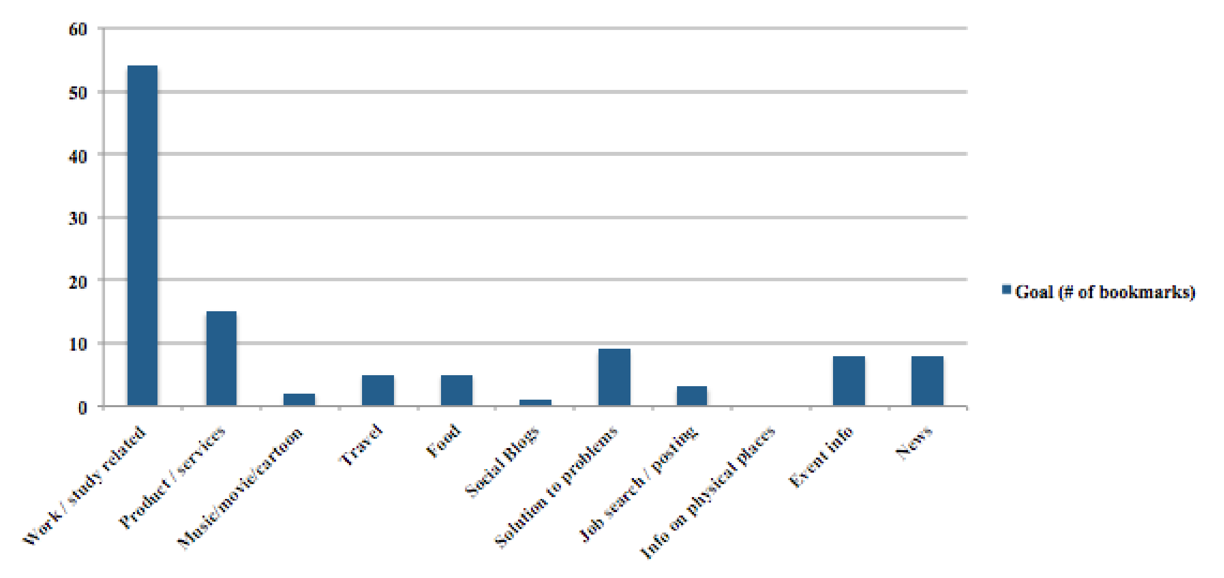


Figure 5.9: Numer of Bookmarks with Goal per Category

related files were used rarely and mainly for work or study related bookmarks.

- **Usage of goals**: Goals were used predominantly for work/study related bookmarks, followed by product/services and the category 'solutions to problems'. This is consistent with our expectations, as people search for information with a clear goal in a working environment. This can be closely related to the study results on university email retrieval, where people remembered the purpose of the work emails more clearly over a long period of time, suggesting that refinding of older information would be more effective by a filing system organized by reason or topic [39]. As far as products/services category is concerned, people used goals to represent their intention of purchase, for instance, "buy a new phone" or "birthday gifts". Finding a solution to a problem is also a targeted search for information; hence users put goals such as "fix battery problem". The other categories of web contents – such as entertainment (music, movie, cartoon), news, travel and food – did not often have any associated goals probably because this type of content is frequently discovered by non-directed free browsing rather than a focused search. Figure 5.9 depicts the usage of goals per category type.

- **Usage of emotions**: Emotions were more often used than initially expected, given the survey results (see Table 5.6). Specifically, emotions were strongly expressed for news and product/services web contents. Positive emotions were observed across all categories, whereas negative emotions depended on the tone of the web pages, such as news, or the level of user satisfaction for content related to their work or solution to problems. For instance, news articles about Brexit or the refugee crisis were associated with "angry" or "sad" emotions while users expressed "happy" for

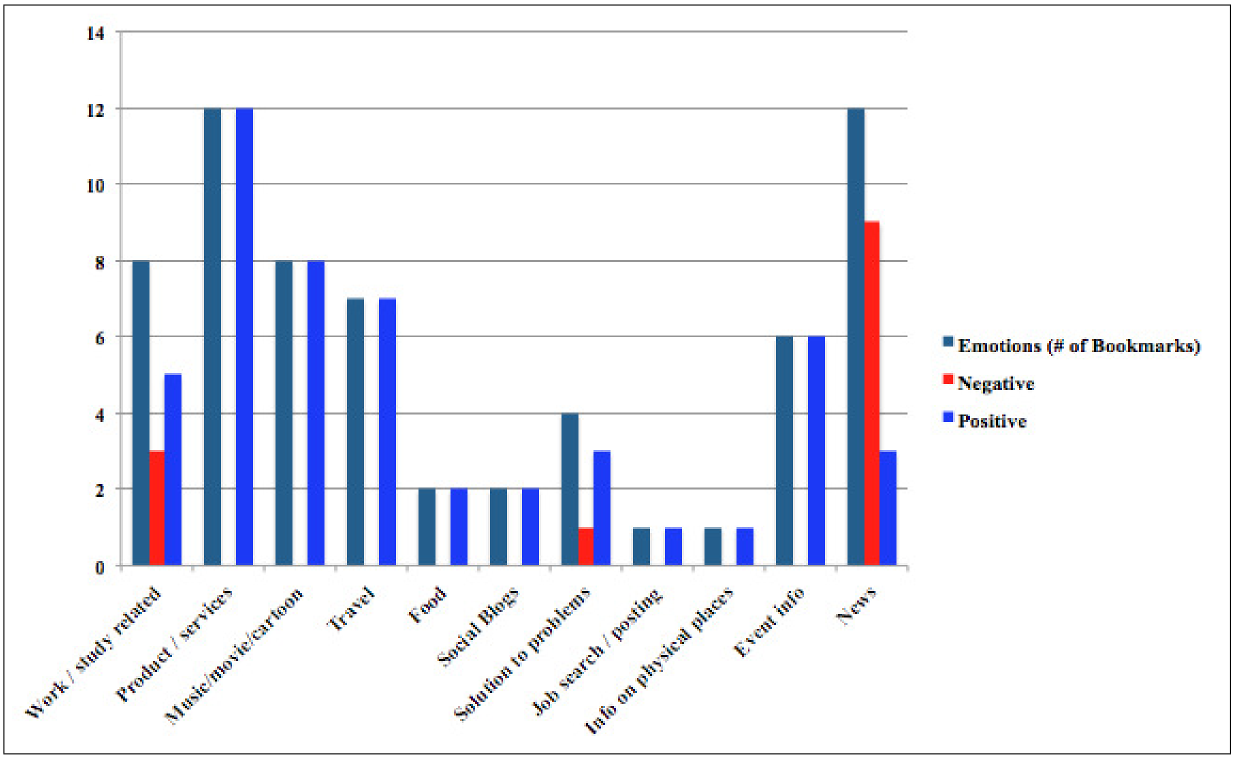


Figure 5.10: Numer of Bookmarks with Emotion per Category

contents about gifts, music and vacation places. Work or study related contents were mostly associated with no emotion. Overall, users mainly expressed emotions for contents related to them on a personal level. The complete results of usage of emotions is shown in Figure 5.10.

- **Usage of locations**: Locations were used for two different purposes: the current location of the user and the geographical location expressed in the web page content. The bookmarks showed that most of the work or study related contents were tagged with current location of the user, but the web pages with specified locations like global news, location-specific events and travel destinations were marked with the geographical locations, as shown in Figure 5.11.

- **Usage of events, reminders, people and related files**: Events, reminders, people and related files were among the least used contextual information, mainly used for work or study related content. Few reminders were set, although the survey results showed that about 16% of the participants said they would remember the next time of visit (see Table 5.6). This could point to the fact that users do not often anticipate when they would revisit bookmarked web pages, but tend to keep them for unknown future needs. In fact, the primary purpose of users' bookmarking behavior was revealed as "to have quick access to information they found useful or

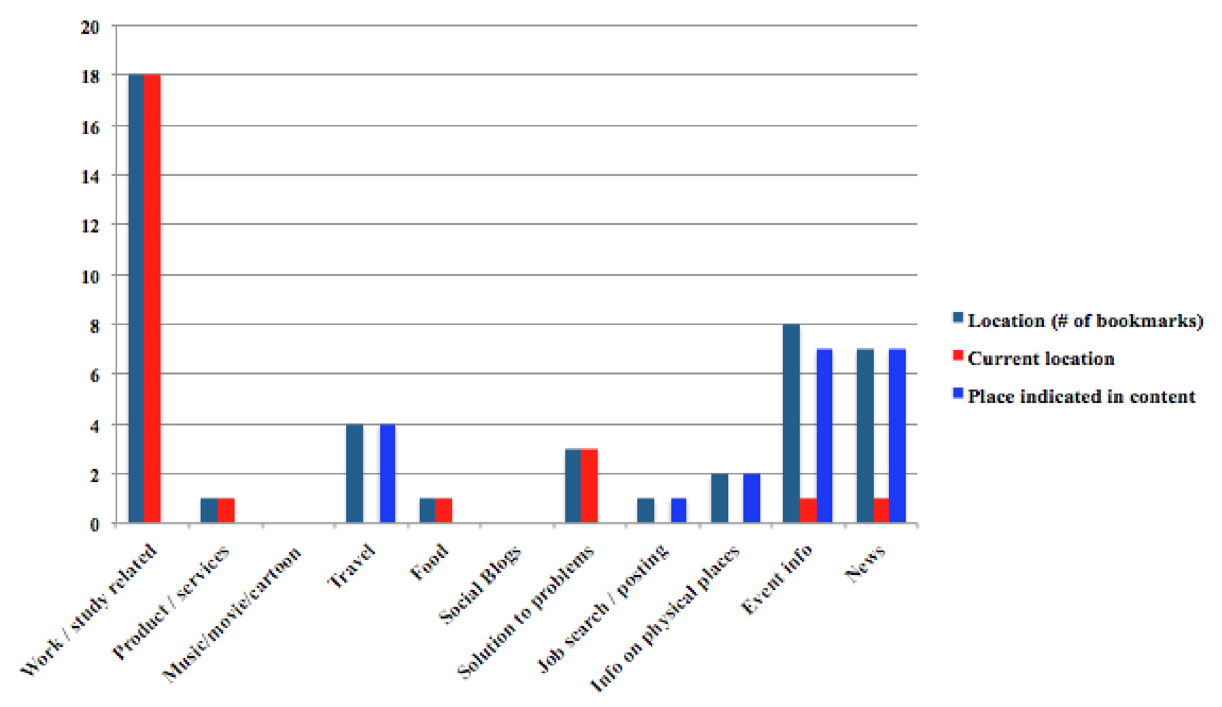


Figure 5.11: Numer of Bookmarks with Location per Category

interesting" [137]. People were also rarely used nor were considered important in the earlier survey. One reason for this might be that web pages are not often associated with a particular person in comparison to other digital resources, such as emails, which require people as "senders".

### Bookmark Retrieval Results

In this section, we discuss the findings from 60 bookmark retrievals performed with six selected users who also participated in Phase II (see section 5.3.1) of the experiment. The details of retrieval tests were already described in the previous section 5.3.1. Overall, the retrieval performance in terms of time using the MemoryLane and Google browser tool showed no significant differences. However, some noteworthy difference was seen in the retrieval success rate between the two tools, in close correlation with the quantity/quality of the recalled information about the target Web page. Moreover, the type of retrieval cues used somewhat depended on the content of the Web page and its personal pertinence to the users.

We present the results from three different angles. First, we discuss how contextual cues were instrumental to successful retrievals of bookmarks when users could not remember accurately the specific keywords or the topic. Next, we lay out which type of semantic and contextual metadata were used as retrieval cues from the most to the least frequent. Lastly we present the findings on the comparative retrieval performance in time between the two tools. Then we wrap up this section with discussion on possible implications our results may have for context-based tools in information search and retrieval.

**Quality of recall and its relationship with retrieval success** Participants were asked to recall any information about the target web page before their retrieval attempts. The quality of recall was measured based on the self-reported specificity and accuracy of recalled information and was divided into three cases: "Accurate and specific", "Vague", and "None". Out of 60 retrieval attempts, 17 were recorded as "specific and accurate", 28 "vague" and 15 were "none". These numbers seem to confirm that most users tend to forget the specific details apart from the top-level summary over time. Below snippets provide real user examples for each of the cases:

- **Case "Specific and Accurate"**: participant remembered specific keywords accurately and was confident.

  > **Interviewer**: Can you tell me something about the most interesting news you bookmarked?
  > **Eleonora**: Yes, it was about Brexit. I am sure of it.

- **Case "Vague"**: participant recalled something, but was not sure if it was correct or the recalled information was too general to be a useful search keyword.

  > **Interviewer**: Can you tell me about the recipes you wanted to try?
  > **Zeno**: Mmmmm.... I am not sure about it. I think I found it on a news website like BBC or on a food blog, but I am not sure.
  > **I**: Can you remember the folder name you might have used?
  > **Z**: No. I have probably chosen something like "Food", but I am not sure.

- **Case "None"**: participant could not recall anything.

  > **Interviewer**: Can you tell me about the new phones you wanted to recommend?
  > **Cristina**: New phones... I remember googling it, but I cannot remember anything about the phones I liked.

When users recalled specific and accurate information, the success rate of retrieval was at 100% equally with MemoryLane and Chrome bookmarking tool. However, there was a notable difference in the success rate between Chrome and MemoryLane when users recalled little or none, as shown in Table 5.8. Contextual cues indeed played a role in helping participants to find their bookmarks when they recalled little or none about the content. In particular, they served as "starting points" of navigation when participants felt lost due to lack of semantic recall. We present the real user cases observed during the retrieval attempts using both tools below.

- **Retrieval success rate with the Chrome bookmarking tool**: with the Chrome browser bookmarking tools, participants mainly retrieved their bookmarks by finding the right folder to look into or by looking at the default page titles. Four out of six participants used folders to organize their bookmarks, while the other two preferred to leave all bookmarks in a long unordered list. When participants recalled detailed and accurate information, they successfully found their bookmarks at 100% of the time. However, this was not the case when they recalled little or none. As seen in Table 5.8, the fewer details participants recalled, the harder it became to retrieve the bookmark with success. When participants could not recall much or none, they either read through all the folder names and tried to guess the "correct one", or scanned through all bookmark titles, hoping they might suddenly remember which one it was. It was also often observed that the folder names that participants believed they used were different from the actual folder names used. In such cases, participants were seen to choose the most likely one based on what they recalled:

  > **Interviewer**: can you tell me something about the gift you wanted to receive?
  > **Silvia**: Well, I think....mmmm... a red dress? I am not sure. It could have been something else.
  > **I**: can you find it in your Chrome bookmarks?
  > **S**: yes, I think it should be in the folder called "Gifts".
  > **S**: I do not have a folder named "Gifts". Let me check the folders. Hold on. [...scanning all folders...] There is a folder called "Shopping". Maybe I put it in here. Yes, I found it.

  Regrettably, folder names or the titles were of little use when users recalled inaccurate information (i.e. a participant recalled the target page must be about "Internet of Things" but he could not find any folder or title related to this) or when they recalled nothing.

- **Retrieval success rate with MemoryLane**:as described in the previous section 5.2.1, MemoryLane provided participants with various types of context or semantic metadata as retrieval cues. When participants recalled specific and accurate information, they retrieved bookmarks successfully at 100%, as with the Chrome bookmarking tool. In contrast with the Chrome tool, MemoryLane maintained high success retrieval rates even when participants could not recall accurate and specific information about their target pages (see Table 5.8). Participants explored different strategies when they could not recall much or none, depending on the type of information they were trying to find. For instance, below examples illustrate how participants used location and emotion to find their target pages.

  **Interviewer**: can you tell me something about the place you wanted to go this summer?
  **Eleonora**: I think it was a place where I could do rock climbing... somewhere in England but I do not remember the name of the place.
  **I**: can you try to find it using MemoryLane?
  **E**: I found it! I went to the Location Navigation and looked at England and there was a marker on Sheffield. Yes, that was where i wanted to go.

  **I**: can you tell me something about the page you saved, which was related to what you were working on?
  **Zeno**: I think it was something about my phD work... "coding" or "SOM" - the name of my project - but I am not very sure.
  **I**: can you try to find it using MemoryLane?
  **Z**: I found it. I remembered I was a bit frustrated with my project so I searched for bookmarks with "angry" emoticon. Yes, that was the page I was looking for.

**Retrieval cues used for bookmarks with MemoryLane** This section provides an overview of the type of retrieval cues that participants used to retrieve target bookmarks with MemoryLane. The most frequently used methods were to use the goal (e.g. the reason for which bookmarks were saved) with 43% of the successful attempts, followed by category with 22%. Emotions and direct browsing were sparingly used for retrievals: 9% and 12% respectively. A few users also made use of images, search queries with 3% both. However, tags and location were used rarely with 2%. Although some bookmarks were saved with people and event information, there were never used for bookmark retrieval. Figure 5.12 summarizes the results visually.

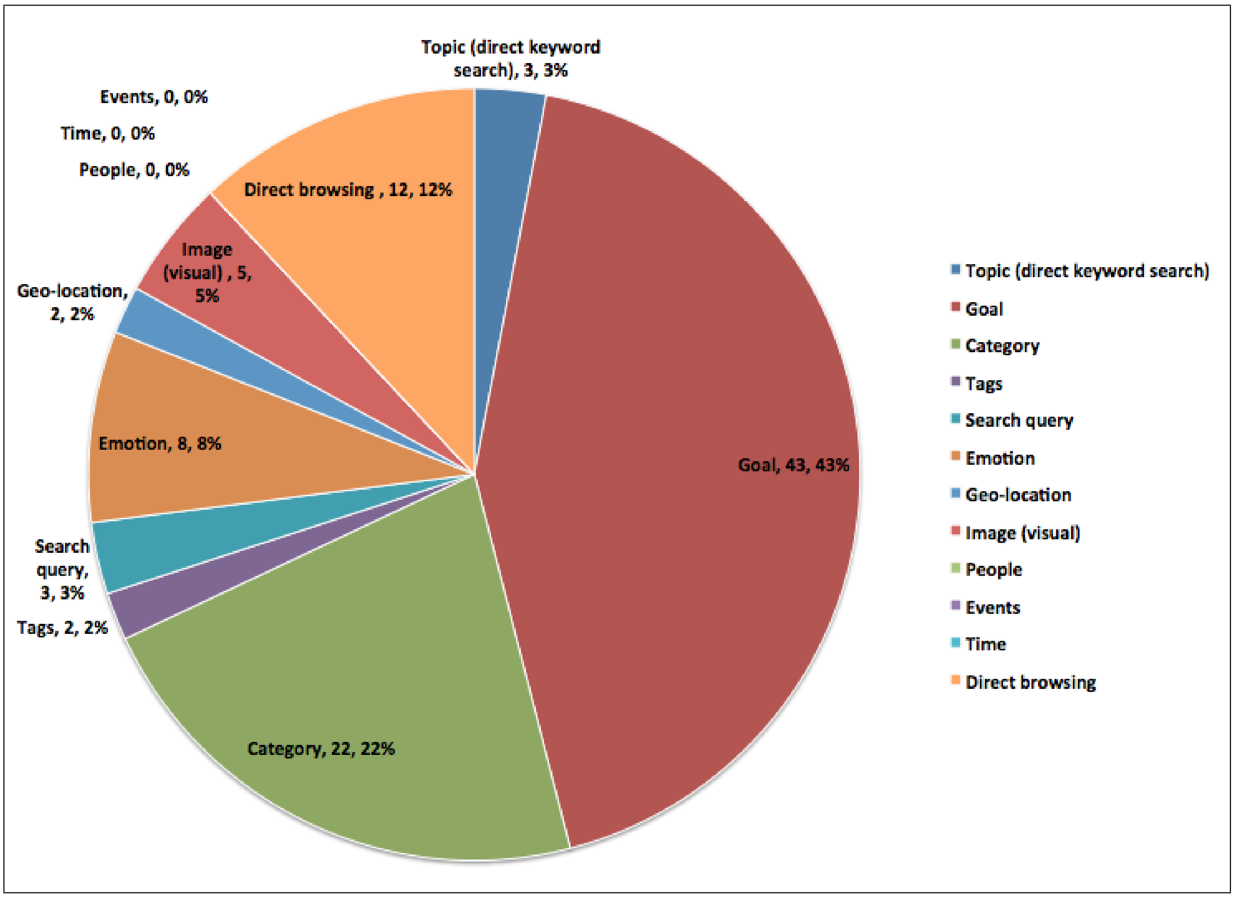


Figure 5.12: MemoryLane: Usage of Semantic and Contextual Cues Used for Retrieval

- **Semantic cues** (category, tags, search queries, direct keyword search) 22% of the successful retrieval was done via using categories. These categories were automatically extracted from the content and suggested to users at the point of saving/bookmarking web pages. When users were not sure or only recalled vague or no information, they tried to find the target web pages using categories as the orientation point. Nevertheless, searching for bookmarks based on other types of semantic cues were not popular. For instance, all bookmarks had at least one tag associated with them but it was used only 2% of the time as the retrieval method. Direct keyword search was not much sought after either, as it also constituted only 3% of the time. This is in line with the results of several previous studies: direct search is not the preferred method of refinding, but browsing is [19, 15]. The results also explain the popularity of categories, as MemoryLane offers a visual browsing interface (see Figure 5.4). Despite the fact that most users said they would remember the search queries in part II of the experiment, the actual use of search queries as retrieval cues was negligible with 3%. We have discussed in Section 2.4.1 that users typically do not recall the exact search queries they used over a long term, but we expected it to be utilized more in this experiment, since MemoryLane offers the list of past search queries saved along with the bookmarks. It is possible that participants did not make use of it, because there were alternative methods that they deemed more useful or less time-consuming.

- **Contextual cues** (goal, emotion, time, location) More than 50% of the successful retrieval results were achieved with contextual cues. Of these cues, *goal* was most frequently used, followed by emotion. Other types of contextual cues – such as location, people, events and time – were rarely or not used at all, even though some bookmarks contained such information.
  - **Goal**: goal was indeed perceived important by the participants in part II of the experiment and, in fact, was used most prominently as the retrieval cue. This result highlights the importance of the reasons for which web pages are saved and how they persist in memory even after a long time elapse. The same discovery was made for emails [39]. Current context-based tools are not making use of this important contextual information, most probably because goal is an internal intention of users, making it hard to make an accurate "guess" by the tool. The alternative way would require direct input from the users, which, in return, may reduce the usability of the tool.
  - **Emotion**: The participants of the survey did not assign much importance to emotions; however, emotions were more frequently used than expected for bookmarking web pages in part II of the experiment and also in the part III, bookmark retrieval. In most cases, participants did not recall correctly which emoticon they had used to bookmark the target web pages, but they did remember if the emotion they had felt was strongly positive or negative – and subsequently used that to narrow down their search results. As an example, when a participant was asked to retrieve a web page about his favorite song, he failed to find it with goal. Then he used "happy" emoticon to filter only those with happy emoticon and he found what he was looking for. Interestingly, participants were also seen to use "no emotion" as the clue to find some of the web pages, specifically work or study related web pages. When asked about this during the interview, they replied they knew that they did not attach any strong emotion or personal feelings to the Web page and that this actually helped them to narrow their search. Expressing emotions about web content is a fairly new phenomenon spurred by social platforms such as Facebook. The idea that emotions can be used for refinding information may sound outlandish at first, but a recent study done in Japan showed that emotions do play a role in memory recall [104]. Users use emoticons as an "aid for personal expression" among other reasons [69], which might be the reason for its prolonged preservation in memory as it makes the web content something "personal".
  - **Location**: Although location is one of the most exploited context nowadays, given the rise of ubiquitous availability of information on smart devices, it was not used much for bookmark retrieval. This is understandable, as MemoryLane was available only on Chrome browser on stationary computers. Nevertheless, as discussed in section 5.3.2, a few bookmarks were tagged with locations to indicate the current location of the user or the location mentioned in the Web content. For the few cases where participants used location as the retrieval cue, the second type of location – the location mentioned in the Web content – was exclusively used, When asked to refind Web pages about places to go for the next vacation, the participants recalled general information (e.g. "a place by the sea", "somewhere in Great Britain where

I can do climbing") but could not recall the exact name of the places and they used the location map provided by MemoryLane (see Figure 5.5 to get a rough idea where these places may be).

– **Time** (date-Time, events): participants could search either by specific date-time (e.g. September 10, 2016) or by past or future events that they had entered into their Google Calendar before. Surprisingly, no retrieval attempt was made using the time context in our experiment, even though most existing context-based tools use it as a key contextual feature, as shown in Section 2.4.4. However, our experiment revealed that, when a significant amount of time has passed - 3 weeks -, participants remembered little about the time when they saved their bookmarks. Furthermore, time is not closely tied to Web pages – unlike other types of electronic documents such as emails – which explains why time was never used in this experiment.

- **Others** (direct browsing): a few participants resorted to directly browsing through the list of bookmarks. While browsing the list, they used the title or the screenshot image of the Web site as the cues to locate what they are looking for. When asked why they chose to browse instead of using other available search options, they told us that they were accustomed to doing so with other bookmarking tools. One particular participant said that he had a photographic memory and looking at the screenshot images worked best for him. In conclusion, direct browsing seems to depend on personal habits and preferences, rather than on retrieval efficiency.

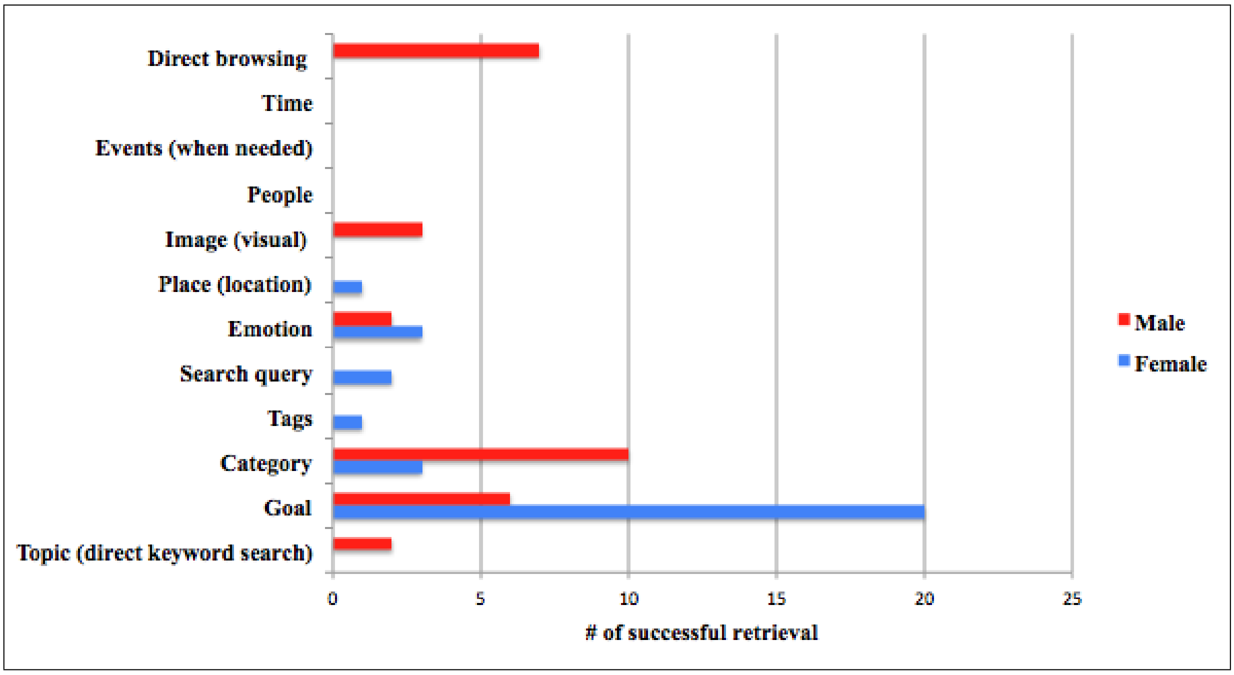


Figure 5.13: Usage of Contextual Cues Used for Retrieval per Gender

## Special observation: Gender-specific preferences for retrieval

**cues**: The retrieval testing results provided a valuable insight into possible variance in preference over retrieval methods by gender. As demonstrated in Figure 5.13, female users showed a particular preference for goal and emotion, whereas male users for category, direct browsing and image search. The gender differences in episodic memory is still a niche topic but there are some interesting experiments that have shown that women recall episodic memory better than men do. Herlitz et al. conducted an experiment with 530 women and 470 men aged between 35 and 80 to see if there indeed was a gender-based difference in recalling episodic memory. Their experiment showed that women consistently performed better than men did on episodic memory tests, while men were better at visuospatial memory tests [58]. Another experiment with 18 men and 18 women arrived at the same results: participants were tested on episodic, semantic, verbal fluency, problem solving and visuospatial ability and women were significantly favored for episodic memory tasks [147]. Our experiment was too small a scale to make conclusive generalizations but it is still interesting how these gender differences in episodic memory were also reflected in our retrieval test results.

**Retrieval performance of MemoryLane vs. Chrome bookmarking tool in time** Though there was a noteworthy difference in retrieval success rates, no significant difference was found in the retrieval time between the tools. This indicates that context could help users to refind their information, but does not promise "faster" retrieval, as evidenced in Table 5.9. Figure 5.14 shows the time elapsed for successful retrieval cases (45 out of 60 retrieval attempts) both for using Chrome bookmarking tool and MemoryLane. The overall difference between performance in time with these two tools was not statistically significant at $p=0.05$.

#### Experiment Summary and Discussion on its Implications on the Usage of Context in Context-based Tools

So far, we have presented the results of our experiment per each stage. In this section, we provide an overall summary of our experimentall results and tentatively discuss how our results could be applied for more effective use of contextual metadata in information search and retrieval. Below are

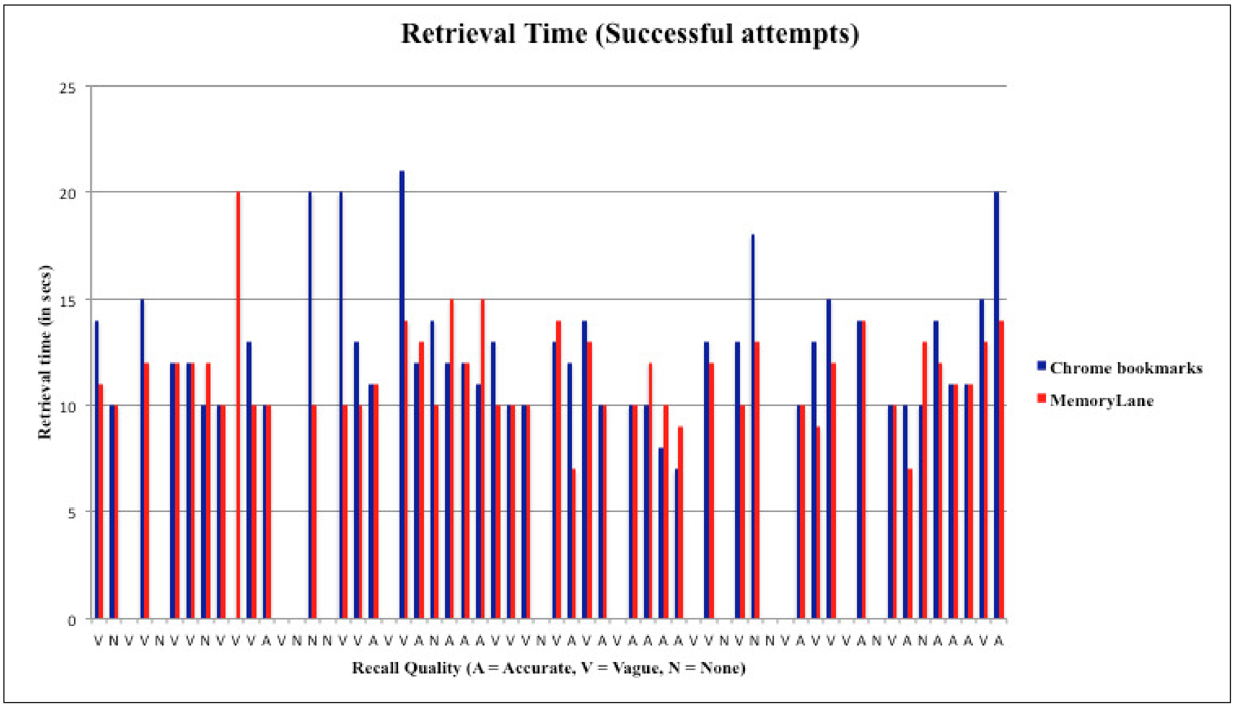


Figure 5.14: Performance in Time for Successful Retrievals

the key findings from our experiments:

- **Different ranks of metadata in perception, actual usage and usefulness as retrieval cue**
  Our results show that *topic* and *goal* were the top two important metadata across three experiment stages. This is consistent with the results from the study by [17], where they found that topic and goal (the usage context) were among the most used types of tags for Delicious bookmarks. Nonetheless, we found several divergences between the users' perception and the actual usage of different types of metadata, as depicted in Table 5.10. The *search query* was perceived as important and thus used frequently provided as metadata in our study. However, it was used only rarely during the actual retrieval. Our assumption was that the search query would be used often if provided in a list, since it would require "recognition" rather than "recall". Nevertheless, users did not make much use of the feature – either because they were not accustomed to such a method or because they found other contextual cues more appealing. On the other hand, the features *people* and *next time of visit*, were used rarely as metadata, even though they were deemed quite important by users. *Emotion*, *location* and *time* were considered least important according to the online survey; however, users used emotion far more frequently than expected as bookmark metadata. As shown in Table 5.10, Bischoff et al. also discovered that personal opinion/qualities (i.e. annoying, funny) were used as tags in delicious

bookmarks and these were found to be useful type of tags for search, even though they were "underrepresented" [17].

- **The role of context when there are semantic gaps in memory**
  Our results showed that context indeed can be a powerful retrieval cue when we recall only incomplete or no semantic metadata (topic or keywords) of the target Web pages. Context does not replace semantic metadata or guarantee faster retrieval but, if used appropriately, can significantly increase the chances of refinding information in absence of recalled semantic metadata. Semantic and contextual cues yield the best results when used together, though, as both types of cues provide users with evidence that they are on the correct path to arrive at target Web page. Furthermore, contextual cues seem to play a greater role for contents with high personal relevancy to the users.

- **Different contextual metadata for different categories of Web content**
  Users made use of different contextual metadata, depending on the content of the Web pages. Work or study related content had goals, people and reminders (events) as metadata. This is not surprising, as we have a a clear objective in our mind when we are at work or are studying. Personally relevant contents had more diverse types of contextual metadata: contents that evoked personal feelings – such as news, shopping or entertainment sites – had emotions as metadata, whereas vacation places, physical shops or events had their locations as metadata. These results are quite interesting, because current context-based tools do not offer differentiated context based on the content (see section 2.4.4).

- **Goal, emotion and location as contextual retrieval cues**
  Bischoff et al. showed that users already use goal, emotion and location as tags to some extent, which is confirmed in our own experiment (see Table 5.10). Goal was the most preferred retrieval cue, even more so for female users than for male users. Emotion was used more frequently than anticipated for personal Web content, but it was also observed that participants also use the *absence of feeling* as a condition to narrow down their search for non-personal Web content. Location could be an effective retrieval cue when it points to the actual location mentioned in the content. Work-related web content had the current location of the users as metadata, but it was hardly used for retrieval, as all participants were either at home or at work.

- **Semantic tags unpopular as retrieval cues**
  Not all types of topical metadata were appreciated equally. While category ranked high both as bookmark metadata and cue for retrieval, tags were only rarely used as retrieval cue, despite the fact that they were added to most of the bookmarks

(see Figure 5.8). As discussed previously in section 2.4.2, after a longer period has passed, users tend to recall only a "general" summary, but tags are usually specific keywords that ask for heavy cognitive load. In fact, a recent empirical study with 40 participants showed that tags not only required a higher mental load and led to frustration while organizing bookmarks, but also to a higher error rate and time demand during retrieval [44]. We asked our participants why they did not use tags to retrieve the bookmarks. They replied that they were highly used to tagging, possibly trained via using tags on various blogs and social network. Interestingly, they also said that they considered tags not to be useful for retrieving, but mainly for "describing" the content of Web pages.

## 5.4 Related work

As seen in the previous section 2.4.4, context has been actively considered important and thus harnessed to help users to refind information with more ease. Some tools focused on external context, like time or location, yet others on internal context, such as user interactions or activities. Some tools also used the contextual attributes of content in question, such as author or file type, while others focused on enhancing visualization of search results.

*Time* seems to be the most enduring and prevalent form of context, though the granularity and visualization vary among tools. Time can be easily and automatically extracted from the system in the form of a timestamp. However, the way it is presented to the user and the way it can be used for search has a significant impact on its usefulness. For instance, LifeStreams [42] and YouPivot [55] provide a graphical visualization, whereas others like Stuff I've Seen [36] use textual visualization (e.g. a calendar interface or dropdown list). How time is used for search also varies: one could select a specific date and time or indicate a range of dates (e.g. last week). Even though time is one of the simplest and common context information, the actual positive impact on long-term refinding is dubious. People do not remember the specific dates after significant time-elapse [49, 18, 39].

*Location* is another type of context often seen in these tools, but its interpretation is different in some tools. Haystack [6] and MyLifeBits [45] used location to represent the "physical" storage location of electronic documents. Whether or not this is effective in refinding can be argued, because users, over long time, are likely to forget such specific details such as file paths or name. Refinder [30], on the other hand, uses location as the geographical location of the user (i.e. home or work). Location can definitely be used to make certain documents or Web pages memorable, but its usefulness is tied to the “mobility” of the devices in use. For example, when people are using a smartphone to browse the Web and find interesting information, one Web page could be associated to Cafe Italia and another one to Berlin’s main train station, making each location unique and memorable. However, for laptop or desktop devices, the variance in locations where they are used is usually very limited, thus making it susceptible to piling on Web pages into just a single or two locations.

The internal context is rarely exploited by refinding tools, mainly due to the difficulty of automatically capturing a user’s goal, tasks or mental state. tools rely heavily on explicit user interactions with the system (i.e. a user is watching a video on YouTube). PivotBar and YouPivot are examples of such tools: PivotBar takes the context of the browser by looking at what user is seeing and provides similar Web Pages from Web history cache [68] whereas YouPivot allows users to search for pages seen before by pivoting around a certain user activity (i.e. Social networking on Facebook) that happened around the similar time-frame [55]. There are also other tools that ask users to explicitly provide their goals or activities. MyLifeBits let users to organize their digital resources under personalized themes or goals in the form of stories [45]. Meanwhile, Refinder specifically asks users to input their activity when saving their digital resource [30]. Research has later been re-birthed as Revisit that guesses user’s activity intelligently by using user’s concurrent computer programs or probabilistically gauging it from accessed Web pages [31].

Most recently, another tool called “WebPagePrev” was introduced by Jin et al. [1] that promises to make it easier to refind previously visited web pages by extracting context and content keywords from each web page and suggesting a list of statistically most probable target web pages based on user search keywords. Although they have reported better performance at retrieval, it is still dubious if the context keywords expected of users to make the search work (e.g. busy programming at the lab) reflect the real user search behavior and how they can pinpoint the fine-grained location such as a computer lab inside an university using just a public IP address. Furthermore, the context they offered were again pre-determined and limited set of context types (time, location and activity) that are not always what users remember, as argued from the results of our experiments. Their study is, nevertheless, interesting as they offered an example of how context can be potentially used to present most likely target web pages automatically using probabilistic models.

Though there is no doubt that using any form of context as seen in these tools is a right step towards better organization and retrieval of digital resources, there still is much more room for improvement. First of all, the context used in these tools is somewhat limited. Several studies have discovered that there were other types of context that aid in information retrieval [49, 18, 70, 39, 104], but these tools are focused on only a subset of such types of contexts: time, location and user activity. For instance, goals (purposes) and emotions are some examples that could be added to increase the synergy contextual cues can bring to information retrieval. Besides, time and storage location were found to be prone to be forgotten over long-term while the purpose was discovered as the most resistant to time-related decay [49, 39]. Emotions are another area one could explore to improve contextual retrieval of information that evokes feelings such as news articles, videos, music, or products / services of personal interests. As seen in a study by a Japanese team of researchers, asking questions about the emotions experienced helped participants to retrieve memory of the news articles that they read previously [104]. Further, capturing emotions is gradually getting easier, as more and more users are acquainted with expressing emotions using emoticons on social media and on-line communication channels.

Secondly, it is not likely that when a certain type of context is deemed useful, it is also true for all types of electronic documents that are available on-line or off-line. All PIM tools presented previously seem to take a one-solution-for-all approach, offering a mixture of contextual cues that must work for all types of personal information, be that an email, a word document, or a Web page. Even for Web-only tools, it is assumed that all Web pages are of one type, which can easily be retrieved by the same type of context. But this is as far from the truth as it can get and some of the studies have shown the differences. Let's consider "Stuff I've Seen" that purportedly offers rich contextual cues, such as time, author, thumbnails and previews, for all digital personal resources to aid in fast and easy retrieval [36]. Their evaluation showed that the important retrieval cues were time and people. However, looking deeper into the evaluation results, we can see that time and people were most important because of the evaluation setting (work place) and the type of digital content mostly sought after in such a setting (email), not because time and people were important contextual cues for all types of documents. It is reported that all 234 participants were from the work-force within the company and that they reported "SIS was used much more for email than for web pages" [36]. A study carried out by Elsweiler et al. confirmed that, as far as emails were concerned, the sender of the email (people) and temporal information (time) were one of the four most remembered context [39].

For social micro-blogging services such as Twitter, people was again turned out to be the most used strategy for re-finding tweets [90]. According to their experiment involving 44 users for the duration of 5 months, users made use of the given timeline to re-find the tweets posted by others in the short-term but they resorted to other strategies like using the notification list or visiting the profile page of other people who posted the tweets of interests. They concluded that the people was the most important factor in long-term tweet search, which again emphasizes the importance of "context" in long-term refinding.

People and time, however, are not effective contextual cues for other types of digital document such as Web pages because the Web pages are not inherently tied to people (i.e. Sender or receiver) and specific time is not the optimal indicator for retrieval due to the large amount of Web pages we view in a short time frame, which is probably why Web history tools never gained wild popularity. Hence, we could tentatively conclude that some contextual cues are more appropriate than others for certain types of documents and one should take this into consideration when choosing contextual cues to offer.

Lastly, although these tools are surely great examples of leveraging context for improved medium-term refinding experiences, there appears to be a lack of similar efforts exerted for the most common yet unappreciated long-term revisitation technique: explicit bookmarking.

Though not too popular as a retrieval method, bookmarking is the most popular way for users to express explicitly their intention to revisit a Web page in the future. The primary motivation for bookmarking is to have access to information people find useful or interesting [137] yet not always with a specific point of future of next visit in mind. Nevertheless, the deliberate action of bookmarking itself hints at the higher importance of the information than that of other Web pages users viewed yet not bookmarked. However, currently available context-based Web tools, as seen in section 2.4.4, are focused on Web history, which by default includes all Web pages viewed, regardless of their significance to the users.

We have seen in section 2.4.1 that users resort to re-searching on search engines rather than using bookmarks for long-term revisit. Nevertheless, explicit bookmarking offers some distinct benefits. First of all, the bookmark list is rather static, in contrast to dynamic search result lists. People, by nature, experience difficulties in finding the items that they need if the order of items in the list changes their positions. This has been proven by the study by Teevan et al. in which she discovered that people have trouble finding previously viewed content in the list when the result list appears to have changed [130]. This behavior was also observed in an experiment with static and dynamic menu items of desktop applications as early as in 1989: Mitchell and Shneiderman performed a comparison study with 63 subjects, who were asked to carry out 12 tasks with a static menu and the other 12 with a dynamic menu. The results showed that people performed the tasks significantly poorer with the dynamic menu and 81% of the participants preferred the static menu [96].

The above studies clearly show that having items in a static order plays an important role in refinding tasks. Moreover, bookmarks give a sense of "known" locations or access points to Web pages seen before, in comparison to the immense pool of Web pages that are available on the Web as a whole. It is like knowing that the books one wants to read again are all stored in a particular section of the library, rather than just knowing they are somewhere in that library. In other words, bookmarks can work as a "starting point", where users know their information resides. Knowing where to start is extremely helpful when we need to find our way to the destination. In fact, this has been shown in a study carried out by Teevan et al. where they found out that people prefer to navigate in small steps from a starting point to the destination point (orienteering) rather than jumping straight to the destination point (*teleporting*), even when they know exactly where they want to go because orienteering provides cognitive ease, a sense of location and a way of understanding if they are on the right track [132]. Despite these apparent advantages, bookmarks are hardly popular as long-term revisit technique: current tools invariably depend on folder or tags for organization of Web pages, which are not without caveats, as discussed in section 2.4.1. Context might come in handy to mitigate limitations faced by folders or tags in bookmark retrieval. More research efforts in this direction may be worthwhile, given the wide-spread use of bookmarking tools.

In such light, our prototypical bookmarking tool is one of a kind. MemoryLane not only provides all types of available context as retrievable index metadata but also offers highly visualized "browsing" interfaces for users to easily navigate their bookmark collection. Our experiments as well provide some engaging insights into the role different types of context play in the information retrieval, depending on the content of the Web page and personal interest level of the user.

Table 5.1: MemoryLane: Elements of Bookmark Dialog

| Element | Description | Reason for Inclusion | User action |
|---|---|---|---|
| **Semantic Cues** | | | |
| Category | Hierarchical classification of the Web page content | Category allows users to navigate from general to specific, easing the cognitive burden of recalling details | Users can choose the recommended category or manually select one from given category list |
| Search query | Search query used to arrive at the Web page if any. Tool displays the most recent search query by default | Users are found not to remember the exact search queries over time [129]. By providing the list of past search queries, users will be asked to "recognize" rather than "recall" | Users can use the default search query if correct; otherwise, users can select one from the drop-down list of most recent search queries |
| Tags | Concepts and Keywords are automatically extracted as suggested tags | Tags are a common way of organizing resources albeit some setbacks [26] | Users can click on the suggested tags to use them or they can directly enter tags of their choice |
| **Contextual Cues** | | | |
| Goal | Users can specify why they are bookmarking the Web page. The most recent goal used by the user will be selected by default by the tool | Goal represents "Why" of the episode and found to be remembered for a long term in [49, 39] | Users can use the default goal (the most recent goal) or choose among the recently used goals from drop-down list. Adding a new goal is also supported |
| Emotion | Emotion pertains to the feeling of users towards the content and users are given 10 emotions that describe different emotional states | Emotion was found to be an important recall factor in [104] and users are familiar with expressing emotions on social media via emoticons | Users can choose the most appropriate emoticon to express their feelings. The default emotion is "No feeling" |
| Contacts (People) | Users can associate the Web page with a person if the content might be also interesting for that person or they intend to share it with that person | People (as email senders) were often recalled by users in an experiment by [39] and users are familiar with tagging "people" on social networks such as Facebook | Users can select a contact (person) from the drop-down list of existing contacts or add a new contact if needed |
| Events & Reminders | Past or future calendar events can be linked to Web page to indicate when the Web page was found. The future event can be used as a reminder | Date-time is often forgotten [18] but people may remember the meaningful blocks of time over long term. Furthermore, this provides users the ability to set a reminder of their bookmarks | Users can select an existing event from the drop-down list or create a new event to use as a reminder |
| Location | The current geo-location of the user or that indicated in content can be linked to the Web page | Location represents "where" of the episode. Geolocation was found to be recalled after 6 months while textual content failed in [70] | Users can select either type of location manually. Current location can be named by users (i.e. Home or Work) and geographical locations can be selected from suggested places |
| Related files | Digital files on the local device such as word document can be associated with the Web page | Often we save Web pages for a document we are working on or download resources onto local drives | Users can select a local file by clicking on "Choose file" button, which will bring up default file browser |

Table 5.2: Mapping of Tag Classification by Bischoff et al. to that of MemoryLane [63] & Data Extraction and Selection

| [17] | Episodic memory | MemoryLane | Extraction & Selection Method |
|---|---|---|---|
| Topic | What | Category, Concepts, Keywords | Automatic data and selection |
| n/a | How | Search Query | Automatic data and selection |
| Time | When | Date-time, Calendar events | Automatic data & Manual selection |
| Location | Where | Geo-location of the user or Location attribute | Automatic data & Manual selection |
| Type | What | (Included in Category above) | Automatic data and selection |
| Author / Owner | Who | People (Google Contacts) | Automatic data & Manual selection |
| Opinions / Qualities | Mental impression | Emotion | Manual selection |
| Usage context | Why | Goal | Manual data and selection |
| Self reference | n/a | Reminders, People, Related files | Manual data and selection |
| n/a | Visual impression | Screenshot of Web page | Automatic data & selection |

Table 5.3: MemoryLane: Implementation Details

| **Element** | **Implementation** |
|---|---|
| Category | Categories are automatically extracted using taxonomy extraction of Alchemy API |
| Search query | Search queries are extracted by parsing the last 50 visited pages via the Chrome History API |
| Tags | Alchemy API is used to get concepts and keywords and then only those with relevancy higher than 0.6/1.0 are displayed |
| Goal | No external API is used. Goals are saved in database and retrieved via backend REST service |
| Emotion | No external API is used. Emotions are saved in database as respective integer numbers and retrieved via backend REST service |
| Contacts (People) | Contacts are displayed using Google Contacts API. |
| Events & Reminders | Events are extracted or created using Google Calendar API |
| Location | Browser Geo-Location API is used to detect current GPS coordinates of the user and Google Places API to used to support manual input by place name |
| Related files | No external API is used. File names are saved in the database and retrieved via backend REST service |

Table 5.4: Stage I: Online Survey Questions

| No. | Question |
|---|---|
| 1 | When you find useful or interesting information online, what do you do? |
| 2 | Which bookmarking tool do you use and what do you like / dislike the most about the tool? |
| 3 | Please elaborate and explain why you prefer not to bookmark the web pages if you answered "other" in question 1. |
| 4 | If you answered "I do nothing because I know how to find it" in question 1, please explain how you find the web page again next time. |
| 5 | How many bookmarks (favorites) do you currently have? |
| 6 | Do you organize bookmarks (favorites) in folders or by tags? (please explain if "other") |
| 7 | When you look at a web page, what would you remember the best (supposing some days have past)? Choose all that apply. |
| 8 | If you have checked "other" in question 7, please elaborate. |
| 9 | What is the top reason for which you save web pages? |
| 10 | If you answered "other" in question 9, please elaborate. |
| 11 | Have you ever experienced difficulty in finding the web page (which you have saved) you are looking for? or you found it but it look a long time? |
| 12 | You had the difficulty in finding the web page because.... choose all that apply |
| 13 | If you cannot find the bookmark you saved, what do you do to refind the web page? |

Table 5.5: Stage II: Premeditated Questions Given to 6 Participants

| No. | Question |
|---|---|
| 1 | Where would you like to go this summer? |
| 2 | I bought a new battery for my laptop but it does not charge, what could be the solution? |
| 3 | What can you do when you drop your phone in water? |
| 4 | I am looking for a new phone to buy, can you recommend me phones? |
| 5 | What is the most interesting news of today in your opinion? |
| 6 | What are you working on these days? Can you bookmark web pages that are most related to what you are working on? |
| 7 | What are the things you would like to receive as gifts? |
| 8 | Which songs are your favorite? |
| 9 | Please find good recipes that you would like to try. |
| 10 | Please find web pages about the latest health/technology trends. |

Table 5.6: Online Survey: Perception of Importance per Type of Information for Recall

| Type of Information | Group A (age 30-49) | Group B (age 18-29) | Average |
|---|---|---|---|
| Topic | 65.7% | 72.6% | 69.15% |
| Goal | 62.9% | 65.5% | 64.2& |
| Source | 36.1% | 33.3% | 34.7% |
| Next time of visit | 13.9% | 19% | 16.45% |
| Emotion | 5.6% | 11.9% | 8.75% |
| Location | 8.3% | 4.8% | 6.55% |
| Time | 5.6% | 1.2% | 3.4% |

Table 5.7: Usage of Contextual Cues per Category of Collected Bookmarks

| Bookmark Category | Total (160) | Goals | Emotions | Locations | People | Reminders |
|---|---|---|---|---|---|---|
| Work/Study-Related | 61 | 54 | 8 | 18 | 11 | 15 |
| Products/Services | 24 | 15 | 12 | 1 | 2 | 0 |
| Music/Movie/Cartoon | 11 | 2 | 8 | 0 | 0 | 0 |
| Travel | 8 | 5 | 7 | 4 | 0 | 0 |
| Food | 7 | 5 | 2 | 1 | 2 | 0 |
| Social Blogs | 2 | 1 | 2 | 2 | 0 | 1 |
| Solution to Problems | 18 | 9 | 4 | 3 | 1 | 1 |
| Job Search/Posting | 4 | 3 | 1 | 1 | 0 | 0 |
| Physical Places | 2 | 0 | 1 | 2 | 0 | 0 |

Table 5.8: Retrieval Success Rate per Quality of Semantic Information Recalled

| **Quality of Recall** | **Total Attempts** | **Failed Attempts** | **Success Rate (%)** | |
|---|---|---|---|---|
| | | | Chrome | MemoryLane |
| Specific and Accurate | 17 | 0 | 100% | 100% |
| Vague | 28 | 8 | 69% | 96% |
| None | 15 | 7 | 46% | 100% |

Table 5.9: Comparison of MemoryLane and Chrome Bookmarking Tool in Retrieval Time and Success Rate

| | **Avg. Retrieval Time (in sec)** | | **Retrieval Success Rate (%)** | |
|---|---|---|---|---|
| **Quality of Recall** | **Chrome** | **MemoryLane** | **Chrome** | **MemoryLane** |
| Specific and Accurate | 11 | 11 | 100% | 100% |
| Vague | 13 | 12 | 69% | 96% |
| None | 14 | 15 | 46% | 100% |

Table 5.10: Comparative ranks of metadata types by perception, by actual usage (including results from [17]) and as retrieval cue

| **Ranks** | **Perceived as important** | **Used as metadata** | | **Used as retrieval cue** |
|---|---|---|---|---|
| | **This study** | **This study** | **Bischoff et al.** | **This study** |
| 1 | Topic | Topic (category, tags) | Topic | Goal |
| 2 | Goal | Goal | Goal (Usage context) | Topic (category) |
| 3 | Source (search query, people) | Search query | Type (category) | Topic (page titles) |
| 4 | Next time of visit (events) | Emotion | People (author/owner) | Emotion |
| 5 | Emotion | Location | Emotion (opinion) | Image, search query |
| 6 | Location | Next time of visit (events) | Location | Location |
| 7 | Time | People | Time | Topic (tags) |

# Chapter 6

# Learnweb: context in searching shared materials

## 6.1 Intro and detailed problem definition

We have seen in previous Chapter 5 that context, in its various types and forms, can potentially assist users in organizing and refinding online digital contents. In this chapter, on the other hand, discuss the dynamics of context play when it comes to searching shared resources among a homogeneous group of users, specifically in the popular form of *tags* commonly used in numerous social platforms. The collaborative tagging system has shown to benefit its own community by knowledge sharing and users of community are observed to be influenced by the social tags in navigation, learning and information processing [29]. The use of metadata to enhance resource discovery is indispensable because it can help users to discriminate between relevant and irrelevant information to users' search needs [79]. In section 2.5, we pointed out the types of context seen in users' tags and how there is a lack of using and recommending personal or contextual tags to improve search in social tagging platforms. The usefulness of tags for search depend on the core content shared, the search scope and users' perception of the purpose of tags.

To experiment the role of contextual tags as search metadata, we have selected a community of language teachers where the knowledge and competence of others in the same profession are highly appreciated and beneficial [82]. When it comes to searching teaching materials for language classes, the topics of the content themselves are not the most relevant metadata as there is no restriction on the domain of knowledge but relevance directly hinges on the learning objectives. These learning objectives are not explicitly expressed in the search queries but rather teachers are left with the burden to explore each material to determine whether or not it meets the information need. LearnWeb platform [1] allows such users to share and collaboratively work on resources either created by the users or collected from the Web [80, 81]. Learnweb supports collaborative tagging for search among shared resources; however, the usage of tags was very rare [2] and users have pointed out that it was becoming difficult to search resources as the amount of shared resources increased and highlighted the need for a more professional tagging system to facilitate the search [82]. To meet this demand, we investigated what type of metadata is most important and relevant for finding suitable learning/teaching materials by directly involving teachers in the process and developed a prototypical interface to better understand if the new types of metadata can potentially enhance search. Thus, our research aims to answer the following questions.

1. What kind of metadata do teachers use when they search for teaching and learning materials? Are there important underlying metadata, not implicitly expressed in their textual search queries? If there are any, are they content-related or contextual?

2. Based on the results of 1), how can we best redesign existing interfaces to encourage users to provide such metadata (tags) useful for community search needs?

3. Furthermore, does user experiment using the new interface and search functions demonstrate that using such metadata facilitates decision-making of selecting suitable materials? More specifically, what type of contextual metadata do users add the most and which do they use to search?

[1] http://learnweb.l3s.uni-hannover.de

## 6.2 Metadata useful for search: teachers' perspective

In this section, we revisit the qualitative summary of results collected during previous studies done in [82] and also mentioned in [20]. While the previous studies focused on the general Web search patterns of teachers, this chapter shifts the focus to identifying the types of metadata important for teachers when selecting materials for their specific use context.

### 6.2.1 Teachers' search pattern and decision-making strategy

In 2016 six experience language teachers from different Italian schools of various competency levels were interviewed. The objective was to gain insight into their Web search patterns and search strategies when looking for new teaching materials [82]. The results showed that teachers follow a rather pre-defined set of steps in their search and a typical search session involved several iterations where search terms change from general to more specific. What was most striking was that teachers had several contextual criteria in choosing the "right" materials, which were not expressed in their search query. These contextual requirements included target audience, type of media and teaching activities for which materials were to be used. The decision-making strategy of all participants thus showed similar patterns, especially on how they narrowed down search results to select particular resources suitable for their teaching scenario. Figure 6.1 depicts the typical decision process observed of the participants.

Resource attributes and teaching context were critical conditions for selecting the teaching materials even though they were not overtly expressed in the search queries. All participants spent a significant amount of time clicking on several potential candidates from the search results. As title and snippet provided in the list was not sufficient to determine their appropriateness, teachers clicked on each link to read the content themselves. Another important factor in their decision making was the "trustworthiness" of the material. Teachers considered resources from well-known portals such as BBC or Cambridge University as well as resources shared by other teachers in the community more trustworthy than others. The opinion of other teachers mattered significantly: they often inquired of their

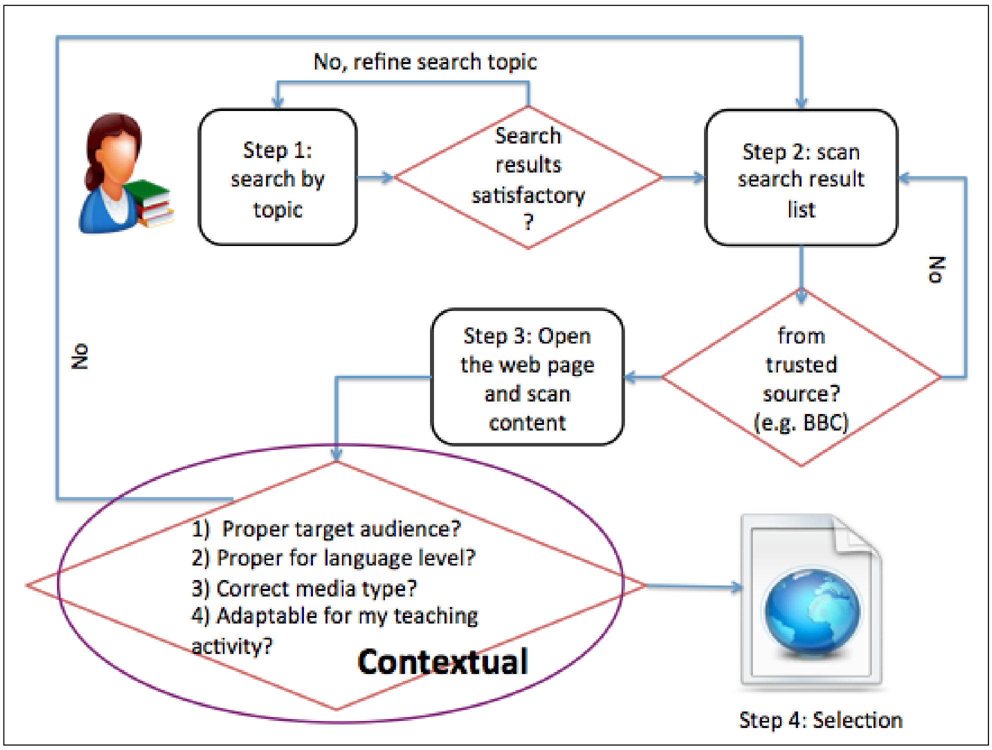


Figure 6.1: The search and decision process of selecting teaching materials

colleagues about the "goodness" of materials they found on the Web.

These findings revealed that using only search query, as general search engines do, may not be sufficient for teachers' looking for suitable teaching materials. In other words, contextual types of metadata should be made available to facilitate searching but such metadata cannot be automatically inferred from the textual query. Moreover, the current Learnweb system itself does not offer the teacher's expertise to decide which material is suitable for which type of teaching scenarios either. However, each member of teachers' community can collaboratively provide such metadata for resources they share.

### 6.2.2 Categorization of resources to facilitate search

The search log analysis, observation of fora analysis and questionnaire conducted in [20] provided insights into how teachers envision their resources to be organized for better search and retrieval though tagging resources collaboratively. As mentioned in the previous section, organizing resources solely by topic does not reflect the information needs of teachers because the usefulness of a certain material depends on its use for contextual teaching scenarios and objectives. According to YELL/TELL community, a community of English teachers of various competency and levels, resources should be categorized per both content-based and non-content based metadata, as demonstrated in Table 6.1. Apart from the typical topic and keywords, teachers focused on the intention or the purpose of their search. Language level, target audience and type of teaching activities belong to this category.

Table 6.1: Categorization of resource suggested by teachers from YELL/TELL community on Learnweb

| **Category** | **Explanation** | **Suggested dataset** |
|---|---|---|
| Authors of the resource | The person(s) who has written or provided the resource | e.g. Kelly Dowson |
| Type of resource | The text-type of the resource | video, song, game, text |
| Language | The language of the resource | English, Italian, German etc. |
| Language level | The level of language complexity of the resource | C2, C1, B2, B1, A2, A1 |
| Target audience | The intended consumers of the resource | Teachers, university students, secondary school students, primary school children, pre-school children etc. |
| Type of learning / teaching activities | The intended learning / teaching activity of the resource | ready-to-use activities, lesson plans, teacher education materials, learning strategies, language skills etc. |
| Topic | Main and high-level topic of the resource | water, food, ecology, human rights |
| Keywords | Additional representative concepts or expressions to describe the resource | learning style, inclusive learning etc. |

### 6.2.3 Comparison to Learning Object Metadata (LOM)

LOM is a set of metadata designed to provide better and comprehensive description of digital learning materials (IEEE Std. 1484.12.1, IEEE Standard for Learning Object Metadata) [87]. Digital contents can be organized into nine different categories as listed below [56]:

- General: general description of the resource such as title, language and keywords

- Lifecycle: features that states the lifecycle of the resource such as version number and creation date
- Meta-metadata: information about the metadata but not the resource itself like who contributed to the metadata
- Technical: technical requirements or characteristics of the resource. Resource format, size or platform requirements belong to this category
- Educational: pedagogical characteristics of the resource belong to this category. Examples include the interactivity type, level of difficulty and intended end users
- Rights: information about the intellectual property rights of the resource such as copy rights
- Relation: description of the relationship between one resource to another. If a resource is based on another resource or a newer version of another, such information belongs to this category
- Annotation: comments made by educators are categorized as this group
- Classification: information about other specific classification scheme used to categorize the resource

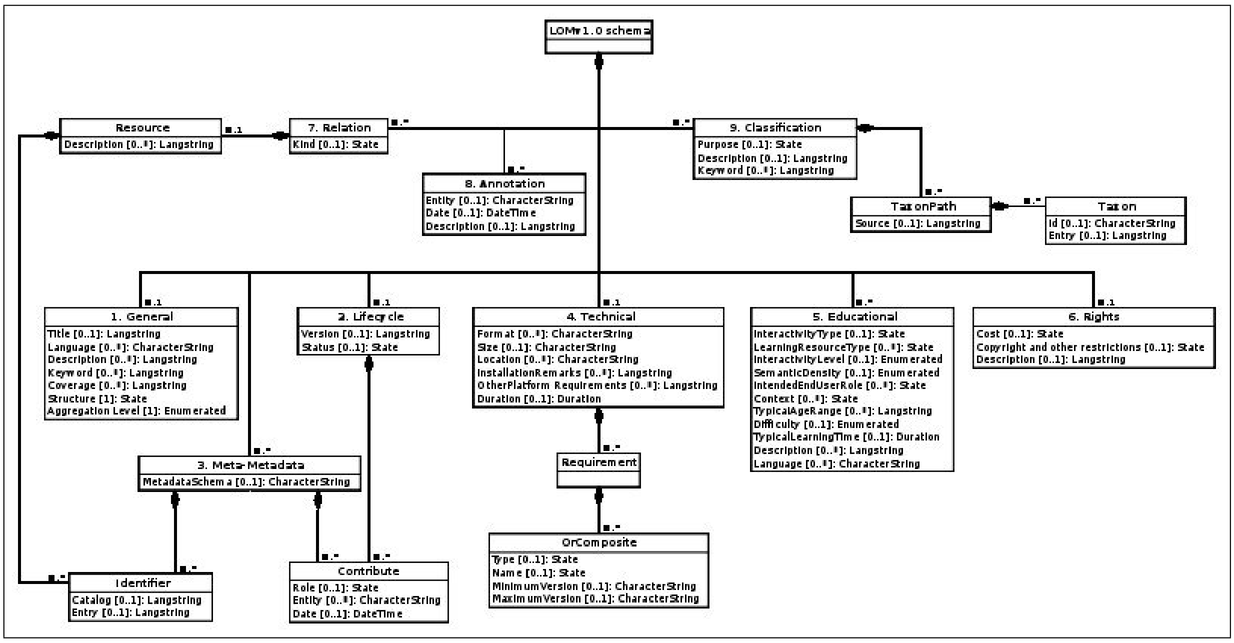


Figure 6.2: The base schema of Learning Object Metadata

Each category comes with sub-elements and may have relationships with other categories as depicted in Figure 6.2. Interestingly, some of these categories do overlap with the results of our investigation discussed in 6.2.1. The educational category seems to encompass many of the metadata teachers implicitly use to search for resources online while the general category covers the explicit search topic and keywords. As far as technical category is concerned, the form element maps to our category to describe the type of resource (e.g. audio, video or text). Table 6.2 summarizes the common elements of categories we defined for this research and those of LOM.

Table 6.2: Comparison of LOM and Categorization of resource suggested by teachers from YELL/TELL community

| **LOM** | **LOM Element** | **Our Category** | **Metadata Type** |
|---|---|---|---|
| General | Description | Authors | Attributes |
| | | Topic | Content-based |
| | Keywords | Keywords | |
| Technical | Language | Language | Attributes |
| | Form | Type of resource | |
| Educational | Difficulty | Language level | Context-based |
| | Intended end users | Target audience | |
| | Interactivity type | Type of learning activities | |

Though LOM standard was created to facilitate sharing and reusing learning materials, the actual use or the usefulness for the said purpose is yet to be researched in depth. Very few studies so far have discussed the use case of LOM in real-world scenarios [101, 99, 105] . The most interesting study is done by Ochoa et al. [105]. They analyzed a total of 630, 317 LOM metadata instances from of the GLOBE (Global Learning Objects Brokered Exchange) repositories to gain insight into the usage of different types of metadata in real learning objects. As depicted in Figure 6.3, the usage of LOM elements are quite low: only 11 elements out of 60 are used frequently (higher than 70%) and mostly in the "General" category such as Title, identifier, language and keywords. Especially, the usage of the "Educational" category is very low - the key metadata category our investigation revealed as important for sharing and searching learning materials - averaging just about 30% of usage. In the subsequent section 6.4.3, we will revisit this figure and compare how teachers actually used some of these types of metadata for organizing and searching for new learning materials.

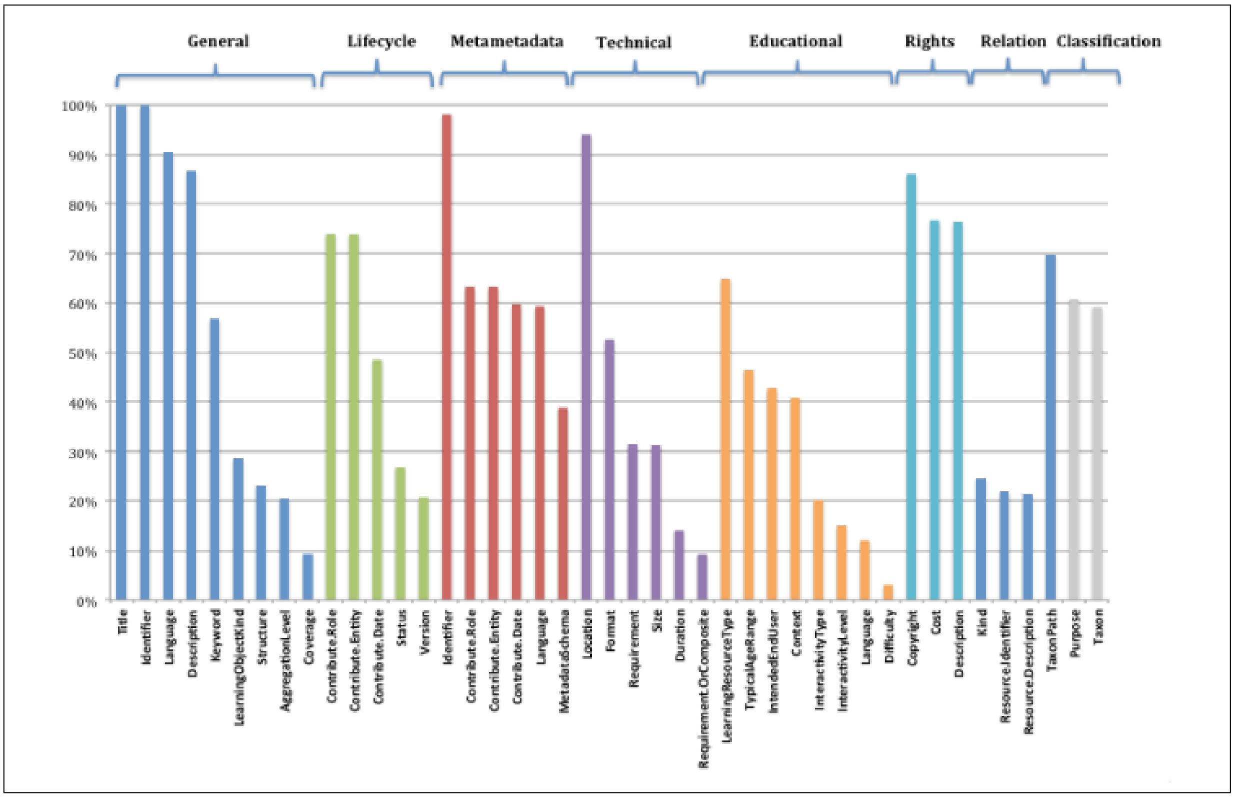


Figure 6.3: Percentage of usage of different LOM data elements in GLOBE [105]

## 6.3 Prototype: redesigning and implement the new interface to facilitate search

According to the results of section 6.2, while semantic keywords and topics are important, there are other types of metadata that teachers use during the search of teaching resources, which are not supported in current Learnweb system. In this section, we provide details of the new interfaces that are designed for eliciting such metadata from the community of users and how they can be visualized to facilitate the search and retrieval of shared resources. In summary, the key aims of the new interfaces are the following:

- Identify and elicit the types of metadata (those found to be important for searching teaching materials) which can be provided by the community of teachers

- Allow users to navigate through a hierarchical category tree in order to reduce the cognitive burden of finding specific topic keywords during search
- Visualize various types of metadata for each resource so that users do not need to click and view the content for decision-making
- Provide search filtering methods for contextual metadata such as target audience, language level and purpose of use (teaching activity)

### 6.3.1 Interface: Eliciting desired types of metadata

Previous observations of the Learnweb logs showed that user did not make use of the tags as expected [2]. Thus, the user interface focuses on guiding the teacher community to provide the types of metadata useful for searching shared resources. The current interface asked for minimum participation from the users in forms of free tagging and comments, whereas the new interface elicits a variety of specific metadata users can provide. Figure 6.4 shows the differences between the old and new interfaces.

Topical metadata such as title, category and keywords are automatically extracted by the system while some attributes of the resources and contextual metadata are elicited from users. Table 6.3 summarizes the types of metadata supported by the previous system and by the new prototype. The new interface aims to provide all type of metadata found to be useful for teachers' search and divided them into those that can be extracted automatically and others that only teachers can provide.

Table 6.3: Metadata support on old interface Vs. new interface

| **Metadata** | **Semantic** | | **Attributes** | | **Contextual** | | |
|---|---|---|---|---|---|---|---|
| | Keywords | Category | Media type | Source | Audience | Level | Purpose of use |
| Support? (Old) | Yes | No | Partial | Partial | No | No | No |
| Support? (New) | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Provider | System | System | Partial | System | User | User | User |

Users can also add their own contextual metadata (a.k.a teaching scenario) to resources shared by others. We believe that in this way, the synergy of community members' collaboration can be maximized and helps to reach an agreement on usage of the materials in teaching activities among

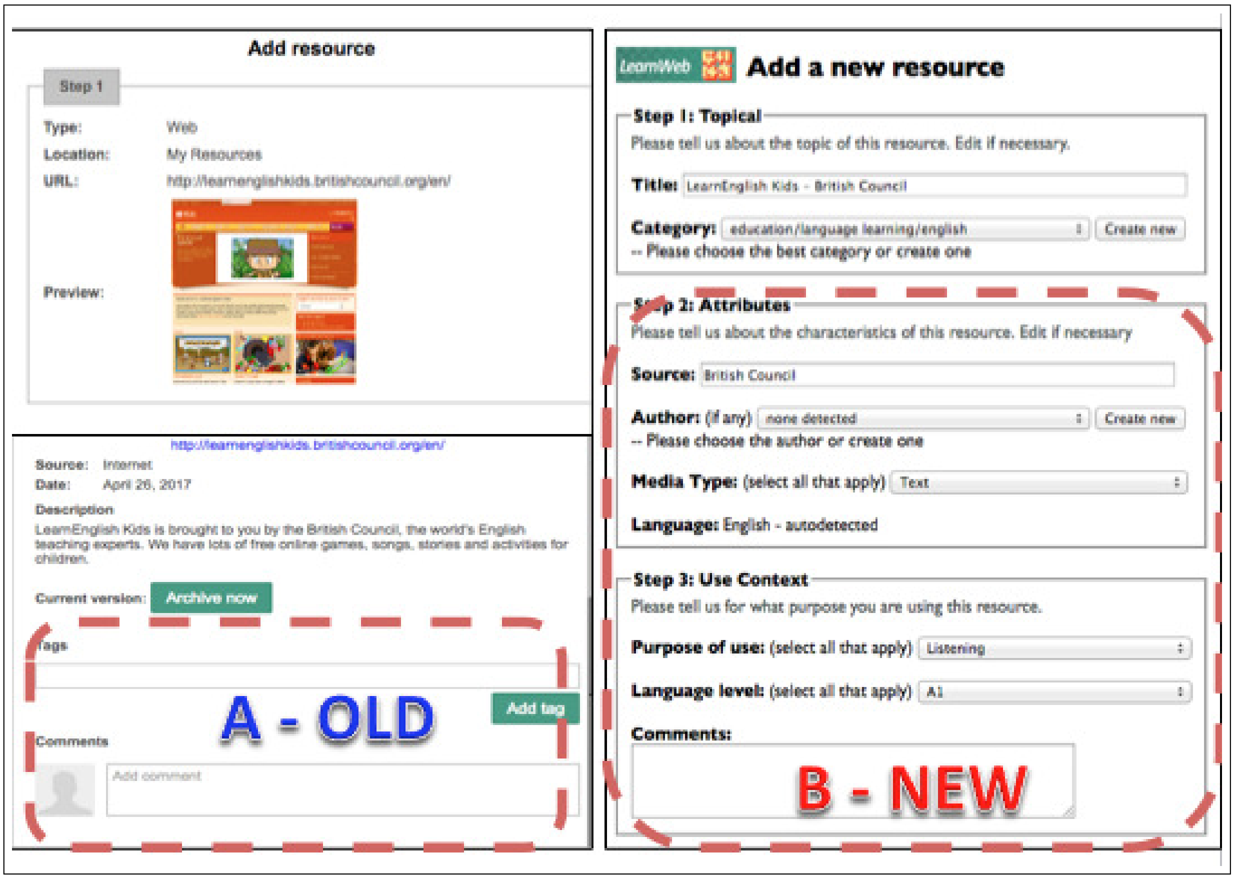


Figure 6.4: The comparison of the old and new interface for adding metadata (tags) to a new resource

the community users. When a user clicks on a resource, he or she is given an option to add a new set of metadata as shown in Figure 6.5. All metadata added by multiple users are used to provide a statistical snapshot of the usage of shared resources, which will be further described in the next section.

### 6.3.2 Interface: Visualization of contextual metadata for search

The search interface needed a great amount of re-work in order to meet the requirements put forward by teachers during previous studies. The old interface did not provide much information about each resource other than the thumbnail and the title as shown in Figure 6.6. This lack of visible metadata made it hard for users to understand what the resource was about

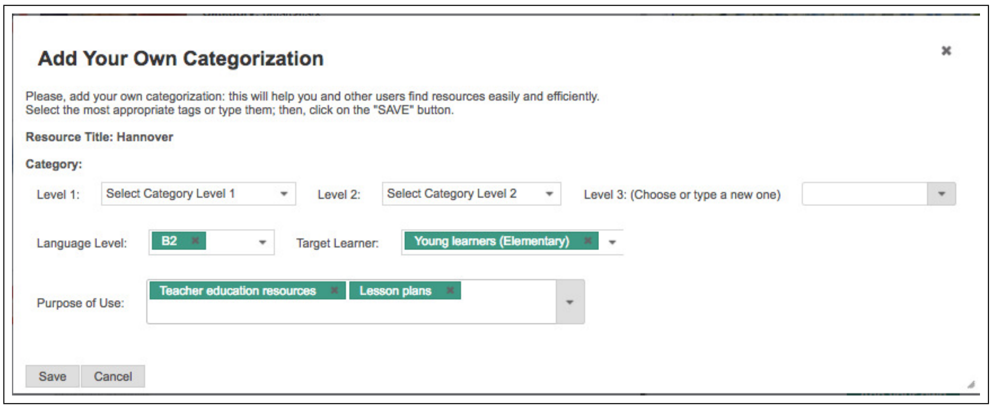


Figure 6.5: Adding metadata to existing resources shared by others

and whether or not it was appropriate for their teaching needs. Therefore, the new interface put a great focus on remedying this difficulty by providing a detailed yet concise snapshot of metadata visible in the search result. Specifically we designed the interface in such a way to minimize the efforts teachers exert in selecting most relevant resources for their teaching context by eliminating the need to click on each resource to evaluate the content themselves (refer Figure 6.1).

**Keyword search and contextual filters**

The keyword search focuses on allowing users to filter search results by contextual filters as well as traditional keyword search. As discussed in section 6.2, we learned that teachers not only search by topic but also evaluate various aspects of the resources and their context of use such as target learners, purpose of use (teaching activity) and language level, which cannot be discerned from the resource title or description. As depicted in Figure 6.7, results are displayed with aggregated contextual metadata collected from members of the community so that users can instantly understand the appropriateness of the resource for their intention. Media types are visualized with graphical icons to make it easy to view which materials are images, web pages or videos at a glance. Furthermore, search results can be filtered by contextual metadata as well. For instance, a user looking for a listening material for pre-school kids can simply narrow search results by using filters (see Figure 6.8).

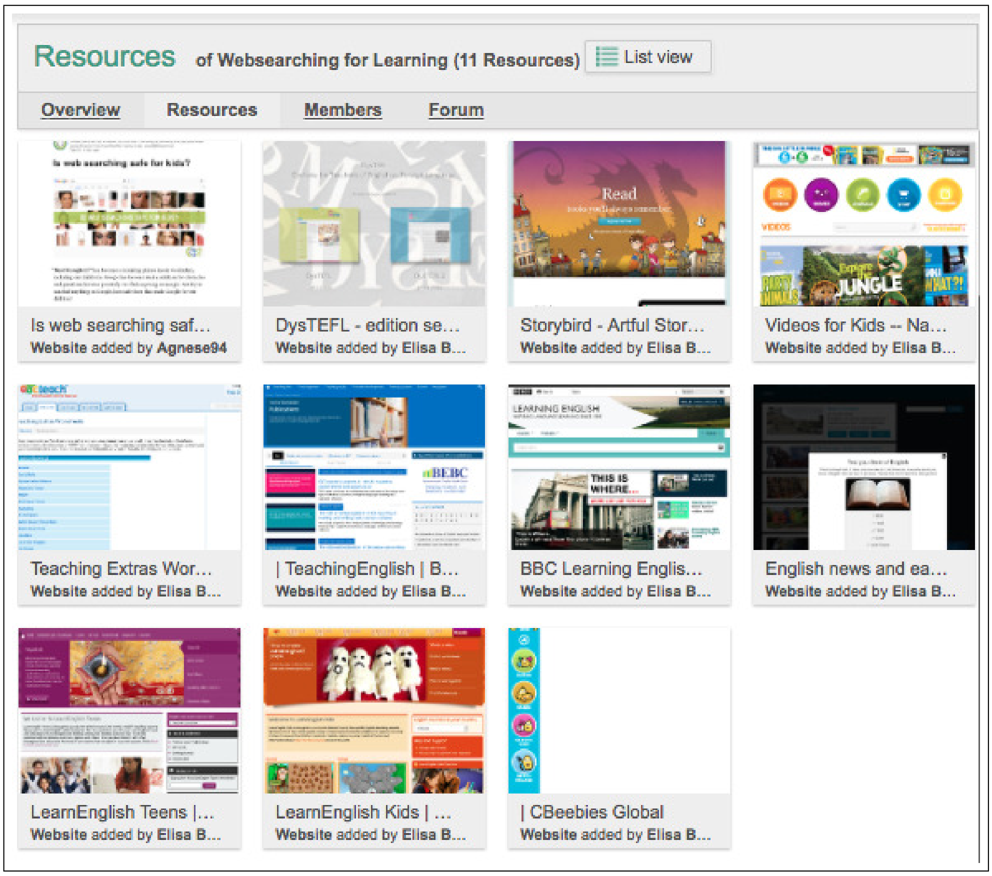


Figure 6.6: Old interface of search result

### Category search

The observation of teachers' searching behavior also revealed that they generally did not have a very specific topic in mind when initiating search but they went through several iterations of keyword search to move from general to specific topic. In order to help teachers to gain an overview of available topics before launching search, the new interface also provided an alternative search method - ***category navigation***. Each resource uploaded to Learnweb was assigned a category and these categories were used to build a comprehensive category tree of all shared resources in the community. Figure 6.9 shows an real example of such category tree in a shared folder of teachers' community. Clicking any node in the tree will display only resources belonging to that category with all types of contextual metadata in the same way as in keyword search interface.

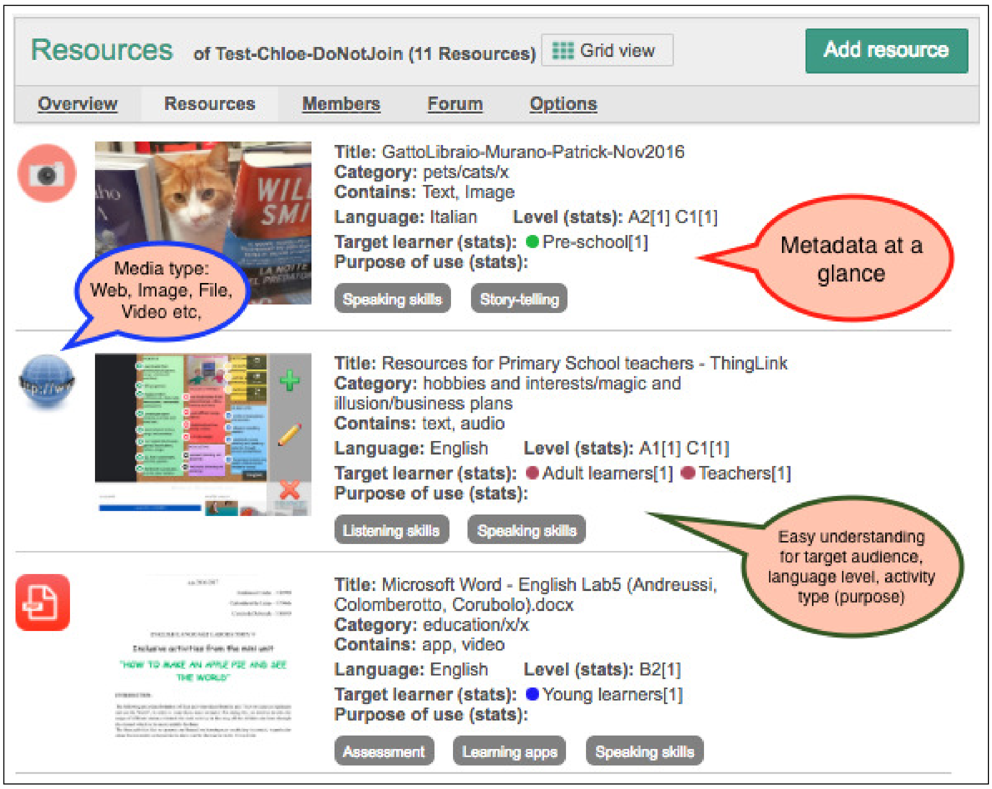


Figure 6.7: New interface of search result

### 6.3.3 Implementation

The new interfaces were implemented using JSF (Java Server Faces), html and javascript with MySQL to store the data. Each resource's metadata has been extended to include the new types by adding new associated tables. For category visualization, external library - D3 (Data Driven Document Library) [2] was used to render the category tree.

As this work involved adding new features to existing system, there were no new architecture changes (Model-View-Controller) and all new codes were added in accordance with the rules and guidelines of the previous work done. Thanks to using JSF, new user interfaces were created using rich custom made components to maximize the usability and aesthetics.

[2]https://d3js.org

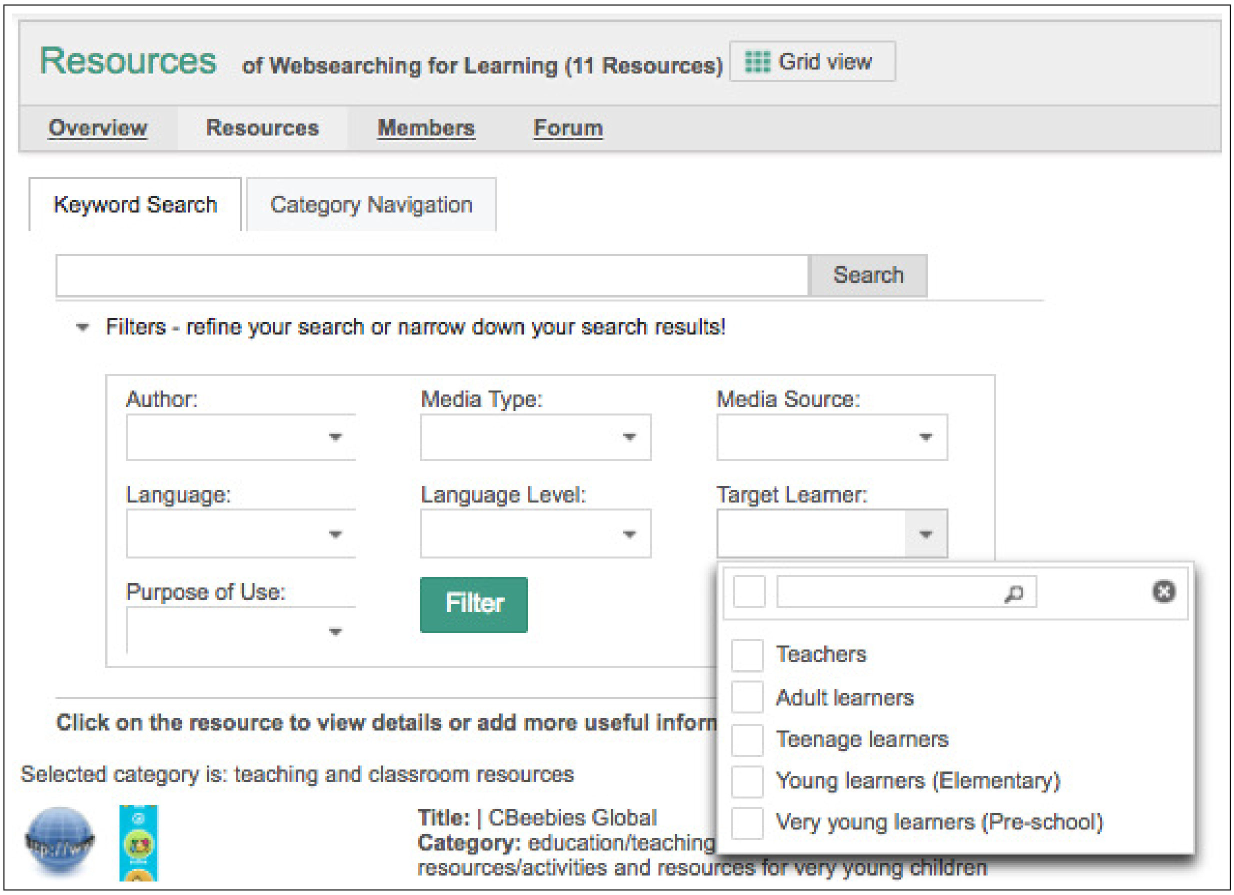


Figure 6.8: Metadata filters on new search interface

## 6.4 Learnweb experiment and its results

The new interfaces were developed to improve the search experience of teachers when dealing with shared resources by others in the community. To validate the impact of such implementations, we have carried out a pilot testing where two batches of users were asked to perform several search tasks using the new interfaces and their actions were logged in database for analysis. Once pilot was finished, the new interfaces were made available to all other users and their actions were logged as well for about 5 and half months.The focus of the experiment was to gain insights into the actual usage and potential benefits of contextual metadata visualization and filters.

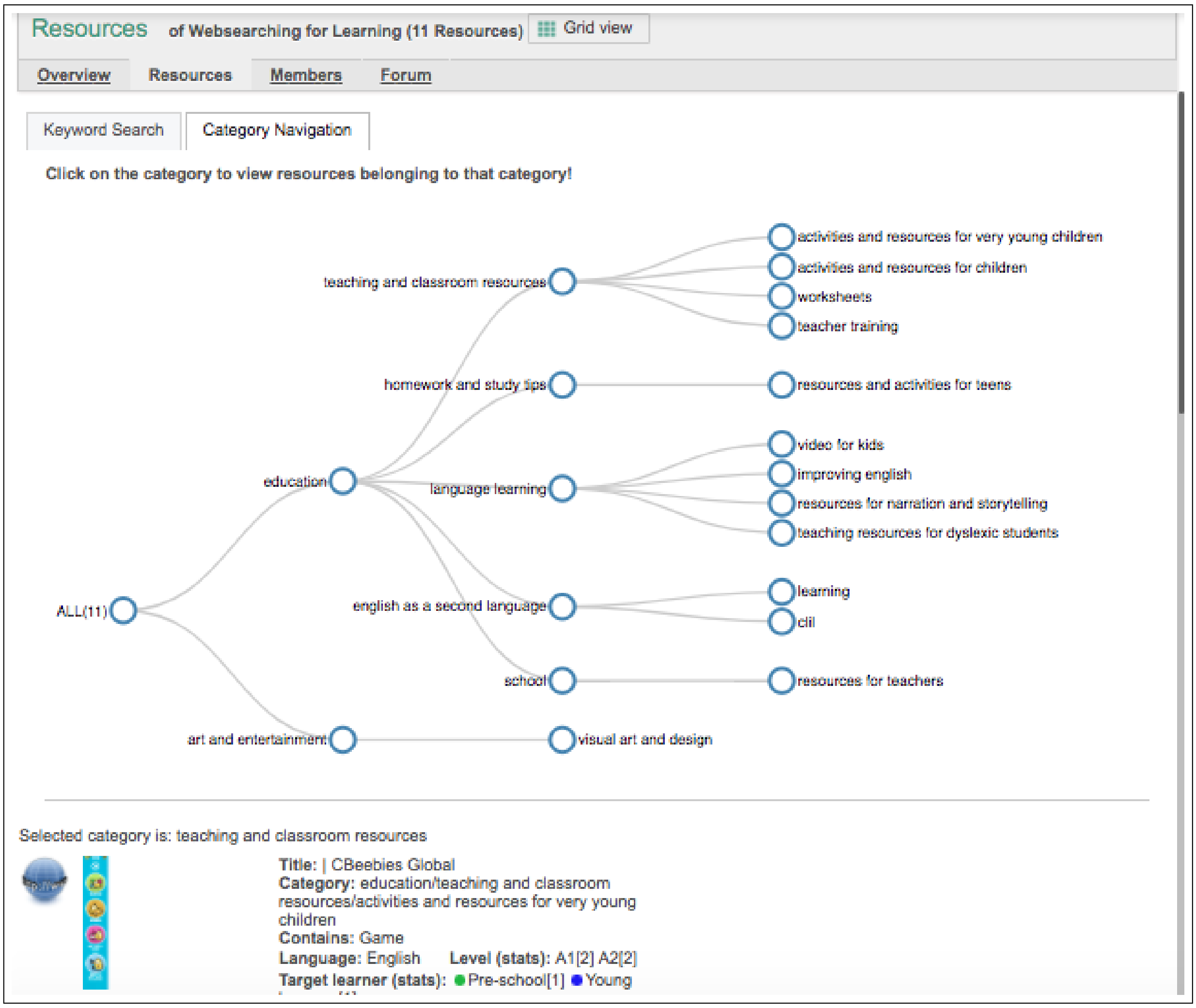


Figure 6.9: Category navigation interface

### 6.4.1 Methodology

YELL/TELL is a virtual professional community for language teachers of various levels and expertise to share resources and practices at different stages in their career. The user experiment was carried out with YELL/TELL groups of users. Initially, we performed a pilot testing with selected users between November 21, 2017 and Jan 19, 2018 - details of the pilot testing is provided in subsequent sections - and once pilot was completed, the new interfaces were made available to all groups of users in community and their actions were logged. The author of this thesis has designed, developed the concept and realization of the prototypical tool as well as collecting and analyzing the experiment data.

**Pilot testing - User tasks**

The first group consisted of 34 post-graduate students of Foreign language who plan to become language teachers while the second group was made up of 6 experienced language teachers of varying educational competencies - nursery, elementary and secondary. Both groups were given a number of tasks to find suitable materials for their teaching scenarios and add their own metadata when required. The aim of the experiment was investigate how participants search for and tag online resources for their teaching practice using the new interfaces. Participants were given 5 different tasks to carry out during the experiment. The tasks were largely divided into two activities: searching teaching materials among resources shared by others or from the Web and adding metadata to new and existing resources. Below outlines each task and its instructions in respective tables.

- Task 1 - Search in Web: search for new resources on the Web and add tags then share them in a group (see Table 6.4)
- Task 2 - Search in YELL/TELL group: tagging unfamiliar resources from more limited digital context and among resources shared by other teachers (see Table 6.5)
- Task 3 - Searching and tagging your own resource (see Table 6.6)
- Task 4 - Tagging resources provided in a test group (see Table 6.7)
- Task 5 - Exploratory search task for a test scenario
  - 'Imagine that your school asks you to replace one of your colleagues who is absent. You are subbing for a science teacher in a class that is not one of yours. The lesson starts in an hour. You need ideas to plan 3 or 4 activities for the lesson. Activities should be suitable for students of your level of school (nursery, primary, etc.). You are free to choose the topic of your lesson but since you are an English teacher, try to adapt it for an interdisciplinary lesson. You have about 10 minutes to conduct a web search to find materials suitable for your class'

Table 6.4: Instructions for Task 1: Search and tag resources from the Web

| **Steps** | **Instruction** |
|---|---|
| 1 | Think of a Web search you need for your teaching or for one of your classes |
| 2 | Enter your search keywords in the main search field at the top of the keyword search interface |
| 3 | Look at the search results, choose what can be useful for your teaching needs and share it in one of the groups |
| 4 | Add your tags and brief description for the resource so that it can be easily found by other teachers |
| 5 | If you do not find anything interesting in the search, try other keywords and go through the process again |

Table 6.5: Instructions for Task 2: Search and tag resources shared by others

| **Steps** | **Instruction** |
|---|---|
| 1 | Choose one of the YELL/TELL groups you are interested in |
| 2 | Carry out a search for teaching materials among resources shared by others in that group |
| 3 | Look at the search results, choose what can be useful for your teaching needs |
| 4 | Add your tags and brief description for the resource so that it can be easily found by other teachers |
| 5 | If you do not find anything interesting in the search, try other keywords and go through the process again |

### 6.4.2 Datasets

The user actions performed with new interfaces were logged into database for later analysis. Table 6.8 shows the types of actions and details of each action that were logged. Two sets of data were collected and analyzed. The first set of data are those collected during the pilot, that is from November 21 to December 19, 2017. The second set of data are collected after the conclusion of the pilot in which users of any YELL/TELL community were allowed to view and use the new interfaces without any training or instructions.

A total of 770 user actions were logged during the pilot and 3846 user actions post the pilot. The composition of logged actions are shown in Table 6.9 (refer to previous Table 6.8 for the action ID numbers). A separate data was collected for the tags and comments made during the same time period for comparison (see Table 6.10). The number of logs shown in below tables are those after removing logs done by persons who conducted or involved in pilot testing as non-participants.

Table 6.6: Instructions for Task 3: Search and tag your own resources

| **Steps** | **Instruction** |
|---|---|
| 1 | Think of an interesting resource you have already used for your teaching |
| 2 | Use Learnweb search tools to find that resource |
| 3 | If you have not shared it in a group, share it in an appropriate group |
| 4 | Add your tags and brief description for the resource so that it can be easily found by other teachers |

Table 6.7: Instructions for Task 4: Tagging resources provided in a test group

| **Steps** | **Instruction** |
|---|---|
| 1 | Enter YELL/TELL community |
| 2 | Access the group called "Web searching for Learning" |
| 3 | You will find 10 teaching resources |
| 4 | Explore each one of them |
| 5 | For each resource, complete or change tags and add brief descriptions so that it can be found by other teachers. Please tag at least 5 resources and possibly all of them |

### 6.4.3 Result analysis

As pointed out in section 6.4.2, two sets of data were collected during and after the pilot. During the pilot, users were given specific tasks to add metadata to their and others' resources and search using the new interfaces. While the logs from the pilot is interesting for gaining some idea about users' impression and usability of the new interfaces, they would not represent the real behavior of users when they are under no obligation to use the new interfaces. Therefore, we collected the logs also after the pilot ended when users from other YELL/TELL communities were free to explore and use the new features as they wished. In this section, we share the preliminary result analysis of the data collected.

#### Pilot testing results

The feedbacks gathered from the participants regarding the new interfaces were very positive. They highlighted the benefits of being able to understand immediately the usage of the resource on the result list, which helped them not to "get lost" in the middle of numerous resources. Below we discuss the quantitative aspects of the pilot testing from the logs.

- **Types of metadata added to resources**: there are two scenarios where users can add metadata to resources. The first case is when they add a new resource (where they can add resource attributes such as

Table 6.8: User action logs of new interfaces

| Action ID in logs | User action | Log details | Interface |
|---|---|---|---|
| 48 | Adding user's own metadata to an existing resource | Clicked resource Id, Type of metadata added | Figure 6.5 |
| 49 | Adding metadata when adding a new resource | Resource Id, Type of metadata added | Figure 6.4 |
| 51 | Searching by metadata filter | Type and value of metadata search filter used | Figure 6.8 |
| 52 | Searching by category navigation | Value of clicked category in the tree | Figure 6.9 |

Table 6.9: User action logs collected during and after pilot

| Collection period | Total logs | Action 48 | Action 49 | Action 51 | Action 52 |
|---|---|---|---|---|---|
| Pilot (Nov 21, 2017 - Jan 19, 2018) | 770 | 251 | 441 | 13 | 65 |
| Post pilot (Jan 20 - June 24, 2018) | 3846 | 88 | 3164 | 264 | 294 |

media type and author) and second when they view resources shared by others and decide to add their own contextual metadata such as target audience or use purpose. We have divided the logs into these two cases and reviewed what type of metadata users add respectively as demonstrated in Table 6.11. When users were adding resources, they added *Author*, *Language*, *Media type* and *Media source*. Language was the most common metadata added in this scenario followed by the author. On the other hand, users added *Categories*, *Use purposes*, *Target audiences*, and *Language levels* to existing resources in the given order.

- **Metadata ratio per resource**: while a much greater number of metadata was added for new resources, the ratio of attribute metadata per resource was 2.18. On the other hand, the ratio was much higher for contextual metadata at 6.2. During the pilot, users were asked to add the types of metadata useful for searching. Given the higher ratio of the contextual metadata added per resource, we may carefully interpret the results as an indication that users consider contextual metadata more useful for search than the attributes of the resources.

- **Design implications for the small number of resources with contextual metadata**: though the ratio of contextual metadata per

Table 6.10: User action logs collected for tags and comments

| Collection period | Total logs | Tags | Comments |
|---|---|---|---|
| Post pilot (Jan 20 - June 24, 2018) | 80 | 70 | 10 |

resource was three times higher than attribute metadata, the sheer number was much lower. This could have been caused by the fact that users were prompted to add attribute metadata at the point of adding a new resource whereas the contextual metadata could only be added by users' direct action to press a button in the interface. Such design may have demanded more efforts from the users' side hence dissuading users from a more willing participation.

Table 6.11: User metadata added for new and existing resources

| Ranks | Metadata for new 202 resources (# of counts) | Metadata for 40 existing resources (# of counts) |
|---|---|---|
| 1 | language (202) | category (76) |
| 2 | author (197) | purpose (60) |
| 3 | media type (21) and media source (21) | audiences (58) |
| 4 | | language level (57) |

- **Metadata search**: the powerful feature of the new interfaces was the search by user-added metadata. Users could search resources by the attributes or contextual metadata added by users in the community. During the pilot, participants performed a total of 78 metadata searches: 13 were done using the metadata filters (see Figure 6.8) and the other 65 were done using the category navigation (see Figure 6.9). The metadata filters used the most was *"use purpose"* (e.g. Lesson plans), followed by *media source* (e.g. Internet), *language level* (e.g. A1, A2). Categories users explored in search were mostly specific. 26 searches were for the top level category and the rest 52 were on specific yet diverse sub categories such as *learning strategies*, *ecolinguistics*, *resources for dyslexic students*. Given the small number of searches during the pilot, it is not possible to draw any inferences or conclusions. Therefore, we will revisit the patterns of metadata search behaviors with the logs gathered after the pilot. Also one must put in consideration that the metadata need to be added for resources before such searches can be performed. Before the pilot, there was no metadata added for any resources (participants were asked to add the metadata during the testing), therefore, metadata search probably was not as useful as it could potentially be.

#### Post-pilot log analysis

Once pilot was completed, the new interfaces were made available to all YELL/TELL users. However, users were not given any training or explanation of the new features and there was no intervention by any person that had been involved in the development or pilot testing. A total of 3846 action logs by 360 unique users was collected between January 20 and June 24, 2018. Various types of metadata were added to 1590 resources. As Table 6.12 shows, most of the activities performed were adding attribute metadata when new resources were added, totaling 3164 logs. 88 logs were for adding contextual metadata. Search using metadata filters were logged 264 times while category navigation 294 times. Below we provide some of the insights gathered from the log data. Where applicable, we also compared the data of the pilot and that of post-pilot in order to see if there was a noticeable difference in the usage of metadata when users were not directly asked to use the new features.

Table 6.12: Post-pilot User Log Profile

| **Action** | **# of logs** | **# of users** | **# of resources** |
|---|---|---|---|
| Attribute metadata | 3164 | 265 | 1567 |
| Contextual metadata | 88 | 19 | 22 |
| Metadata filters | 264 | 33 | N/A |
| Category navigation | 294 | 73 | N/A |

- **Types of metadata added**: there were 265 users who added attributes to 1567 new resources. Similar to the result of the pilot testing, users added mostly the *Author* and *Language* to their new resources. However, a noticeable difference between the pilot and post-pilot was that users added *media source* and *media type* even much less. Out of 3164 logs, only 14 logs were recorded for adding such attributes. The ratio of attribute metadata per resource remained similar to that of the pilot at 2.0. Likewise, the ratio for contextual metadata was higher than that of attributes at 4.0. Nevertheless, this

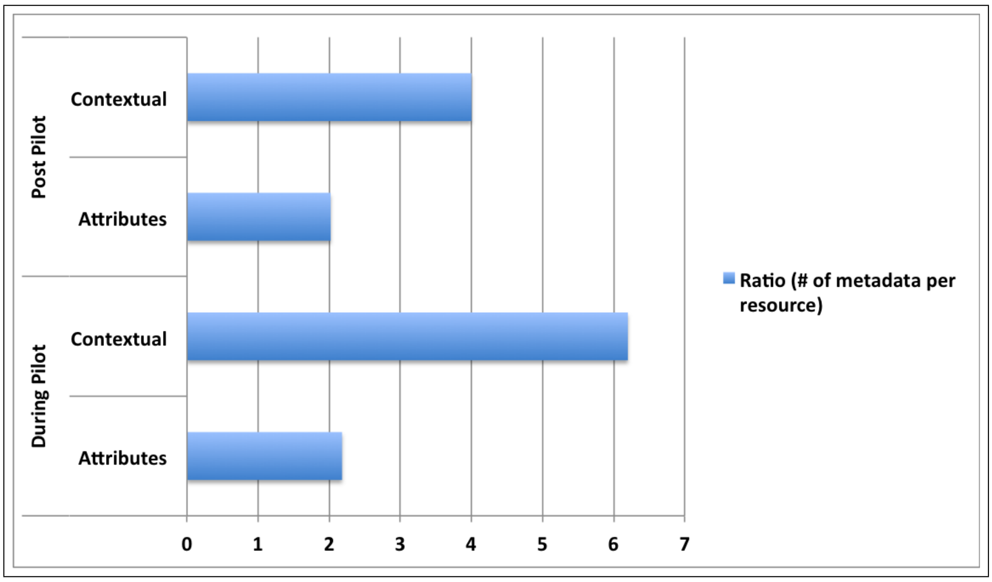


Figure 6.10: Metadata Ratio per Resource

number is lower than 6.2 from the pilot testing. Figure 6.10 shows the metadata ratio per resource for pilot and post-pilot logs. In summary, users were more inclined to add more contextual metadata per resource but the number of users that add such metadata was significantly smaller. As we mentioned previously, adding contextual metadata requires more time and efforts from the users given the current design of the interface - users manually need to click a button to open the contextual metadata dialog to add - which probably deterred users from adding contextual metadata even though such metadata was found to be important in their normal search process (see section 6.2). Post-pilot logs show that 19 users added 88 contextual data to 22 resources. Figure 6.11 shows the types of metadata added to the resources and also comparison with those from the pilot testing. The types of contextual metadata added to resources showed negligent differences between two cases. Category metadata was added the most and the rest (target audience, language level and use purposes) were more or less evenly added.

- **Metadata search**: during the pilot testing, participants used very little of the enhanced metadata search because there had been no

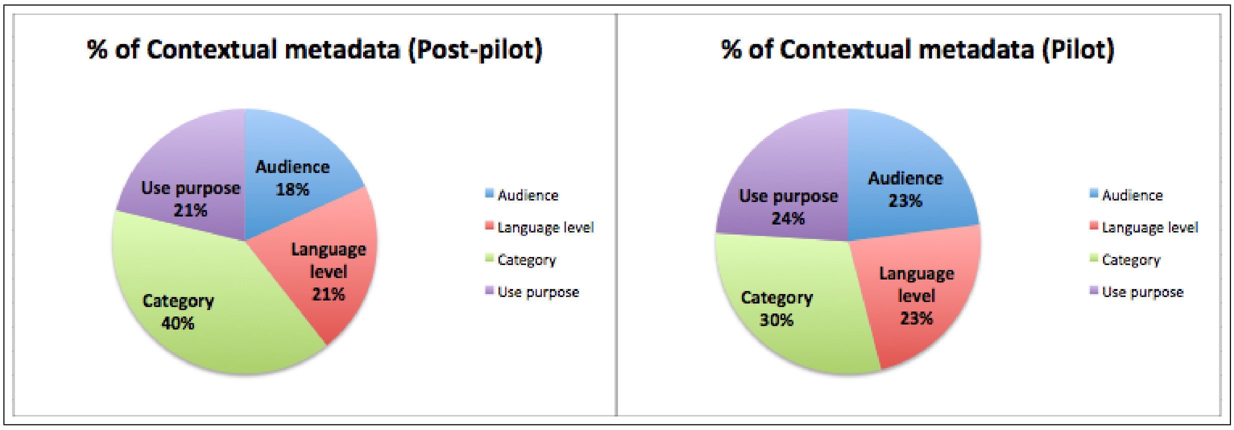


Figure 6.11: Contextual metadata type (in %) Post-pilot Vs. Pilot

resources with additional metadata prior to the pilot. The logs from the period post pilot shows that, indeed, a higher number of searches using the contextual metadata filters and category navigation. A total of 558 searches were performed using the new interfaces, of which 264 were by metadata filters (see Table 6.12). *Audience* was the most frequently used metadata filter. Users searched resources suitable for particular target audience like pre-school or elementary children. The next was *Media type* such as "text", "image", "game", etc. What is interesting about the media type search is that most users did not add media type metadata when adding new resources as we pointed out earlier. From the logs, however, media type is a highly sought after metadata filter that users should be encouraged to add more. *Purpose* was also used often where users searched for resources adapted to teaching objectives like listening skills, reading skills, story-telling, or lesson plans. Author, language and language levels were those used less frequently used. Author and language, as we have seen in previous analysis, were added for all new resources by the users. Nevertheless, the usefulness of author and language does not seem to be highly estimated when users actually search for resources. The details of each metadata filter used is demonstrated in Figure 6.12. A similar number of searches were done via category navigation by 73 users post-pilot. As with during the pilot, a majority of searches were done on the specific category, rather than the top node: only 54 searches were done for the top category and the rest for specific sub categories.

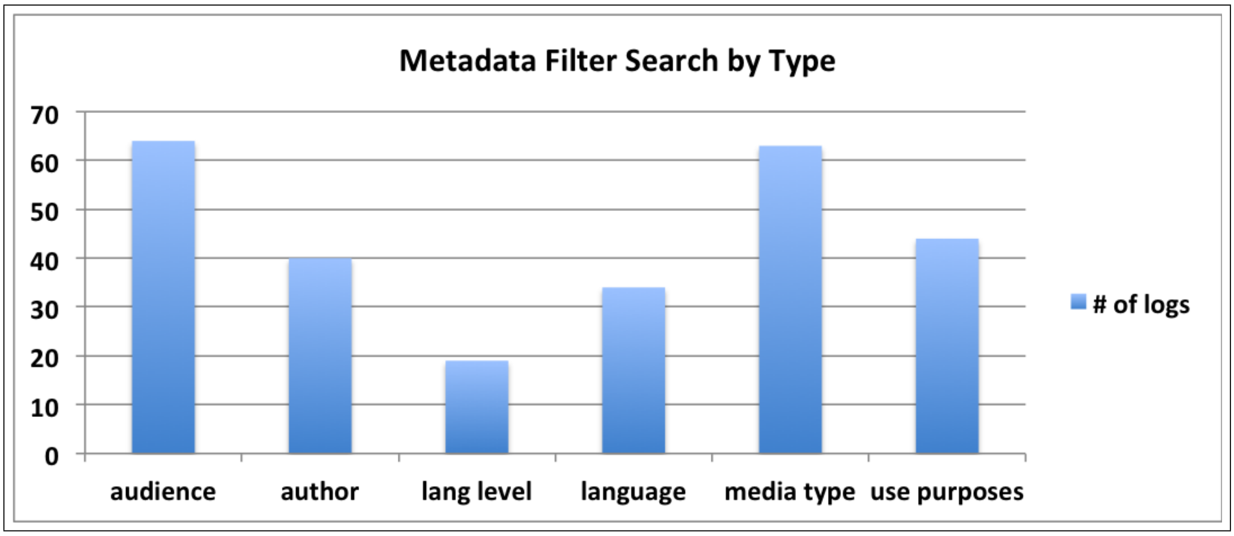


Figure 6.12: Metadata filter search by type

Table 6.13: Ranks of metadata added by users Vs. those used for search

| **Ranks** | **Metadata added by users** | **Metadata used for search** |
|---|---|---|
| 1 | Author | Category |
| 2 | Language | Target audience |
| 3 | Category | Media type |
| 4 | Use purpose | Use purpose |
| 5 | Language level | Author |
| 6 | Target audience | Language |
| 7 | Media type | Language level |
| 8 | Media source | Media source |

So far we have discussed some findings from the logs collected during and after post-pilot. Our logs showed that a small number of users added contextual metadata to resources even though the previous investigation with the teachers revealed that such contextual metadata were instrumental to their successful searches (see section 6.2). In fact, the number of users who performed searches using the metadata were almost 3 times higher than that of users who added them. This shows that, while users appreciated using the metadata for search, they were reluctant to spend their time and efforts to become the provider of such metadata. The current design of the new interfaces might have also worked against encouraging users to add more. Users were asked to manually press a button to add contextual metadata to resources instead of being prompted. The type of metadata added by users and those used for search were also different. Table 6.13 shows the different ranks of types of metadata users added versus those actually used in search.

Despite the lower participation of users than anticipated, users were definitely more willing to use the new interfaces as a means to add their own metadata than the free-form tags and comments offered in the old interfaces. As a study done on usage of tags and comments back in 2009 demonstrated, users rarely tagged or left comments on resources [2]. We have collected the number of tags and comments added to resources during the same period to evaluate whether or not users were more willing to use the new forms of adding their own metadata than the tags or comments. As shown in Table 6.10, a total of 70 tags and 10 comments were added to 38 and 10 resources respectively. Table 6.14 shows the details of the tag and comment logs. In order to compare how much more users are engaged in adding metadata to resources, we have calculated the metadata ratio per user. The calculations are shown in Table 6.15. On average, users added 4.0 tags or comments compared to 11.5 attribute or contextual metadata. The big difference between these two cases show that users were inclined to add much more metadata to each resource with the new interfaces than previously. This could have been spurred by giving users the clear idea what kind of metadata is expected from them when adding new or viewing existing resources. A study on users' perception of tags showed that most users still did not quite understand what tags were or what functions tags perform [72]. Free-form tagging and comments do not encourage users to add a certain type of metadata nor they are organized into different types of categories to be used later for searching and filtering. In fact, we have seen that a much greater number of users made use of the new metadata search functions despite the low number of metadata available per resources. With the old interfaces, users were not given explicit methods to search by tags or comments, therefore they only acted as the "secondary relevance indicators" [2] for their search activities.

Table 6.14: Tags and comment logs collected post-pilot

| **Type** | **total # of logs** | **# of users** | **# of resources** |
|---|---|---|---|
| Tags | 70 | 13 | 38 |
| Comments | 10 | 7 | 8 |

Table 6.15: Comparison of ratios per user

| **Metadata Ratio** | **Attribute and contextual metadata** | **Tags and comments** |
|---|---|---|
| Per user | 11.5 | 4.0 |

#### Revisiting LOM: The Usage of Different Categories

In earlier section 6.2.3, we briefly discussed the various categories and elements offered by LOM and their actual usage in real sceanrios (Figure 6.3. We had pointed out that, even though the elements of "Educational" category seemed most important for sharing and searching learning materials, the usage was the lowest of all other categories. Our results showed some similarities and differences:

- Similarly to the LOM, participants did not add contextual metadata as much as the content-related or attributes of shared resources; nevertheless, showing them the possibility of adding such metadata did encourage some to add them, as opposed to adding none before the implementation of new interfaces. This demonstrates that most users are not aware or believe such metadata can be used for their organization or search of resources though they are useful

- Although the number of users who added such contextual metadata was lower than expected, the number of users who made use of such metadata for their search was much higher. This is paradoxical since users seem to find such metadata useful for their search but not so willing to be the provider of such metadata. The system should be designed carefully not only to encourage users but also make it simple and easy for users to add such metadata as users may find the task difficult, time-consuming or burdensome.

Having said that, it would be worthwhile to investigate further why the usage of such metadata is low and how to encourage users to add more of the educational (contextual) metadata to learning materials for better sharing and search. One possible cause might be that there is no standardization of the values for "educational" category of LOM, making it too broad for users to put the right value for each element. For instance, the element "Intended end users" could have a fixed list of sub elements such as "elementary", "adult learners", or "teachers" to make it more plausible for users to choose one from the given options. As our results demonstrated, more users added contextual metadata after the new interfaces were provided for them to choose the metadata type and its value while the previous free-end tagging system did not work because the users were given complete freedom to add whichever metadata they choose to add. Providing the guidance and giving a proper nudge to users seem to be instrumental to eliciting the desired types of metadata.

## 6.5 Related work

Incorporating context in search has garnered much interest in the recent years. Typically search entails users typing in some textual keywords and results were returned solely based on the inclusion of such keywords in contents regardless of various - yet mostly not explicitly expressed - user context information that may influence the accuracy of the results returned. In previous section 2.5, we have discussed how the ”social” aspect of the Web 2.0 has driven users to share potentially unlimited number of online resources with other users and how to organize and index this vast amount of resources has been a hot research topic. The notable key characteristic of these social sharing platforms was the “folksonomy” tags, which are essentially user-defined keywords that inherently has no structure or relations, which makes it a challenge to use them as search metadata. However, as per the study results of [119], [17], and [57], users are observed to express their user context in forms of tags on various platforms and in fact, some of these were found to be useful for search, depending on the search scope, user motivation and the design of the system.

Using context, as we have seen in 2.4, has been mostly applied in personal information management (i.e. bookmarks). In recent years, context is being heralded as the new critical ingredient in personalizing search results as it can be “leveraged to support users’ broader information-seeking behaviors” [12]. To that end, researchers have dabbled in using search histories of users [78, 139, 123], location [13], task-based search activities [91, 114] and short-term and long-term interests [74, 14]. However, these studies center on rendering better search results for individuals. Search behaviors in community are directed by a common overall task goals, which may be different from those of non-members. Teevan called this "groupization" in [133], which inversely can be used to improve personalized search.

To our best knowledge, our work is the first in experimenting using specific context as tags and offer such as search parameters in community resource-sharing platform. Specifically, our work is unique in following aspects:

- Systematic gathering of design requirements by investigating user motivation and behavior though their Web search behaviors and interviews
- Embodying such requirements and re-designing existing system tailored to the search needs of a specific community
- Experimenting the use of context as search metadata and observe the types of context most appreciated in targeted or exploratory search

Though our experiment was limited by the lack of resources (i.e. time and participants) and hence could not provide sufficient data for definitive conclusions on how effective contextual metadata can be, the preliminary results showed a higher user engagement in providing such metadata than free-form tags or comments and a willingness to use such metadata to filter their search results. As the usefulness of metadata search greatly depend on its availability (i.e. more resources with metadata will return more search results), our next task would be to probe how to encourage users to add more of such metadata with least efforts.

# Chapter 7

# Conclusion

In this paper, we focused on the challenges users face from having transitioned from paper-based to digital materials with which they perform daily activities. In particular, we were interested in finding out the dynamics of using context could bring about in learning, organizing and searching information as pointed out in Chapter 3. To meet this quest, we introduced three different prototypical tools developed for each scenario and performed a set of user experiments to answer our research questions.

To find out the impact of personal context in learning, we centered our question on the role of annotations readers make while studying a text. Annotations constitute a form of giving personal context to the information given, a sort of our natural way of internalizing the given knowledge as our own. Our results of the user experiment carried out with the prototypical tool, Q-Book, showed that there was no significant overall difference in learning outcomes using the multimedia annotation tools; however, a moderately positive correlation could be seen between the number of annotations and the test scores: the higher number of annotations, the better the test score. Moreover, the group who used the tool showed a more evenly distributed test scores than the control group. This may indicate that students who academically performed poorly may have benefited from the annotations made by peer students, thus bringing their test scores closer to that of class average. In fact, the number of students who failed the test was reduced after using the tool in class. The most preferred type of annotation was the image and highlights. However, students showed more interested in using the videos during the survey. The lack of time to view the videos during the lectures probably have hindered them from adding video annotations. Overall, the experiment gathered positive feedback both from the students and the teachers. Nevertheless, our experiment showed that having such tool available and to be used also after school may bring better results in terms of learning outcomes. To achieve this, the teacher should also actively participate in giving students assignment using the tool and make the tool an essential part of their lesson plans.

Our second experiment entailed using context in organizing and refinding personal bookmarks. In this scenario, we explored a different set of context types from the previous experiment: we considered a bookmarking event as an autobiographical event made up of 5W1H (when, why, what, who, where and how) and developed a prototypical tool, MemoryLane, that allowed users to add such contextual information to their bookmarks as retrieval cues. Our experiment was carried out in three stages - online survey, collection of bookmarks and retrieval tests - to examine the perceived importance, the actual usage of semantic and contextual cues at the point of bookmarking as well as retrieval. Our results showed that the "purpose" was perceived as the most important contextual cue for recall. Nevertheless, some other contextual cues were most effective depending on the types of Web content: while the purpose, people, events were most frequently used for work or study-related Web pages, location and emotion were preferred for Web pages of personal interests. The impact context plays alone was not significant; however, our results showed that context played an outstanding role in successful bookmark retrieval when users have forgotten the semantic cues (i.e. keywords). Paradoxically, the type of context widely used in existing tools - *time* was not used at all in our experiment. It might be worthwhile investigating further the underlying causes. in conclusion, contextual metadata as retrieval cues do not replace semantic metadata such as topic or tags; rather, context can dramatically aid users in refinding when there are gaps in the semantic memory, provided that the contextual features used are relevant for the specific type of Web content. Moving forward, these contextual metadata should be collected as automatically as possible, as otherwise users might bookmark to a lesser extent due to the time it takes. Purpose (goal) extraction is hard, but it might be good to find out how well goals can be formulated based on a combination of previous queries and similar ones from other users. The surprising twist of our experiment result was the role emotion played as retrieval cue. Even though users did not consider it important - based on the survey results - , they were observed to recall and use it to retrieve bookmarks when all failed. Providing emotion from the user's point of view does not cost that much perceived effort as seen by the smooth transition on social media like Facebook from just "likes" to reacting with emoticons/emojis.

Lastly we experimented the use of context as metadata for search in a homogeneous community. We focused on first gathering the types of metadata most desired by the members of the community through workshops and interviews. Based on the results, we re-designed the existing resource sharing tool, LearnWeb, to support adding and searching by contextual metadata. Logs gathered during and after the pilot testing showed that there were differences in the types of metadata users add and users use for search: users mostly focused on adding the "attributes" of the resources like the *author* and the *language*. However, the metadata most useful for search were different. Metadata that reflected their teaching scenario were most frequently used as filters: *target audience* and *use purpose*. Further it was clearly seen that, while users appreciated and used contextual metadata for their search, they were reluctant to be the provider of such metadata. The system design seems to have played a part as well since adding contextual metadata required additional actions from the users. Despite the overall enthusiasm users exhibited about the new features, the actual participation was lower than expected. Nevertheless, the user feedback gathered during the pilot was strongly favorable and in fact the logs showed that users were definitely more wiling to use the new features than the free-form tags or comments that were offered previously. Explicitly labelling tags as contextual metadata as we did in our experiment seems to encourage users to provide more tags since they have a clearer idea what kind of information they are asked of. Increased time and efforts from the users' side is a concern but this can be somewhat mitigated by educating users of the benefits of adding such metadata and by automating the extraction of such metadata once sufficient data is gathered to feed into machine learning. In addition, it might be worthwhile to integrate context metadata into regular text query search as well instead of offering a separate set of search filters.

In this thesis, we have explored the role and the impact of context has in helping us to perform learning, refinding and searching information. Notwithstanding the limited extent, the overall results from our three different experiments show that the context by itself does not bring significant difference in the performance outcome. However, it does play a secondary, though as important, role in helping us learn more actively, retrieve information in the absence of semantic cues, and finally contribute to collective search in community. Our experiment results point out some further challenges to address in applying context in user applications. The first challenge is that there is no “one package for all” solution when it comes to choosing the right mix of contextual information. The effectiveness of contextual cues tend to vary depending on the information needs of individuals, circumstances and communities. A careful design of tools would be needed to make sure users are equipped with the right set of semantic and contextual cues to yield the optimal experience. The second and even bigger challenge seems to be increasing users’ awareness of the usefulness of context and their active participation as the provider of such metadata. After all, we as humans do not consciously encode the “context” when we carry on our daily tasks. How we can also "automate" gathering context information without users’ explicit actions would indeed be the next hurdle to overcome.

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