Information Seeking from Web-based Resources: Sensemaking Strategies and Implications for Interaction Design

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Related Publications

Abraham A. (2006). How learners make sense of the information they gather whilst completing web-based learning activities and the implications for interaction design. *In Doctoral Forum, at First International Information Interaction in Context Symposium, 2006, Copenhagen,* ACM

Abraham A., Petre M., Sharp H. (2007). Information Seeking and Sensemaking for 'Personal Fit'. *In Proceedings of the ACM SIGCHI 2007 Workshop on "Exploratory Search and HCI: Designing and Evaluating Interfaces to Support Exploratory Search Interaction".* Available online http://research.microsoft.com/%7Eryenw/proceedings/ESI2007.pdf [last checked March 2013]

Abraham A., Petre M., Sharp H. (2008). Information Seeking: Sensemaking and Interactions. *In Proceedings of the ACM SIGCHI 2008 Workshop on 'Sensemaking".* April 05-April 10, 2008, Florence, Italy. Available online http://dmrussell.googlepages.com/sensemakingworkshoppapers [last checked March 2013]

Abstract

Abstract

The internet has made an enormous volume of information available, and there has been substantial research into how users *look for* information. However, there has been much less research about how they *make sense* of what they find, and how sensemaking is shaped by the tasks they are trying to achieve. This research addresses that gap, with empirical studies of sensemaking during web-based information tasks.

Two main studies are presented, which aimed to expose the relationship between information *seeking* and information *comprehension and use*. The first study explored the actions of experienced information processors (in this case, doctoral students) as they undertook research-related web-based tasks related to their own work. The second study observed experienced users as they undertook an unfamiliar topic comprehension task. In both studies participants were encouraged to 'think-aloud' as they completed web-based tasks. Audio-recording was used in Study-1 with video-recording in Study-2. In addition to the task session, background questionnaires and sample interviews were applied. A detailed, iterative inductive analysis was undertaken for each study.

The analysis produced a framework that models the users' process in terms of five categories of information interactions: *seeking, evaluating for selection, evaluating for use, compilation,* and *planning*. A range of visual representations were developed to capture the user sessions, expressing facets such as how resources were used over time and in combination, and the sequences of user behaviours. Attention was given to the use of representation throughout this process. Sensemaking goals and strategies were inferred from users' behaviours and utterances, and were related to their activity and output. The intertwined nature of information seeking and sensemaking activity was revealed, and *planning* (not addressed in previous literature) was identified as a significant behaviour that drives strategy and binds the other behaviours to the task-in-hand. These findings have implications for interaction design and for tools to support sensemaking.

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Chapter 1 - Introduction

1.1 The Context

In every aspect of life, whether it is education, work or play, there are instances when individuals need to seek out information to understand a situation and/or solve a problem/task. Examples of such situations include learning about a topic in order to complete an assignment, finding out more about a hobby, researching facts and figures prior to a purchase, generating a report as part of a work-task, and so on. These information 'gaps' raise 'information needs' which activate information seeking (Dervin, 1983). Typically information seeking involves gathering, interpreting, organising and integrating new information, in order to make sense. Furnas and Russell (2005, pg 2115) explain this as leading to "the creation of new sense", i.e., the sensemaking process.

There are several different perspectives on sensemaking, for example, Dervin (1983), Russell et al.(1993), which are discussed more fully in the literature review (Chapter 2), but for the purposes of this research project, sensemaking can be considered, in the general everyday meaning, as

> "the strategies and behaviours evident when users collect, evaluate, understand, interpret, and integrate new information for their own specific problem/task needs"

For many years, researchers have closely coupled sensemaking with information seeking; for example,

- Dervin, whose contribution and influence on information seeking research is readily acknowledged, argues that 'information seeking and use' are central to the sense-making process (Chapter 2);
- Kuhlthau, who acknowledges Dervin's influence in her seminal information processing model (ISP, 1991), considers information seeking to be a sensemaking process, where the individual is actively interpreting and constructing their own meaning to fit in with what they already know;
- Russell et al. (1993) early sensemaking model evolved from work related to information behaviours;

Web-based information seeking is concerned with interactions between the information user and a computer-based information system (e.g., Sutcliffe & Ennis, 1998; Wilson, 1999a; Broder, 2002). These involve at least two types of associated interactions, namely

i. interactions with the search-engine interface (e.g. query input);

ii. interactions between the user and the information sources (e.g. search results and web-pages/documents).

The first of these type of interactions, query-based searching, typically returns multiple results for any given search query, and the preferred response to an information need is often

> "a good collection of links on the subject rather than a good document"
>
> (Broder 2002, pg 6).

The latter of the two types of interactions can be complex and involve several subtasks; for example, there is at least (i) a source evaluation/decision-making aspect and (ii) an extraction of content or usage aspect.

As with many terms within information behaviour research, information *use* is interpreted in numerous ways and several alternative interpretations are discussed in Chapter 2, but Wilson's definition provides a rounded explanation:

> "Information Use Behaviour consists of the physical and mental acts involved in incorporating the information found into the person's existing knowledge base. It may involve, therefore, physical acts … as well as mental acts …" (Wilson 2000, pg 50)

In other words, information usage typically requires users to extract, organise, represent and integrate, i.e., make sense of the located information for their own specific problem/task needs. However, despite the volume of empirical studies, this extraction or usage aspect of information seeking has received little attention as yet; this oversight is considered a failing by many, including Kuhlthau (Pettigrew et al., 2002).

Similarly, the literature reporting empirical investigations into everyday sensemaking was scant at the point-in-time this research began; one exception was Qu et al.'s (2005) study into sources of external representations, i.e., sources of sensemaking artefacts. Since then, a few other studies have emerged parallel to this research (Chapter 2). However, more needs to be understood about how users make sense of located information, i.e., how they use the located information, and the underlying relationship between the sensemaking and the information seeking process.

This thesis attempts to contribute to this body of knowledge; using an empirical approach, it aims to

- provide further insight into how users make sense of and represent their sensemaking whilst seeking information in web-based environments;
- indicate any relationship(s) between sensemaking and the seeking process;
- offer indicative implications for the design of sensemaking support tools and systems (technologies).

1.2 Background and Motivation

Discussions about information behaviour invariably raise questions as to the interpretation of the terminology. Alternative interpretations for several of these terms are offered in the literature review (Chapter 2), but three terms are important. The three terms and their definitions as used in this dissertation are:

i. information behaviour describes the broad activity associated with ‘information needs’ through to ‘information usage’; such activity might involve computer-based and/or human information resources;

ii. information seeking is where the focus is on user’s observable behaviours as they locate and interact with the information sources in order to obtain and use the desired information;

iii. information searching is to do with the user’s ‘micro-level’ behaviours as they engage with an information system, e.g., the search query interface of a computer-based retrieval system. It is a sub-set of seeking.

In line with many others, these definitions are influenced by Wilson’s definitions (1999a, 2000) and the relationship between each term is illustrated by Figure 1.1

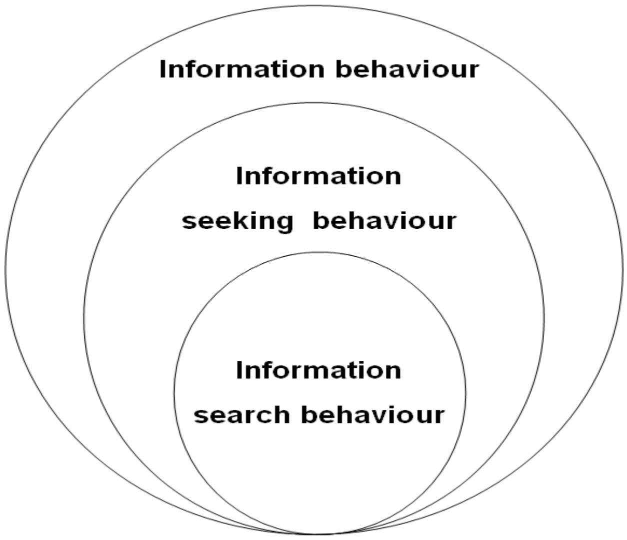

Figure 1.1 Wilson's nested model of information behaviour and related research areas (1999a, pg 263)

Research during the 1980's signalled a significant shift from a 'system-oriented' to a more user or 'person-centred' paradigm. Despite the very different profiles of current everyday information seekers, i.e., early users were typically specialist groups of users such as scientists, academics and library users, several of these early emergent seminal behaviour models continue to influence empirically-based behaviour research. At least two of these seminal models are of interest to this research, namely Kuhlthau's (1991) Information Search Process (ISP) model, and Ellis' Behavioural model (1989, 1993). Both of these models have subsequently been empirically tested for a range of users in web-based environments. For example, Kuhlthau's model has been applied to studies conducted by Swain (1996), Choo (1999), and Vakkari (2001) and Kuhlthau et al. (2001). Ellis' model has been tested by such as Choo (2000) and Meho & Tibbo (2003).

Two concepts are either explicitly or implicitly common to almost all behaviour models, namely,

i. expression of the information 'need', e.g. the query formulation

and

ii. 'evaluation' of the broadly relevant, available information sources.

Accordingly, two underlying components or elements of such models are *seek/search* and *evaluate*. Whereas the subsequent 'use' of the located information is rarely explicitly captured.

This lack of attention to information usage in emergent pre mid-nineties models, is perhaps not surprising; these early models were typically derived from empirical studies of fairly specialised users deploying customised or specialist database engines with no more than search and locate facilities. Document or information usage was not a function of the computer-system or dedicated database. Instead, it is probable that any explicit 'use' of the source content occurred whilst working with a paper-version. Only a few of the more recent models explicitly identify an information 'use' component. For example, Wilson's 1996 revised 'behaviour' model (Wilson, 1999a) generated from extensive analysis of behaviour models, Choo et al.'s two-dimensional 'Empirical Model of Web Use' (2000) based on Ellis' earlier model (1989), and Vakkari's (2001a, 2001b) model of a 'theory of the task-based IR process' informed from Kuhlthau's earlier ISP model. It could, also be argued, that there is some implicit recognition of information usage in Kuhlthau's ISP (1991), in the '*Presentation*' stage, and in both '*Extract*' and '*End*' features of Ellis et al.'s refined Behavioural model (1989, 1993).

The rapid development of Information Communication Technologies (ICT) and the growth of the World Wide Web (WWW or the Web) with its vast range of end-user applications, helped generate a fresh surge of behaviour studies. The Web now affects every aspect of our day-to-day lives; it provides immense sources of information which can be located and used in both work-related and personal interest tasks, and as such, 'searching the web' is, and will probably remain, fundamental to how we use it. For example,

- Kobayashi and Takeda (2000) in their review of information retrieval on the Web, reported that 85% of internet users claimed to use search engines and search services to find information, and forecast exponential growth by 2010;
- a report from Sims-Berkley (2003) offered further insight into online activities. They reported 319 million searches were conducted worldwide per day, with Google being credited for 112 million of these. The breakdown of activity showed
    - 32% searched for news, 29% used search engines to find information,
    - 21% looked for information related to a hobby whilst 19% undertook job related research,
    - another 19% searched for answers to specific questions, and 19% researched facts about a product before purchase.

Predictably perhaps, there is a considerable range of types of empirical studies on web-based information behaviour. These include several studies that provide some insight into why users search the web and report on the information 'need'. An example is Morrison et al.'s (2001) investigation into the user's purpose; their approximate interpretation of user's purpose, based on their web-survey of users, suggests that as many as 83% of search tasks were for information-related purposes. Nonetheless, in the main, the majority of empirical work continues to focus on only a subset of behaviour, i.e., aspects of the *search* and *evaluation* processes during the seeking process. Recent examples of these types of studies are

- comparative studies such as differing behaviour between novices and experts (e.g., Holscher & Strube, 2000);
- a large body reports specifically on search strategies, e.g., query (re)formulations;
- an equally large corpus reports on evaluation strategies, e.g., relevance judgements.

Some pertinent examples, listed in Table 1.1, are discussed in detail later (Chapter 2.4)

Authors & date	**Topic:**
Ivory et al. (2004)	the key features of search engine results that inform result selection
Aula et al. (2005)	experienced web-users query formulations and choice of search engine and browser;
Rieh (2002)	information quality and cognitive authority judgements in web-based source evaluation;
Tombros et al. (2005)	range of non-academic source' content features influencing utility judgements;
Wang and Soergel (1998) and Wang & White (1999)	offer a conceptualised 'Document Use Model', based on a longitudinal study investigating academic's decision-making, source selection, & citation (use);

Table 1.1 Pertinent examples of recent information seeking studies

Wang et al.'s longitudinal project (1998, 1999) is one of the few to have researched across the whole seeking process, i.e., considered the *search* through *evaluate* and *use* of located information sources; however, the *use* is measured only by citation usage. There are two observations worth making, namely, the act of citing sources says little about how users make sense of the located content, and everyday users are unlikely to use the source for purely citation purposes, i.e., such a study is more relevant to academic contexts.

Despite the relatively high percentage of information-type tasks and the continuous advances in web technologies, there still appears to be little attention paid to the *use* aspect of the located information. This failing has been criticised by many key researchers in the field, for example,

- Wilson commented that information use had received little attention in 1981 and judged little had changed over 15 years later (Wilson 1999a), with most studies interested in the use of the information sources and systems rather than the human aspects of information use (Wilson 2000);
- Ingwersen (1992) stated that almost nothing was known about post search, specifically 'use of information' behaviours, any associated derived knowledge structures, nor about how these structures themselves generate new information or knowledge which might be stored in or used from later information sources;
- Vakkari (1999) laments

> *"Information Use is a seldom studied area"* (Vakkari, 1999, pg 460)
> and Kulhthau has argued that information systems will not serve the needs of their users until investigations focus on the information users and their uses (Pettigrew et al., 2002)

Information usage has been explained as an activity that typically requires users to make sense of the located information for their own specific problem/task needs (1.1). To understand what 'use', i.e., to extract, organise, represent and integrate located information sources might entail, the seeking process needs to be unravelled further.

Query-based searching in web-based environments typically returns multiple results for any given search query, thus the source evaluation/decision-making process prior to subsequent information use can be complex and involve several subtasks. Marchionini refers to these activities as "examining and extracting"

> "… users must study, copy, and integrate this information so that it may be applied to the original problem" (Marchionini, 1992, pg 159).

Extraction for integration and usage is the organisation and representation aspects necessary to progress and make sense of the located information. This would suggest that investigations into *sensemaking* might better progress collective understanding of the *use* aspect of information seeking. Indeed, the impact of the WWW has not only renewed interest in information behaviour, it has also renewed interest in everyday *sensemaking*, i.e., how users make sense of the located information (e.g., Furnas and Russell, 2005).

As with 'information behaviour', 'sensemaking' has been explained and investigated variously and two key contributors to the field, Dervin and Russell, are discussed in more detail later (Chapter 2). Their perspectives are quite different;
Dervin's 1983 framework models three concepts, *Situations*, G*aps* and *Uses*; the basis is that users find themselves in situations where they meet problems or gaps in their knowledge that they must resolve in order to proceed, i.e., they have to bridge gaps in order to progress to an *Use* (outcome). This typically involves some type of usage action. Dervin's early research led to her 'Sense-Making Methodology' and indeed the term 'Sense-making' - written in this format - is understood to be solely reserved to reference Dervin's framework and methodology. Empirical studies that apply Dervin's methodology continue to contribute to the growing body of sensemaking literature, although their focus is most often concerned with retrospective cases of 'how' the user becomes informed, i.e., typically concerned with understanding the communication process.

On the other hand, the more general interpretation of the term 'sensemaking' can be seen in work of such as Russell et al. (1993). Russell and colleagues were interested to investigate the cost of extracting information from located information sources; their emergent seminal model, i.e., sensemaking modelled as a "Learning Loop complex" shows it to be an iterative process wherein users search for an efficient and cost effective representation. This seminal model has been extended with a further component, namely an explicit foraging loop prior to the core sensemaking component (Russell et al., 2008). Albeit Russell et al.'s seminal model provides considerable insight into sensemaking, but it is from a 'macro-level' perspective. Qu and Furnas (2005) have built on Russell et al.'s work; their empirically based investigation into the "Sources of structure in sensemaking" shows gathered information contributes to both the representation structure and the representation detail in a more integrated manner than suggested by Russell et al.

However, little is as yet is known about the detailed or 'micro-level' sensemaking process, particularly during web-based information seeking activities. Further, whilst a relationship between information seeking and *sensemaking* has been acknowledged, e.g., the influence of Dervin's early sensemaking research on information behaviour research and Kuhlthau's ISP model (1991), there are renewed calls to investigate and better understand this relationship (e.g., Qu and Furnas, 2005).

This research bridges previous studies which focused on specific aspects of information interaction such as search or information capture. The purpose is to investigate and identify example behaviour strategies exhibited by users as they make sense and use, i.e., collect, extract and organise relevant information from web-based sources for their own needs. Given the increased reliance on the WWW for everyday tasks, the insight gained should help inform the design implications and requirements for improved sensemaking tools, systems, and aids.

1.3 Research Questions

This thesis was interested to know about the '*how*' of user interactions whilst they conduct problem-solving type tasks in certain contexts. More specifically, the motivation was to discover

> *How users make sense of and represent their sensemaking whilst seeking information from web-based environments; further, to gain insight into any consequent implications for interaction design to support such sensemaking activity*

As an overall exploratory type of question, it can be expressed in five more specific exploratory or investigative sub-questions.

1.3.1 Research Question 1

Whilst many information seeking empirical studies have investigated web-based activities, there is a need to go beyond previous studies that have focused on the search and evaluate aspects of the process. In order to understand how users make sense of the located information, more needs to be understood about their interactions with the information sources, e.g., how they use the information sources.

Research Question 1 asks:

> *What is the broad range of typical behaviours and strategies deployed by experienced end-users as they interact with information sources whilst undertaking information-related tasks in web-based environments, and where is sensemaking evident?*

The objective of question 1 is to identify a range of typical behaviours and strategies deployed by experienced users as they conduct relevant web-based seeking tasks. The behaviours and strategies of interest are those associated with their interactions with the information sources; these could be surrogates, i.e., the results returned from a search engine, or the actual information sources. Their specific search behaviour, e.g., interactions with the query interface and their initial relevance judgements about the search results are not of direct interest at this stage. Instead the focus is to understand the range of behaviours evident as users progress from initial results evaluation through to source usage, and identify when there is explicit evidence of sensemaking. Sensemaking itself might be indicated by a user's uttered claim, their emergent external representation, or from the author's interpretation of gathered evidences.

The range of typical behaviours and strategies captured across a collection of users performing authentic tasks will help to scope further, more focused investigations into the sensemaking process and how it relates to information seeking.

1.3.2 Research Question 2

The indicative sensemaking behaviours and strategies evidenced by the results from the first stage of the investigation (Research Question 1) need to be further investigated. Research Question 2 asks:

> *How do experienced end-users make sense, i.e., collect, extract and organise relevant information from web-based information sources?*

The objective of this second Research Question is to conduct a more detailed examination into the range of behaviours and strategies exhibited by experienced end-users as they interact with information sources in web-based environments (findings from Research Question 1). In particular the objective is to focus on those behaviours and strategies that are related to, or indicative of sensemaking activity.

Web-based environments are being used more and more by 'everyday folk' (Russell et al., 2008) as they undertake work, leisure or formal/informal learning-related tasks. The literature suggests that more needs to be understood about these behaviours; this question helps address this gap.

1.3.3 Research Question 3

It is commonly accepted that non-trivial information seeking tasks typically involve some type of external representation, e.g., notes, lists etc., as artefacts of the sensemaking process. Indeed representation has been shown to be at the core of sensemaking (Russell et al., 1993).

Research Question 3 asks:

How do users externally represent both the collection and the meaning being derived from the information sources?

The objective of this third Research Question is to capture the range of types of representation emergent as experienced end-users progress a problem-solving task. If future sensemaking support technologies are to support all, if not most of the emergent representations, then the potential range needs to be appreciated.

1.3.4 Research Question 4

Two renowned researchers who were influential in the information behaviour community each offered an assertion about the relationship between information seeking and sensemaking:

- Kuhlthau (e.g., 1991) believed that information seeking was a constructing, making sense process;
- Dervin (e.g., 1983) argued that 'information seeking and use' were central to the sense-making process.

More recently, web-based tasks that have been variously categorized as 'informational' in nature (e.g., Morrison et al., 2001), and whose goal(s) have been to solve an ill-structured problem, are commonly referred to as sensemaking tasks (e.g., Qu and Furnas 2005). However to better understand where or at which points in the seeking process explicit sensemaking behaviours are apparent, more research is needed.

Research Question 4 asks

How does users' sensemaking relate to the seeking process?

This Research Question is a meta–question in as much as it cannot necessarily be answered by participants' behaviour alone, but instead by the analytic process. For example, points at which their external representations emerge as explicit examples of their sensemaking, can be mapped against the stages of the seeking process to evidence an underlying relationship at those specific points.

1.3.5 Research Question 5

Research Question 5 asks:

What are the implications for interaction design of sensemaking support tools and systems?

The objective of this Research Question is to understand and interpret the findings from Research Questions 1-4 and identify indicative implications for interaction design of sensemaking support tools and systems (technologies). For example, *sensemaking* behaviours at significant interaction points can be analysed to indicate some of the functional design requirements needed to support the activities.

Whilst it is anticipated that most of the implications for interaction design discovered by this research will arise from the insight gained into sensemaking behaviours and strategies, this might not be the sole case; for example, other factors related to seeking behaviours may highlight implications not recognised in other research more focused on search and evaluation strategies.

1.4 Research Approach

The research approach was qualitative, i.e., broadly similar to the interpretativist paradigm with an emphasis on exploration and insight (Cryer, 2000, pg 81). It was designed as a series of empirical studies, each Study informing and shaping the focus of subsequent studies.

Each Research Question was either addressed by, or informed by, one or more empirical studies as shown diagrammatically in Figure 1.2:

- empirical Study-1 was devised to address Research Question 1, i.e., to discover the broad range of typical behaviours and strategies exhibited by experienced end-users interacting with information sources whilst undertaking web-based information-related tasks, and further, to gain insight into their explicit associated sensemaking;
- empirical Study-2, was devised to address Research Question 2, i.e., to focus on the behaviours and strategies that reflected sensemaking as they collected, extracted and organised relevant information found from web-based information sources;
- both empirical Studies 1 and 2 helped inform Research Questions 3, 4, and 5.

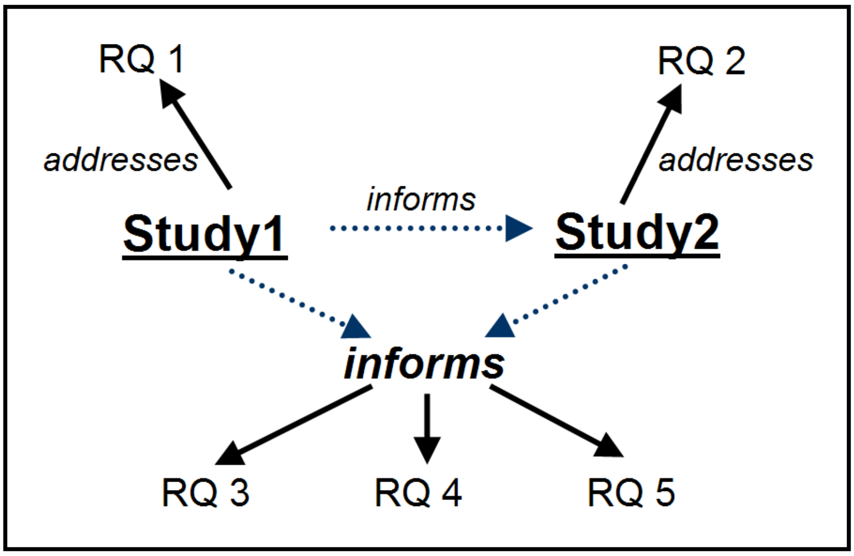

Figure 1.2 Research approach: Research Questions 1-5 and the Empirical Studies

Two key advantages of this approach were

- it provided scope for comparison and some validation between studies; for example, Study-2 could help validate the findings from Study-1;
- further comparative studies are readily accommodated in the framework which could offer further validation;

A more detailed discussion about the research design & methodology is found in Chapter 3.

The project offers three contributions to research which are discussed in more detail in Chapter 8.

1.5 Dissertation Structure

The structure of this dissertation, in terms of each of the remaining chapters, is seen in Figure 1.3. Additional annotation shows in which chapters particular Research Questions are discussed and where specific contributions are detailed.

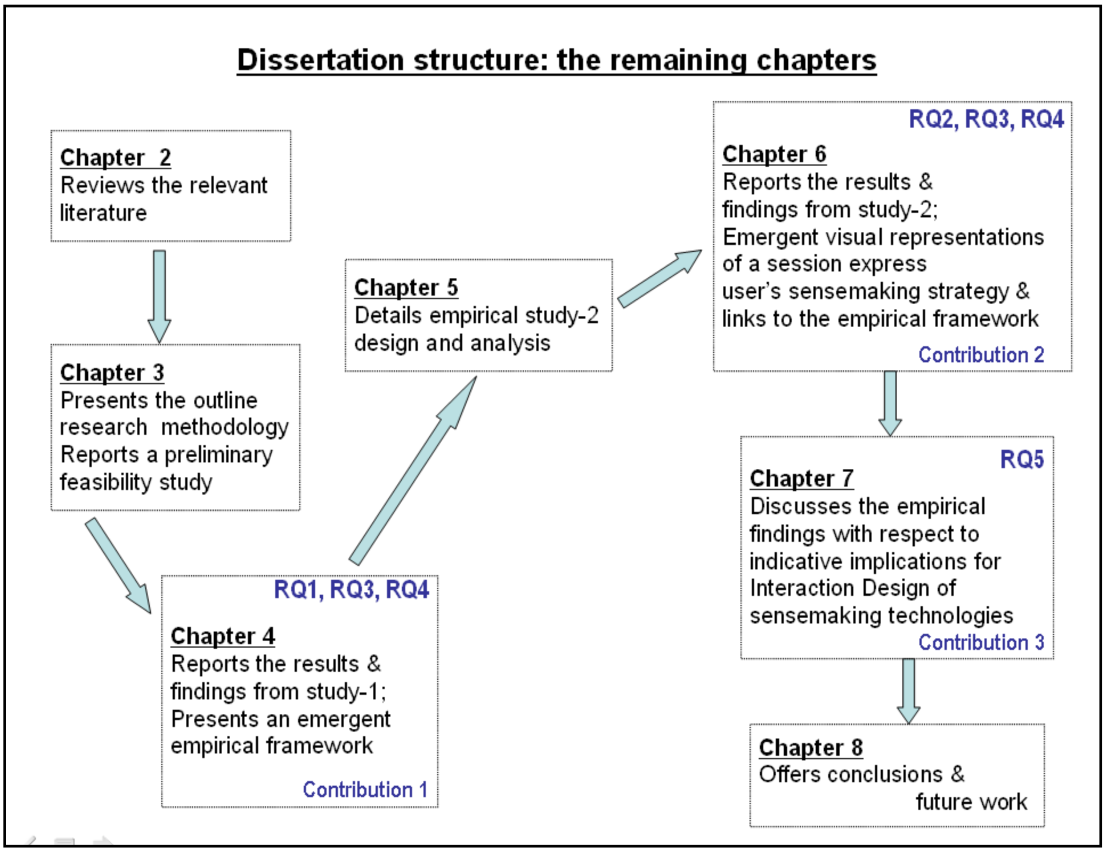

Figure 1.3 The Dissertation structure: remaining Chapters

Chapter 2 reviews the relevant literature across the main themes of information seeking and sensemaking and considers where information foraging and exploratory search relate to the two main strands. The prior work on search algorithms and relevance judgements is acknowledged but it is not examined in detail as it is not central to this current research. Gaps in the existing literature are highlighted; it is these that informed the aims and objectives of this research project.

Chapter 3 details the overall research methodology. It develops the argument for the overall approach as a series of empirical studies, first introduced in this Chapter (1.4). The methodology is common across the studies and several aspects including elicitation methods, participant sampling, task allocation, and environment settings are discussed and where appropriate, reference is made to existing literature and best practice to support any decisions. The Chapter offers the outline guidelines for the common aspects of the methodology whereas the more specific procedural implementation decisions are presented in the respective Chapters detailing each Study. The Chapter concludes with an evaluation with respect to validity, reliability and limitations of the overall methodology.

Chapter 4 reports on Study-1 which explores how a group of experienced end-users interact with information sources whilst undertaking web-based information-related tasks.

It also aims to gain insight into their associated explicit sensemaking by gathering user's emergent external representations, and to highlight where their sensemaking behaviours might relate to their seeking task (Research Questions 1, 3, 4, 5, Figure 1.2). The Chapter begins by detailing how aspects of the overall methodology, as reported in Chapter 3, were applied to this first empirical Study, presents the Study's analysis approach and then reports the Study's results and findings. The results offer an emergent empirical framework which classifies the information seeking process from an information interaction perspective. This framework is a significant contribution of this research (ref contribution 1, Chapter 8.1), and provides a basis for further investigation into sensemaking in a web-based seeking context.
Some provisional findings from this Study have been published and presented: the Doctoral Forum, IIiX conference 2006 (Abraham et al., 2006), and at the Exploratory Search workshop (Abraham et al., 2007).

Chapter 5 details how aspects of the overall methodology, as reported in Chapter 3, were applied to the second empirical Study and explains the detailed design decisions relevant to this second Study. The pilot run for this Study is also reported. The Chapter presents the five-step analysis approach for the Study with case examples to illustrate where appropriate. The Chapter concludes with an evaluation of the design and approach.

Chapter 6 reports the results from empirical Study-2 which was devised to investigate deeper into the findings from Study-1 and focus specifically on the sensemaking in web-based information tasks (Research Questions 2, 3, 4, 5 *Figure 1.2*).
The Study produced a range of significant findings which are organised and presented as outputs from the five-step analysis. A range of emergent visual representations were devised to express the user's session and three of these are significant, i.e., considered contributions from this research:

i. emergent interaction timelines (ref contribution 2.i, Chapter 8.1);
ii. behaviour sequences in algebraic notation from which sensemaking strategies can be inferred (ref contribution 2.ii, Chapter 8.1);
iii. mappings of behaviour sequences onto the emergent empirical framework (output from Study-1), to model session sensemaking within a seeking context (ref contribution 2.iii, Chapter 8.1).

Some provisional findings from this Study have been published and presented at a Sensemaking workshop, CHI 2008 (Abraham et al., 2008).

Chapter 7 reports selected empirical findings with respect to indicative implications for Interaction Design of sensemaking support tools and environments (Research Question 5). Three groups of findings are discussed with respect to their implications for design of sensemaking technologies:

i. switching including navigation
ii. external representation and re-representation
iii. planning and management.

Chapter 8 concludes the thesis. The research approach is revisited and the research is discussed with respect to its contribution. Three distinct contributions are offered. Extensions to the research are offered, with some examples to help address known limitations. The Chapter concludes with suggestions for future work.

The *Glossary* contains definitions of key terms as used in the dissertation.
References, followed by Appendices A-D conclude the Dissertation.

Chapter 2 - Background Literature

This Chapter offers a background for the research described in this thesis: an investigation into sensemaking in a web-seeking context and its implications for interaction design. The project is informed by two broad areas of literature, namely that of

i. Information behaviour;

ii. Sensemaking.

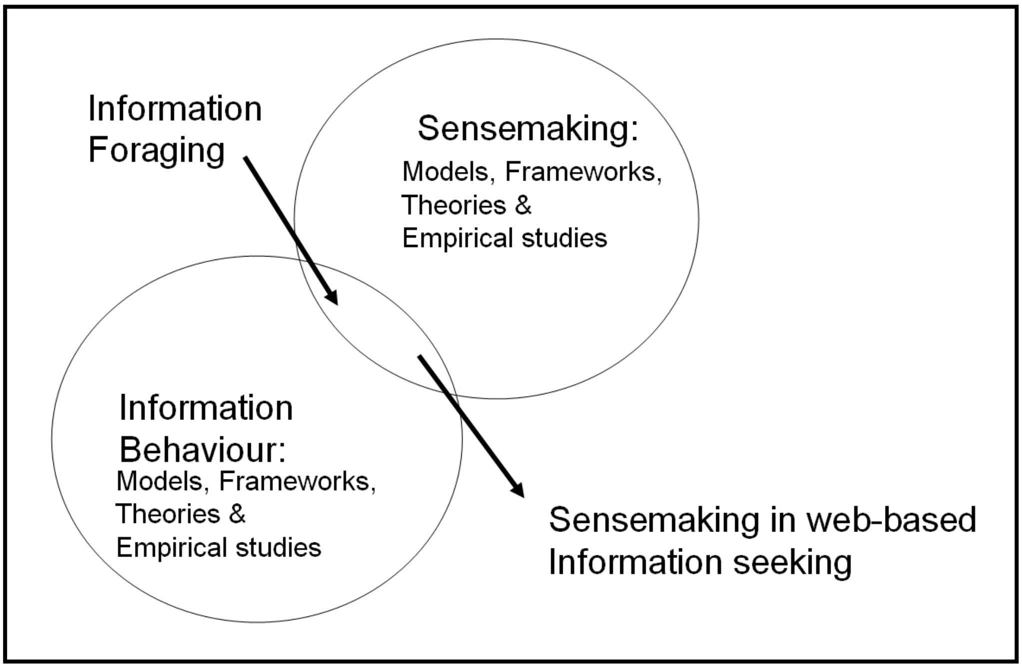

Figure 2.1 Context of Thesis literature: Information Behaviour and Sensemaking

Information foraging, which arises from information behaviour, bridges into sensemaking (Figure 2.1).

2.1 Roadmap

Section 2.2 presents an overview of the two major strands of the literature, information behaviour and sensemaking research, and summaries of information foraging and exploratory search which are on the boundary of this research;

Section 2.3 details three seminal information seeking models:

i. Bates' Berrypicking model (1989) (2.3.1);

ii. Ellis' Behavioural model (1989, et al.,1993) (2.3.2);

iii. Kuhlthau's Information Search Process (ISP, 1991) (2.3.3).

Section 2.4 reports on selected information seeking studies that are judged informative to this research;

Section 2.5 provides a more in-depth look into aspects of sensemaking. Two seminal models are detailed:

i. Dervin's (1998, 2003) Sense-making framework (2.5.1);

ii. Russell et al.'s (1993) Learning Loop model (2.5.2).

This Section ends with a brief overview of recent empirical studies in sensemaking undertaken within the same time period as this project (2.5.3);

Section 2.6 offers a discussion on selected models and studies and their relevance to this project.

2.2 Overview

Despite previous and some ongoing criticism of the term 'Information Behaviour', for example, some critics felt it was too suggestive of associations with psychology's behaviourist paradigm, it has gradually gained acceptance to describe the academic work based on the broad concepts of information need, information seeking and use (Pettigrew et al., 2001, pg 44). Within Information Behaviour, several commonly used terms are often used differently and the key terms used in this dissertation are defined in Chapter 1.2.

Information Behaviour has been researched and reported for over 50 years (e.g., Wilson, 1999a; Wilson, 2000; Case, 2002), with over 2000 studies reported just between 2000-2004 alone (Case, 2006). Contributions are from several disciplines including Information Science, Library Information Systems and Social Sciences, and increasing contributions from the Human Computer Interaction (HCI) community in line with the switch to a user-centred focus.

In the early studies, Information Behaviour focused predominantly on the system-side information retrieval (IR) and as such, offered little or no insight into the user behaviour outside the framework of the information computer system (e.g., Ingwersen et al., 2005). This system-focused context is illustrated in Figure 2.2:

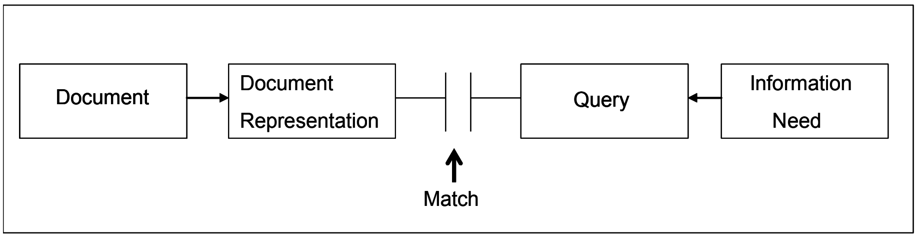

Figure 2.2 The classic Information Retrieval Model (Bates 1989, pg 408)

It was not until the early eighties that the focus began to change with Dervin and Nilan acknowledged as one of the significant influences in the shift from system-centred to a more cognitive, user approach. In their landmark review of information seeking research, they reiterated a call "… for focusing on cognitive behaviour and developing cognitive approaches to assessing information needs and uses" (Dervin & Nilan, 1986, pg 15). Furthermore, they echoed previous calls to borrow theory and qualitative methods from such as social science, and for "conceptual enrichment within the field" (Pettigrew et al., 2001, pg 43). They encouraged a paradigm shift towards viewing users as active *actors* constructing subjective information in a situation-sensitive context, rather than simply viewing users as situation independent, passive receivers of information from the system. They were not alone in their criticism of the system focused approach. Attfield (2004, pg 23) recalls Paisley's earlier 1968 criticism of the research community's failure to recognise the user's role in information seeking. The subsequent general shift in emphasis from a 'system-centred' to a 'person-centred' approach throughout the information behaviour research community is attributed not only to Dervin, but others including Ellis, Wilson and Kuhlthau (e.g., Wilson, 2000; Ingwersen et al., 2005)

Several user-oriented Information Behaviour models emerged to challenge the classic system-oriented Information Retrieval model (ref Figure 2.2). Some of these emergent models were theoretically based and those that were empirically based typically conducted studies with professional staff using specialised databases or within academic institutions. Many of these studies observed library users, typically academics and students, using library systems, e.g., dedicated Bibliographic databases, with the primary aim to understand the research habits of such groups in order to design appropriate (library) systems and services. The literature contains numerous reviews of the many emergent models. Ingwersen et al. (2005) is one example; they offer a comprehensive review of the development of Information Seeking Research & Models against a timeline from 1960-2000. Other similarly detailed reviews include Marchionini (1995) and Case (2002).

Two reviews of information behaviour models are selected to convey the range of the reported discussion. The first review is that of Wilson (1999a) who considers such models to be either behaviour, seeking, or searching models. It is this categorisation that led to the nested model of information behaviour shown in Chapter 1 (Figure 1.1). He argues that the then existing information behaviour models were limited to scoping the research area and providing a framework for further investigation. Information seeking models, he explains, were concerned with the general behaviours of information seeking and held only broad implications for the design of information retrieval systems, whereas by contrast information searching models focused on the search interaction with the information system. By way of conclusion, Wilson introduces his own problem-solving model of information seeking and searching, which emerged from his work in the 'Uncertainty project' (Wilson 1999b).
The models, as critiqued by Wilson, are shown in Table 2.1, grouped within the related research areas as defined by Wilson's nested model.

Information Behaviour	**Information Seeking**	**Information Searching**
Wilson 1981(a)	Wilson 1981(b) & 1996	Belkin et al. 1995
	Dervin 1983	Ingwersen 1996
	Ellis 1989, Ellis et al. 1993	Spink 1997
	Kuhlthau 1991	

Table 2.1 Information Behaviour Research Models as reviewed by Wilson (1999a)

Dervin's model (1983) is not an information seeking model as others, although it is frequently cited as such due to the influence Dervin's theory has had on information behaviour research (e.g., Wilson 1999a; Case 2002; Ingwersen et al., 2005).

The second selected review is Pettigrew et al. (2001). They trace the many models and theories existing in Information Behaviour research from 1978 and categorise the literature into three groupings. Their groupings are (pg 46):

i. cognitive approaches that examine the individual as central to the information behaviour regardless of context;

ii. social approaches are those that investigate the user with a focus on social context;

iii. multifaceted approaches include those that consider multiple contexts such as cognitive, social and organisational.

Information behaviour research within a cognitive approach is interested in how users apply or use their view or model of the world to the broad processes of seeking and using information.

Pettigrew et al. consider how various emergent models, such as Vakkari's (cited 2001) build on previous seminal models such as the Ellis model (1989) and the Kuhlthau Information Seeking Process (1991), and highlight where there was a change of direction. They cite Bates (1989) as an example who applied an ecological theme to their research. The models of interest to this research, namely Bates' Berrypicking model (1989), Ellis' behavioural model (1989, 1993) and Kuhlthau's ISP (1991) are all grouped within the cognitive approach, but both the Ellis and Kuhlthau models are categorised as information seeking models by Wilson (1999a). Indeed many of the reviews offer different labels to the various models.

The next significant shift of focus for information behaviour research occurred with the rapid expansion of the World Wide Web (WWW) and its applications. This technology generated considerable and renewed interest for the Information Behaviour community; researchers were interested to test and validate existing models as applied to web-based environments and others endeavoured to identify new models and frameworks reflecting both a broader user base, i.e., encompassing everyday users as well as specialist and professional users, and a broad range of tasks. Another strand of investigations was into task influences. Bystrom et al. (1995, 2005) and Vakkari (1999, 2001a, 2001b), investigated the influences of task context and complexity on information seeking in various online, non-intermediary task situations. Indeed, Vakkari offers a comprehensive review of task-based information searching and calls for work and search tasks to be considered in any behaviour studies (2003).

Whilst behaviour models might vary in their context, e.g., developed from observations of particular types of users in a particular setting, they generally explicitly capture two key underlying components or elements of most information seeking activities, namely *seek/search* and *evaluate* elements. On the other hand, the third key element of seeking activities, namely, 'use' of the located information, is rarely explicitly captured. This lack of recognition of 'use behaviour' is an ongoing criticism of information seeking models (e.g., Wilson, 1999a; Ingwersen, 1992; Kuhlthau, 2005). A few do, however, explicitly recognise 'use' behaviour in their models: Wilson's 1996 revised general model of information behaviour (Wilson, 1999a, pg 257), emergent from extensive research into information behaviour, is one of the few. Other examples are

- Choo et al.'s (2000) two-dimensional 'Empirical model of web use', emergent from research into thirty four professional Users' use of the web in their daily work-tasks. The model shows seeking activity categorised against four types of scanning mode and the six stages of Ellis' Behavioural model;
- Vakkari (2001a, 2001b) emergent model of a 'theory of the task-based IR process' is informed from Kuhlthau's earlier ISP model.

A discussion with respect to implicit 'use' behaviour in Ellis' model (1989, 1993) and Kuhlthau's ISP (1991) is left until later (2.3.2). Furthermore, several projects have undertaken to validate or enhance the earlier seminal models to reflect information behaviour in web-based environments. Indeed, many of the more recent models and frameworks acknowledge the influence of Ellis' Behaviour model and Kuhlthau's ISP (see 2.3).

The volume of empirical information behaviour studies undertaken to date can be counted in 'the thousands'. The observed 'user base' has expanded from academics and specialist professionals to an entire cross-section of people who interact with the WWW to seek information related to their everyday work, studies or leisure. A considerable volume of the earlier studies focused on query formulations and system responses, e.g., how best to execute the queries for maximum efficiency, and alternative ways for the system to present the returned results. Other investigations have explored the broader aspects of the strategies users apply when interacting with an online or web-based IR system.

Not only are there many hundreds of empirical studies, but there are numerous reviews of the reported studies. Reviews are usually conducted by groupings or categories of studies and typically each review categorises the studies differently. The following sample illustrates:

- Martzoukou (2005) reviews the studies by grouping them by the most common user characteristics investigated, namely, user experience such as novice v expert behaviours, and users' cognitive style and ability. Martzoukou criticises how many of the studies are quantitative rather than qualitative in their approach, although acknowledges that more qualitative work is beginning to emerge, for instance, studies from a socio-cultural perspective;

- Case (2002) argues his categorisation of information seekers by occupation, by role (e.g., student), by demographics (age, gender, etc.) and offers an update by similar categorisation later (Case, 2006);
- Vakkari (2003) considers the volume of studies with respect to the context in which they have been observed;
- Ingwersen et al. (2005) review and summarise the wealth of studies with respect to behaviour, and cognitive styles (pg 214ff), standard online IR interaction (pg 217ff), web IR interaction (pg 225), searcher associated best match IR interaction (pg 231ff), and relevance issues (pg 234-244).

In this review, selected studies are grouped into three broad categories of examples,

i. investigating seeking/searching with a user characteristics focus (Table 2.2a);

ii. investigating aspects of seeking/searching behaviour (Table 2.2b);

iii. specifically examining the users' 'use' of information (Table 2.2c).

In addition, such as Kobayashi et al. (2000) review studies of the growth of the Internet & technologies with respect to search engines and their features, and discuss past and future trends. They suggest the growth has been exponential over the previous decade and will follow the same pattern over the next decade.

As Table 2.2b suggests, the largest percentage of all studies undertaken report on user behaviour, and most of these focus on either aspects of relevance judgements, or aspects of the search and navigation process. On the other hand there are very few studies that attend to the 'use' of located information (Table 2.2c).

User behaviour characteristics:	Example studies:
gender	- Liu & Huiang (2008) explored gender differences in online reading environments and amongst their findings they noted that females have a stronger preference for paper than men who prefer screen reading;
experience	- Holscher & Strube (2000) investigated for any differences in behaviour between experienced experts and 'newbies'; - Cothey (2002) monitored to determine if web-based seeking behaviour changed with experience gained
age influences;	Graff (2005) investigated the influence of age against cognitive styles;
cognitive style	- Iivonen (1995) investigated the differences between searchers with respect to the most and least consistent approaches; - Tsai & Tsai (2003) explored students searching strategies and the role of self-efficacy, and Tsai (2004) report on study of experts' and students' differences when evaluating sources - Kim & Allen (2002) conducted two independent studies into the impact of differences in users' cognition and search tasks on Web search activities and outcomes;
by roles/types of user, e.g. students, work roles etc.	- Fidel et al. (1999) studied the Web searching behaviour of high school students;

Table 2.2a Examples of Information Behaviour studies: specific to user characteristics

The few studies that do investigate the 'use' aspect of information behaviour, interpret the meaning of 'use' differently. Wang et al. (1998, 1999), Zhang (2001) and Huuskonen et al. (2008) consider use to be citation use, and Tenopir et al. (2004) investigate use with respect to Use of Electronic Science Journals and systems in Undergraduate Curriculum. Marshall et al. (2005), considered it to be the 'use of clippings from located information sources', whereas Priemer et al. (2004) investigated whether students used text from web sources as *compilers*, i.e., who typically (acknowledged) copied text into their own work or *authors*, i.e., who typically interpreted the found text as their own words (Table 2.2c). These examples illustrate how, within information behaviour, the term 'use' means different things to different people.

Topic – aspects of user behaviour:	Example studies:
search engine preferences	- Aula et al. (2005) investigated search strategies & tools for use and re-use in information search;
query formulations	- Various aspects of query including length, use of operators, etc.: Belkin SIGIR 2003; Jansen et al. 2000; Spink et al., 2001; Lucas et al. 2002; Topi et al. 2005;
relevance judgements & decision making	- Aside from the volume of studies which investigate the system processing side of relevance, with respect to the various weighting algorithms applied to document retrieval, many studies report the user's relevance judgements: Spink et al. 1998; Mizzaro 1997, 1998;
style of navigations within/ across resultant information sources	- Kim (2001) found problem-focused users navigated in a non-linear pattern, i.e. breadth first , whereas emotion-focused individuals navigated the Web in a linear mode, mainly following embedded links, i.e., "depth first";
search result influences for selection	- Ivory et al. (2004) investigated which characteristics of search results influenced the selection of sources
why users search the web, i.e., the 'need'	- Morrison et al. (2001) interpreted '*why'* from the *purpose* of their task; - Broder (2002), used both a user survey and log analysis to identify three classes of search queries, namely *informational*, *navigational* and *transactional;* - Rose et al. (2004) used log analysis to offer slightly differing results from those from Broder but more in-line with Morrison's findings
web search trends	- Spink et al. (2004) summarises their work on trends between 1997 -2003

Table 2.2b Examples of Information Behaviour studies: aspects of behaviour

Use as:	Example studies:
use of information	- Wang et al. 1998, 1999; - Zhang 2001; - Tenopir et al. 2004; - Marshall et al. 2005; - Huuskonen et al. 2008
users using as *compilers* or *authors*	- Priemer et al. 2004

Table 2.2c Examples of Information Behaviour studies: use of information

Pettigrew et al. (2002) express concern about this wide range of alternate interpretation re the term ‘use’, and at the same meeting Kuhlthau argued that much of research concentrates on system use rather than information use and that we will only be able to design information systems that address the real needs of the users if we ask the relevant questions, ‘what do people do with the information they are seeking’.

Indeed, it is difficult to find a common definition or interpretation of the term: Choo (1999) explains that ‘information use’ broadly encompasses any action/purpose it is used for, and usage is dependent on such as the cognitive style and preferences of the individual, as well as the emotional responses such as embarrassment and conflict that can arise when information is made available for use. Whereas Dervin (1983), describes ‘Uses’ in terms of outcomes from the process of sense-making, i.e., how the located information facilitates (*helps*) or blocks (*hurts*) the need (knowledge gap) the user is trying to bridge or overcome. Examples of her Use/outcomes are Reach a Goal, accomplish something; get started or get motivated; facilitate moving on to something else. On the other hand, Kuhlthau (2005) talks of ‘use’ as a construction process, a description that closely follows the definition given by Wilson (2000) which is the basis for the interpretation used in this dissertation (Chapter 1).

As with the lack of explicit ‘use’ in models, one of the most commonly cited criticisms of information behaviour empirical studies is the lack of attention paid to the *use* aspect of information behaviour. For instance, Kuhlthau (2005) argues that systems do not support construction (use), and Toms et al. (2008) state that information behaviour studies exclude use behaviour**.**

Information seeking and sensemaking have been coupled for many years:

> *“… the single most obvious way that our view of information seeking has changed is the rise of the sense-making paradigm…” Case 2002, pg 288*

Dervin (1983; et al. 1986, 2002) considers information seeking to be a constructing activity, i.e., where people construct sense as they proceed to seek information to satisfy information needs (gaps in their knowledge), whilst Kuhlthau (1991) describes her Information searching process as a construction, making sense process. However, Furnas et al. (2005) state that the relationship between seeking and sensemaking needs further investigation.

Dervin's early work, as well as being influential on information behaviour research, is seminal with respect to sense-making. Her base concepts of sense-making base are expressed in the '*Situations-Gaps-Uses'* model:

- *Situations*: The time-space contexts at which sense is constructed.
- *Gaps*: The gaps seen as needing to be bridged, translated in most studies as "information needs" or the questions people have as construct sense and move through time-space.
- *Uses*: The uses to which the individual puts newly created sense, translated in most studies as information helps and hurts.

  (Dervin 1983, pg 9)

Dervin's Sense-making Methodology (to which this model is applied), is based on the principle that information seeking and use are "constructing" activities, i.e., as personal creations of sense at specific moments in time-space to enable them to progress in whatever task**.** The model is explained in more detail later (2.5.1)

The methodology has developed over 25-plus years, primarily from her work in the field of library and information science, where applications focused on the study of information needs and seeking. Since then, there have been over 100 reported documented applications across many diverse areas. The main goal, of the Sense-making approach is to find out

> *"…what Users really think, feel want and dream."* (Dervin 1998, pg 39)

Russell et al. also investigated sensemaking but from another perspective; they were interested to explore the cost of sensemaking. Extracting information from resources, which includes the subtasks of finding documents, extracting and transforming it into alternative form, is often judged to be the most time-consuming subtask (e.g., Russell et al. 1993). Any such costs are typically weighed in terms of perceived benefit or value of the information. Their "Learning Loop Complex" model emerged from these investigations (Russell et al., 1993). Russell et al.'s perspective on sensemaking is well-cited and has foundations in information behaviour theory, and bridges to information foraging theory.

There are other alternative perspectives on sensemaking. Klein (2006) considers several alternative perspectives on sensemaking and concludes that

> *"Sensemaking is a motivated, continuous effort to understand connections (which can be among people, places, and events) in order to anticipate their trajectories and act effectively."* *Klein 2006, part I, pg 71*

Klein goes on to describe a sensemaking theory based on a Data/Frame Theory (2006, part II). Weick(1995) considers sense-making with respect to how organisations structure and communicate information within the organisation context. Neither the Klein nor Weick perspectives were of focal interest. Dervin's Sense-Making and Russell et al.'s 'Learning Loop Complex' model are discussed in more detail in Section 2.5.

Similar to its impact on information behaviour research, the WWW and its associated applications generated new interest in sensemaking, particularly everyday sensemaking, and many empirical studies have been reported in the literature in parallel to this project. One of particular interest is Qu and Furnas' (2005) investigation into "Sources of structure in Sensemaking" and is discussed later (2.5.3.1).
There are two topics on the periphery of this project, namely

i) information foraging
ii) exploratory search.

These are briefly explained.

Information Foraging Theory emerged during the early 1990's, in parallel to the explosion in the volume of information that became available to the average computer user, and alongside the availability of new technologies for accessing and interacting with the information (Pirolli, 2007). It draws from previous 'optimal foraging theory' which attempted to address interesting and curious findings that arose in ethological studies of food seeking and prey selection amongst animals (Pirolli, 2007). Information Foraging theory is explained as

> "An approach to the analysis of human activities involving information access technologies" (Pirolli and Card, 1995, pg 51)

It was developed to

> *"understand predict and improve human-information interaction"*
> (Pirolli 2007, Tutorial Notes, pg 2)

The theory is concerned with understanding how people adapt their strategies in pursuit of valuable information when seeking, gathering and using from the vast and varying volumes of information available. It analyses trade-offs in the value of information gained against the costs the human-computer-interaction tasks and the design problem, they argue, is to optimise the user's time in an information rich world (Pirolli and Card, 1999).

The foraging tasks require users to apply ever increasing complex information gathering, sensemaking, decision-making and problem-solving strategies. They must adapt the search strategies to the conditions surrounding the information source and make an assessment of the value to be gained from the source against the cost of accessing and extracting it. Numerous factors can inform this decision including ease of accessibility, characteristics of the search result and web-page themselves, and user time-constraints. Eliminating irrelevant information and sources moves the forager towards an optimal solution.

There are three important concepts associated with information foraging borrowed from optimal foraging theory (e.g., Pirolli, 2007; Card et al., 2001):

i. Information Patches: the WWW is conceptually and structurally arranged into hierarchical information patches that users have to navigate to obtain relevant information. A Webpage is a basic information patch and users may have to navigate from one information patch – one website- to another. Thus web foraging is "patch-like" and the user has to make decisions including how long to spend on any one information patch;

ii. Information Scent: user's navigate through the WWW with little or no knowledge of its layout and rely on signs, labels, views, and cues etc. that help them navigate through the information space. This information is the scent;

iii. Information Diet: Information sources have associated costs for the forager. Scent based assessments help the user (forager) decide which items to pursue for maximum advantage. Assessments consider such as access costs and the rarity or availability of the item.

Other concepts are the trade-offs between enrichment and exploitation of information patches. Users might enrich their information patch through specialised keyword searches or query filtering techniques. Another enrichment action when gathering information might be to organise/arrange patches of information sources in physically located piles, to minimise the between patch costs.

Foraging is seen as one of the sub-tasks of sensemaking and one forward direction for Information Foraging research has been into sensemaking research (Pirolli, 2007, pg 189). Many empirical studies also take influences from and/or relate to foraging theory; for example, Qu et al. (2005) found that users tend to search in an information rich patch whilst searching to build representations for a sensemaking task.

The newly emergent field of Exploratory Search research has its roots primarily in Information Retrieval. It is a relatively new research community that emerged from the paradigm shift away from systems that support searches as single stand-alone events, to designing systems that support search as a complex process typically accessing large volumes of information via the Web (e.g., Qu et al., 2008). Publications from an early Workshop on 'Exploratory Search Issues' (e.g., White et al., 2005) highlighted the aim to support everyday users who often had only a vague idea of their search needs. Rarely, it is argued, are searches single, stand-alone events, instead they are part of a complex process to access the increasing volumes of information on the Web. The growing research interest on Exploratory Search is part of this shift (Marchionini, 2006; White et al., 2006, EESS workshop).

Exploratory Search has been described variously; it typically involves undefined information needs which generally involve an iterative process of queries and exploration of the retrieved information to find cues as to what the next step might be. The user often submits multiple queries. An exploratory search exercise comprises a mixture of serendipity, learning, and investigation (White et al., 2006 EESS workshop pg 1). Marchionini (2006) explains that the browsing nature afforded by the Web has encouraged strategies that include selection, navigation, and trial-and-error tactics, which in turn generate expectations of the Web as a source for learning and exploratory discovery. He describes Exploratory Search as having two types of search activity, namely learn and investigate (Figure 2.3).

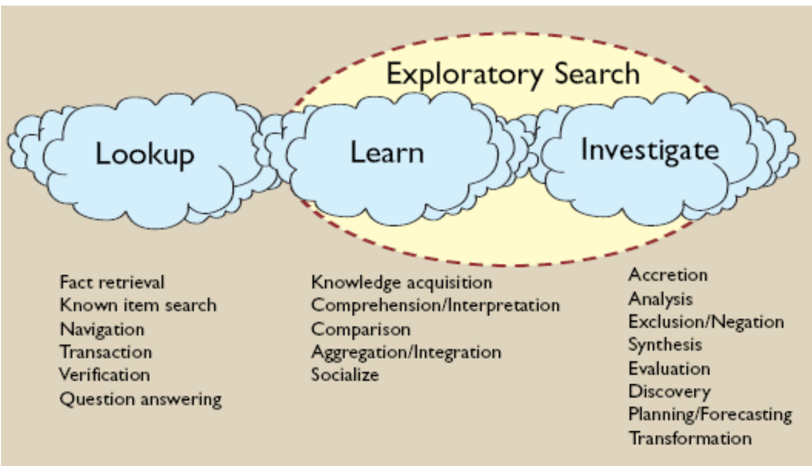

Figure 2.3 Search activities, Marchionini (2006, pg 42)

The categorisation into three information seeking activities is derived from three underlying levels of information needs:

Lookup: the need to lookup basic facts of 'who when and where' for varying purposes

Learn: the need to understand related concepts in order to undertake complex activities

Investigate: the need to gain tacit and explicit knowledge to further develop our expertise.

Learn and investigate activities often incorporate lookup searches and Marchionini explains that exploratory search embraces the 'what, how and when' of information needs.

Whilst computer systems are well suited to lookup queries, researchers began to recognise the challenge to provide more interactive systems, with highly interactive user interfaces engaging users continuously in the seeking process and enabling them to resolve complex information problems (Marchionini, 2006; White et al., 2006, EESS workshop).
By 2006, there was a critical mass of interest and numerous examples of novel interfaces existing to encourage those interested in Exploratory Search tools and system development to turn their attention to devising and establishing evaluation criteria of such Exploratory Search Systems (ESS). The emergent broad model of the exploratory search process is seen in Figure 2.4.

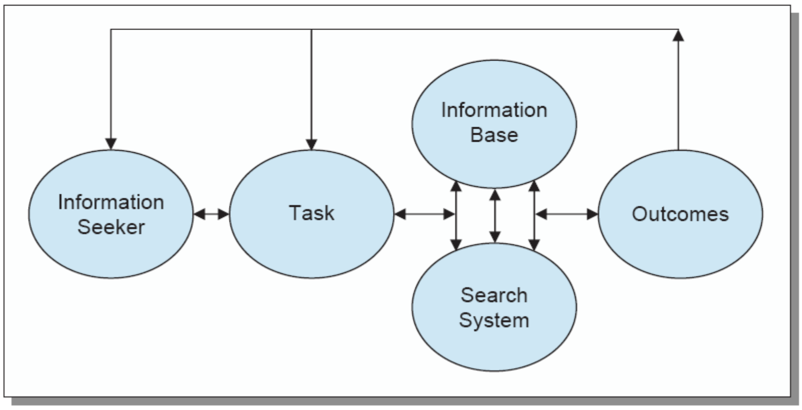

Figure 2.4 Model of Exploratory Search Process
(White et al., 2006, ACM SIGIR Workshop on Evaluating Exploratory Search systems)

Legend:

Arrows illustrate the interrelationships and double-sided arrows suggest two-way interactions as exploratory search progresses.

Whilst offered as a general model, it importantly incorporates the seeker and the task as elements of the model. The user might choose many possible paths, i.e., as depicted by the multiple arrows between the information base and system, and there are likely multiple iterations over the exploratory session, as suggested by the arrows from outcomes (effects or search results) back to task and information seeker.

Qu and Furnas (2008) conducted a "Model-driven formative evaluation of exploratory search: A study under a sensemaking framework" to explore new design possibilities for Exploratory Search Systems. This was a report on findings from a second phase of analysis on data gathered from an earlier study (the findings from their first phase analysis (Qu et al., 2005) are discussed earlier in this Chapter (2.5.3.1).

Another focus of this Qu et al. part II (2008) was to investigate the relationship between information seeking and representation using visualizations of log data from the search activities and representation construction activities (as previously reported in their part-1, 2005). An initial premise (part-II) was that exploratory search queries are

> *"... embedded in a larger process of bridging a knowledge gap that prevents the user from accomplishing her task"* (Qu et al., 2008, pg 538)

Thus they explicitly make the connection between exploratory search and sensemaking. Their findings from this phase-II showed there was a tightly coupled relationship between search and representation construction in their exploratory searches; search tools were strategically deployed for varying purposes during an exploratory search to find new useful structure ideas and to validate existing structure ideas. There was no evident tendency to simply accumulate information without structure. Qu and Furnas suggest three implications for interaction design, of exploratory search systems (supporting sensemaking tasks), namely

- support for expressing structure needs; for example, other than query keywords which users often find difficult to express;
- support for finding useful existing representation structure matching their own externalised representation structure;
- support for task management; for example tools to help manage the users growing and sometimes shifting search needs, their various structured representations and further perhaps manage the relationship between the search and representation.

This concludes the overview of the literature of interest. The following Sections address selected models and studies in more detail.

2.3 Selected Information Behaviour Models

Many Information Behaviour models have much to offer in their own right, but three models are of particular interest to this research, namely Bates' Berrypicking model, Kuhlthau's ISP and Ellis' Behavioural Model. These are discussed in more detail here.

2.3.1 Bates: Berrypicking Model (1989)

Bates' Berrypicking (1989) model, named from the "bit-at-at-time retrieval" (pg 410), arose from a period when new online information systems were being developed and attention was focusing on the search process. At that time Information retrieval research (IR) was almost entirely concerned with a single query in order to ask one question.

Bates was one of the few early studies that investigated user search strategies as direct interactions with the system rather than involve intermediaries such as librarians, as part of the search process. Her findings challenged both the single query concept and the system-side focus of the classic IR model. For example, Bates contends that real life queries change as information is gathered, i.e., the 'evolving query' concept, and argues that users employ a number of strategies, such as chaining and scanning, as they search through a range of information sources, selecting content from several sources in turn (akin to berry-picking); as information is found new ideas and directions are followed. Bates' model captures the sequence of search behaviours, during which bits of information are gathered from encountered multiple sources.

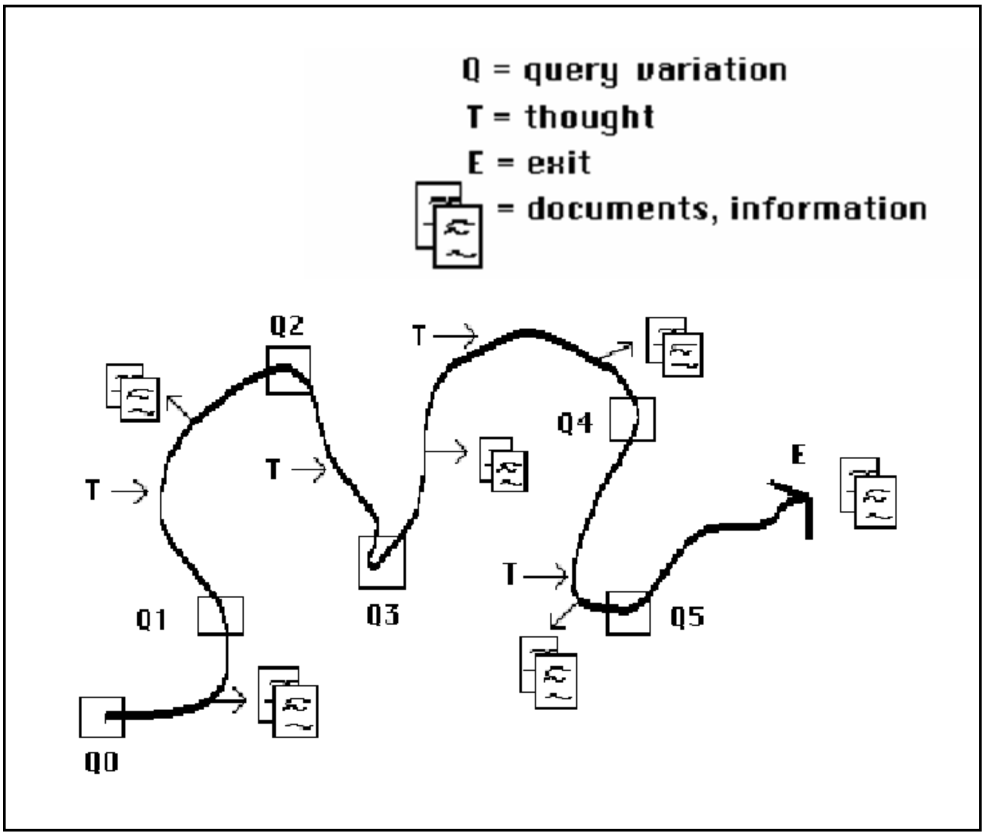

Figure 2.5 Berrypicking Model (Bates, 1989)

The path through the model (Figure 2.5) represents the users' Berrypicking search. Changes in direction at query points reflect their shifts in thinking and associated changing needs. Access to documents depicts their information extraction and usage along and throughout their pathway.

2.3.2 Ellis: Behavioural Model

Ellis' model, typically described as a 'feature' or 'staged' behavioural model, was more interested to identifying patterns of behaviour in the seeking process than capture aspects of the users profiles per se. The model emerged from investigations into the information seeking patterns of groups of researchers including scientists and engineers in both academic and industrial environments undertaking Research and Development project tasks using dedicated library databases. One of his early stated aims was to provide recommendations for information retrieval system design (Ellis, 1989). There were three major studies informing this model:

Researcher and date:	Participant base:	Primary data collection method:
Ellis (1989)	Comparative studies with groups of academic social scientists	interview
Ellis Cox & Hall (1993)	research physicists and chemists	interview
Ellis & Haugan (1997)	engineers and research scientists	interview

Table 2.3 Ellis' Behavioural Model: stages of development

Ellis followed Glaser & Strauss' 1967 grounded theory for data analysis, a fact often cited as a strength and uniqueness of his work. The original model (1989) proposed six broad characteristics or '*features'* of behaviour

Starting, Chaining, Browsing, Differentiating, Monitoring, Extracting.

From his work with physicists and chemists, Ellis extended the six features to eight (1993): The eight features are:

i. *Starting*: activities such as gaining an overview of the topic or locating key people working in the field;

ii. *Chaining*: this could involve forward chaining, i.e., following citations or footnotes in other articles from a known article or backward chaining, i.e., tracing back to articles a known article cites;

iii. *Browsing*: semi-structured searching through primary and secondary sources ,i.e., materials of interest;

iv. *Differentiating*: exploiting known differences between sources as a filtering mechanism to control the amount and quality of information examined, e.g., by approach or perspective;

v. *Monitoring*: keeping up-to-date with developments in the field through the monitoring of particular sources;

vi. *Extracting*: selectively identifying and extracting relevant material in an information source;

vii. *Verifying*: activities associated with checking the accuracy of material;

viii. *Ending:* typically activities associated with finishing an information seeking process, what Wilson explains as "tying loose ends" through to a final search (Wilson, 1999a, pg 254).

Ellis intentionally presented the *features* as a list rather than in diagrammatic form to emphasise that they could be found in any combination and do not imply sequence or stages of a process.

In his review of the later 'eight feature' model, Wilson (1999a) argues that Ellis' set of features can be sequenced to some extent and offers a model as a stage process version which is frequently cited in the literature (Figure 2.6):

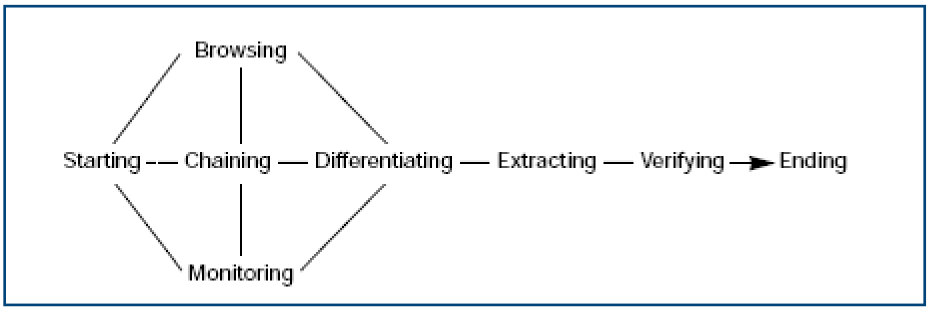

Figure 2.6 Stage process version of Ellis' eight feature set (Wilson, 1999a, pg 255)

Wilson (1999a) argues that starting and ending have a natural position in the process, whereas differentiating, extracting and verifying could be iterative and initiated in different combinations and at different times in the overall process, although they would typically be expected to follow a search behaviour such as browsing, chaining or monitoring. This diagrammatic process version, perhaps highlights more clearly the significance of Ellis' contribution, i.e. it was one of the early models to empirically show that there are discrete sets of features or strategies concerned with searching, selecting and extracting/ending (which implies some information *use*). Indeed it can be argued that information use is implicit in Ellis' model.

Although Ellis' model was derived from studies using dedicated library databases, it has been used to underpin or inform other more recent web-based information seeking models and studies. For example, Choo et al. (2000) undertook a project to investigate how professional managers and workers use the Web to seek external information as part of their daily work, in organisational settings. Their findings offered an 'Empirical Model of Web Use' reflecting each of the six features of Ellis:

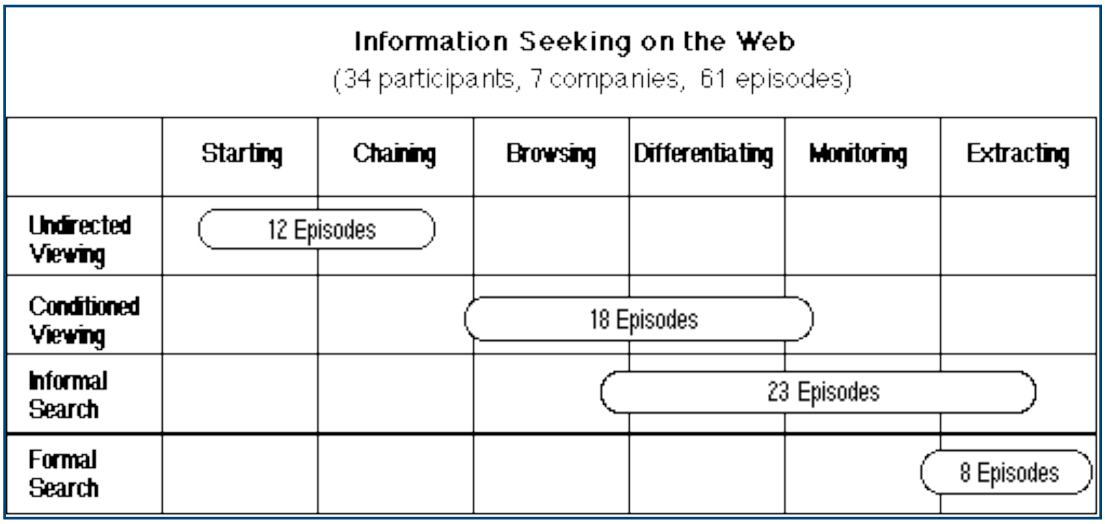

Figure 2.7 An Empirical Model of Web Use (Choo et al., 2000)

Choo et al.'s research was informed from the research into organisational scanning modes, initially undertaken by Aguilar, which was combined with Ellis' six feature behavioural model (Figure 2.7).

Other examples extending or building from Ellis' work are:

- Meho and Tibbo (2003) investigated the seeking behaviours of sixty faculty members tasked with an information search across four identified bibliographic databases. Results confirmed Ellis' model and enhanced it with another four features, namely *accessing*, *networking*, *verifying*, and *information managing*. Further they offered a new model grouping all 10 features into four interrelated stages: searching, accessing, processing, and ending;
- Shanker et al. (2005) studied pairs of students from Seven Secondary schools in Singapore as they undertook assigned history-based and science-based tasks. Their online movements were captured using screen capture software, *Snapzpro*. Findings revealed the majority of students primarily focused on the *starting*, *browsing*, *chaining*, *differentiating* and *extracting* stages of Ellis' model. They observed two levels of *starting*, *differentiating* but no significant patterns were observed in relation to the *monitoring* component in Ellis' model.

Ellis is credited as the first to identify the importance of browsing (Bates, 1989) and at the time he offered insight into how these features could improve or inform information retrieval systems, for example by employing hypertext software. His model explicitly captures the behaviour of information seeking without imposing any fixed sequence on stages, and has been shown to be robust under web environments. It is considered a general model to fit a wide range of situations (Jarvelin et al., 2003).

2.3.3 Kuhlthau: Information Seeking Process Model (1991)

Kuhlthau's Information Search Process model (ISP, 1991) is often compared with Ellis' Behavioural model; the strength of both is their empirical grounding but there is a clear distinction. Kuhlthau was interested to capture detail about the user as well as the process itself, and as Wilson (1999a) observes, Kuhlthau intentionally captures and conveys a sequence, unlike Ellis who intends no sequence in his model.

Kuhlthau's ISP describes the information search process as understood by users; it emerged from a series of five studies, some longitudinal, using a variety of data collection techniques in naturalistic settings. The initial studies considered library users, the majority of whom were students undertaking academic assignments, but Kuhlthau, amongst others, has since validated the model for different users, tasks and context. For example, Kuhlthau (2001) validated the model with studies involving lawyers using a mix of resources including online resources

Information seeking is considered to be a sensemaking process, where the individual is actively interpreting and constructing their own meaning to fit in with what they already know, and Kuhlthau postulates that the ISP captures the "user's constructive approach to finding meaning from information" over a space of time (1991, pg 361). In this respect she acknowledges the influence of Dervin and Nilan (1986) and like Bates (1989), she recognises the information need as evolving. The emergent ISP represents a six stage process and captures the changes that users experience as they progress through the seeking process, i.e., associated feelings (affective), thoughts (cognitive) and actions (physical). The framework presented in her earlier papers (e.g., 1991, pg 369) was later refined as replicated in Figure 2.8:

Tasks	**Initiation**	**Selection**	**Exploration**	**Formulation**	**Collection**	**Presentation**
Feelings (affective)	Uncertainty	Optimism	Confusion, frustration, doubt.	Clarity	Sense of direction, confidence	Satisfaction or disappointment
Thoughts (cognitive)	Vague →				Focused	
	→				Increased interest	
Actions (physical)	Seeking relevant information			Seeking pertinent information		
	exploring				Documenting	

Figure 2.8 Information Searching Process (ISP) Model (Kuhlthau, 1993, pg 343)

The six stages are recognised as sub-tasks of the process:

- **Initiation** is when the user becomes aware of lack of knowledge or recognises the Task (information) need; little or nothing may be known about the problem and uncertainty and apprehension are common feelings whilst users seek background information;
- **Selection** is when an assignment topic or approach is chosen, sometimes after discussion and/or weighing up the alternatives, and feelings often change to optimism;
- **Exploration** leads to further uncertainty and frustration; there is a need to focus and select relevant information at this point, but often the topic is not understood which compromises the users ability to communicate their needs, e.g. to formulate a request or query for information services;
- **Formulation** is what Kuhlthau calls the turning point. It is pivotal (website); it is when thoughts start to clarify, e.g. from initial relevant information sources, and confidence increases;
- **Collection** is the stage when the user gathers information related to the focused topic. Actions involve interacting with the information systems function more efficiently and effectively, selectively gathering more focused and relevant information, and constructing detailed notes;
- **Presentation** is when the search is complete and there is a sense of satisfaction if the search has gone well, else disappointment. The task is to synthesise and organise the information, e.g., prepare to present or use information in some way as original assignment dictates.

Kuhlthau considers the ISP a process of seeking meaning, not simply finding and reproducing information. It reflects an evolving process of construction where knowledge is initially vague with associated feelings of uncertainty; as knowledge and understanding develop, uncertainty is replaced with confidence and personal construction begins to emerge. It is only when confidence develops is the user best able to communicate and interact with the information systems functions, be it librarians or technology. As Wilson (1999a) observed, the progressive stages of problem refinement are inherent in the ISP and reflect the gradual refinement of the problem situation as the information seeking continues. Hence, a successive search process is implicit in Kuhlthau's analysis of the search activity. Wilson also suggests that it is independent of the problem-solving, and each stage in a problem-solving model could lead to an information seeking process going through all stages.

Kuhlthau was one of the first to reflect an affective dimension to information seeking, i.e., how users exhibit decreasing levels of uncertainty as understanding increases; acknowledgment is given to the influence of Kelly's 1963 personal construct theory, and Wilson's work on the affective needs of information seeking. The ISP is recognised as one of the early and influential contributors to user-centred information seeking. It is widely cited and is accepted as a general process model, applicable to a range of empirical domains. Other contributions that acknowledge and build on the ISP are,

- Swain (1996) tested the model on a group of five college 'freshman'; she conducted interviews adopted from the sense-making approach and asked the students to maintain diaries. Swain's results showed the freshmen generally progressed through the stages of the ISP but at their own and varying timing; some students skipped some of the stages and others progressed in a different order. Swain identified the importance of social communication in the process;
- Wilson's (1999b) offered his uncertainty model with acknowledgments to ISP;
- Choo's theoretical "Human Information Seeking: An Integrated Model" (1999) was influenced and reflects the dimensions of the ISP as it does Ellis behaviour model. Choo's model is another of the few that explicitly identifies the *use* aspect of information seeking;
- Vakkari (2000, 2001a, 2001b) used Kuhlthau's results to underpin his empirical studies into task complexity in information seeking;

- Ingwersen's (2005) Cognitive Framework of (longitudinal) Information Seeking and Retrieval (IS&R) acknowledges and incorporates Kuhlthau's research;
- Kuhlthau has conducted several subsequent studies and finds the results in-line with those of the ISP (e.g., Kuhlthau et al., 2001).

Like other Information models, Kuhlthau does not explicitly identify or expand the *use* stage of the process although it can be argued as implicit in the 'presentation' stage of her model.

2.4 Information Seeking: Selected Empirical Studies

The sheer volume of empirical studies reported can make it difficult to filter what is of particular importance to a research project. This project is interested in how users make sense, i.e., use located information, and more generally in the range of broad interactions that occur between the user and information sources.

Studies that have helped frame this project are studies which have dealt with some aspect of interaction, are recent, and framed within a web-based context. These are

- Aula et al. (2005) investigated the range of search engines, queries and search strategies users' deploy. The data collection method was also of interest (2.4.1);
- Ivory et al. (2004) investigated which of the search results' characteristics influenced the selection of sources and thus their foraging patterns (2.4.2);

Early empirical studies that investigated individuals' relevance assessments, considered the judgments of printed sources, output from bibliographic library databases, but two more recent studies have contributed to the debate from a web-based perspective, Rieh (2002) and Tombros et al. (2005). These are discussed in Sections 2.4.3 and 2.4.4.

Other studies of interest were those that considered the 'use' aspect of the information behaviour. These were few (see 2.2) and those that did investigate 'use' had their own interpretation of what 'use' meant, but Wang et al.'s longitudinal study is considered in more detail (2.4.5).

2.4.1 Aula et al. (2005)

Aula et al. (2005) is an example of a more recent empirical study that focused on web-based searching. They utilised a web-based questionnaire to determine the prevalence of fourteen strategies known to be used by experienced users when searching and re-accessing information. Two hundred and thirty six (236) experienced users were asked to indicate, on a five-point Likert scale ranging through Never, Rarely, Sometimes, Often and Almost Always, how frequently they used each of the fourteen strategies. Demographic data, preferred browser and search engine, additional details about book-marking behaviours, and their use of advance query operators were captured in an electronic questionnaire.

The findings suggested that, in common with other previous studies, experienced users preferred to use browsers that supported tabbed browsing, and the majority of respondents (95.3%) preferred to use a general search engine such as Google for all, i.e. including work-related search tasks. However, some mention was made of the usefulness of alternative search engines that support categorisation or clustering of results. Bookmarks were known to be problematic, e.g., high levels of maintenance needed, and caused difficulties for even experienced users, thus many tried to find alternative re-access strategies, often relying on attempts to formulate and execute the query again. Query formulation itself was found to resemble novice attempts i.e. with little application of the advance query operators, and some misconceptions as to how the search engine functions. Overall Aula et al. argued that experienced users struggled with many of the strategies because they were not supported by the existing search engines and browsers. They argued that their web-based questionnaire data collection method provided for a better understanding of the strategies, regardless of tools used, and that the student responses provided some additional detail about the rationale behind the strategies. Further they argued that these advance strategies employed by experienced users are seen to be effective and if support for these were implemented in web browsers and search engines, then novice users would also benefit.

2.4.2 Ivory et al. (2004)

Ivory et al. (2004), study design was based on the premise, from ‘Information foraging’, that users attempt to optimise benefits and minimise costs in pursuit of information; as such they were interested to understand which features in pages of returned search results lists (information source surrogates), help Users determine which results are worth pursuing. Interactions with search engine results pages are one example of the user’s range of interactions with information sources experienced in web-based or online seeking activities.

A partial factor design gave eighteen experiment conditions based on four from thirteen factors known to influence Users' exploration decisions. The four factors were

i. search result relevance,

ii. search result features,

iii. page processing effort,

iv. Users' visual ability.

Two lab experiments of nine conditions each were set-up and implemented via nine factoid search tasks across sixteen users (ten sighted and six blind). Pre user-session searches, for all nine tasks, were conducted by the researchers to capture source surrogates and corresponding web-pages for both true positive results (TP), where the result is relevant and its corresponding web pages contains the desired information, and false positive results (FP) where the result seems relevant but the corresponding page does not contain the required information. An automated evaluation tool then computed additional source surrogate details such as number of words, adverts, and quality of the associated web-page. It was these manipulated surrogate objects and their web-pages which were presented to the users during their lab-based search sessions.

Findings showed that users, when deciding whether to explore the linked web-page or not, referenced the surrogate's standard features, i.e., summary, title and URL to predict search result relevance, prior to considering the additionally calculated features provided to help them differentiate between a TP and an FP result. When the additional features were available, the search time taken by both sighted and blind users decreased. They did not waste effort reading pages that did not necessarily match their information needs. Ivory et al. suggest that their preliminary findings could help inform search engine interface design, but they did not explore the reasons why standard surrogate features were examined, i.e., what these features were telling the users about the associated web-page.

2.4.3 Rieh (2002)

Rieh identified information quality and cognitive authority to be the most prevalent judgments in relevance assessment, and further claimed to be the first to investigate these two judgments with respect to their use in web-based environments. Rieh offers a well argued methodology. Rieh studied 15 university scholars as they executed four different web-based search tasks,

i) research related, ii) travel related, iii) medicine related, and iv) purchase related.

Rieh claimed to have corroborated Hogarth's 1987 earlier research by demonstrating that two types of judgments were taking place, namely,

i. predictive judgments: the student considered a result in the search results lists for further selection by examining the information surrogates for indicators of the associated web-page's content;

ii. evaluative judgments: the student examined the web-page source itself to decide about its actual quality and cognitive authority.

These two judgments were observed to be made continuously throughout the search activity and when they matched, the student typically decided to use the source content.

Information quality and cognitive authority were found to be key dimensions in both predictive and evaluative judgment types; however the level of importance varied according to the type of task being performed. Rieh showed that quality and cognitive authority judgments are both multi-faceted and identified several facets of each not previously seen elsewhere. Both judgments were found to be subjective, relative and situational, being influenced by a number of factors including previous knowledge, type of task, etc., as well as external factors such as source characteristics. Rieh also identified six categories (some with sub-categories) of criteria for each of the predictive and evaluative judgments of quality and cognitive authority. Again, the significance of each criterion was found to vary according to the type of search task.

2.4.4 Tombros et al. (2005)

Tombros et al.'s study is one of the few known to focus on utility evaluation with respect to which features are considered during users interactions with the located information source

They explored source interactions with respect to which characteristics of the source the user interacted with to aid their utility judgements. Their premise was that the term *relevance* is commonly accepted to loosely mean either topicality i.e. subjective judgment about topic appropriateness, or utility i.e. judgments about the ultimate usefulness of a piece of information. Their study focused on relevance in terms of utility: 24 students in a single seeking session were observed as they assessed the usefulness of non-academic web-page sources, which had been previously located. Students were given three short search scenarios, a background search, a decision task type search and a 'many items', compile-a-list type search task.

The emergent source features, identified as 'useful' or 'not useful' were grouped into five categories of features overall: Text, Structure, Quality, Non-textual items, and Physical. The most important category proved to be the Text category, which contained features such as content, title/headings etc.. They also found the two most commonly cited single indicators of useful or not-useful were content and 'query terms' (keywords) – both features contained in the Text category. In total nine features were mentioned as single indictors of source usefulness and the variation in feature importance reflected the variation in task type. The stage of the task was also found to be influential and there was no single pattern across tasks. Tombros et al. found their results, based on non-academic sources, were comparable with previous studies that focused on research related and academic sources.

Tombros et al. argue that their contribution is the detailed breakdown of source features within categories, in particular the breakdown of Text features. Further, they suggest these findings help inform interface design of returned search results.

2.4.5 Behaviour Studies Exploring the 'Use' Aspect of Behaviour

The term '*use'* is open to many interpretations (2.2); Wang et al. (1998, 1999) premised that there are three stages of document use namely, selection, reading and use, where source citation was taken as an indicator of source ***use.***

They undertook a longitudinal study three years apart, i.e., the first part undertaken in 1992 (reported in 1998) and the second part undertaken in 1995 (reported in 1999). They were interested to observe the decision making process at three identified points of document use, namely, at selection, at reading and at citation. This differs from many of the other relevance assessment studies in that this study considers criteria reference judgments a component of the broader decision making process across the three stages of document interaction.

The first phase of their study focused on the selection process: 25 academics were supplied with print-outs of search results reflecting their own expressed information need. These results were, e.g., conference papers, master theses, dissertations, etc., previously located by the researcher using a library bibliographic database. The academics were observed individually as they worked through the selection process.

Two models were the significant contributions from their two-phase research work

i. a Document Selection Model (phase-1, 1998), that identifies a range of document information elements, Title, Abstract etc., used by users to inform a set of criteria such as topicality and quality. The decision could be 'accept', 'reject' or 'maybe';

ii. the second model, a Document Use Model (phase-II, 1999) illustrates how most selection criteria evident in earlier reading, persists through into the *use* (citation) stage of work.

This work was conducted using paper-based bibliographic sources and had a considerable time lapse between studies.

2.5 Sense-Making and Sensemaking

Two models of sensemaking are discussed in detail in this Section.

i. Dervin's Sense-Making Methodology and model (2.5.1)

ii. Russell et al.'s 'Learning Loop Complex' model (2.5.2)

Thereafter, an empirical study from Qu et al. (2005) is reviewed (2.5.3.1), followed by a study from Pirolli et al. (2005) (2.5.3.2).

2.5.1 Dervin's Sense-Making: Model and Methodology

Dervin's Sense-Making is concerned with the study of

> *"how people construct sense of their worlds and, in particular, how they construct information needs and uses for information in the process of sense-making"*
>
> (Dervin, 1983, pg 3)

According to Dervin, people live in a world which changes across time and space, with gaps at any given time-space, and at any point in time-space, for whatever reason, we have to make sense of information/knowledge. These time-space points are referred to as ***Gaps***.

> *"Humans, Sense making assumes, live in a world of gaps: a reality that changes across time and space and is at least in part "gappy" at a given time-space;…"*
>
> (Dervin, 1998, pg 36)

The theory is based around a '*Situations-Gaps-Uses*' model of information needs with a bridging action as the means of closing the gap between the *Situation* and the *Use* or outcome. Dervin emphasises the importance of understanding the *Situations*, i.e. the time-space, context in which people find themselves when an information need occurs. This 'need' arises from the *Gap* in their understanding at that point-in-time; as such it 'blocks' progress and needs 'bridging'. It is iterative in as much as the outcome from bridging can lead to another information need which has to be satisfied. The *Uses*, which describe the way the person might apply their newly created sense are described in terms of 'hurts' or 'helps', i.e., does it hinder or enable progress.

Dervin's early research developed into Sense-making Methodology that applies categories of *Situations*, *Gaps* and *Uses.* A Sense-Making view of sense-making as offered by Dervin is shown in Figure 2.9.

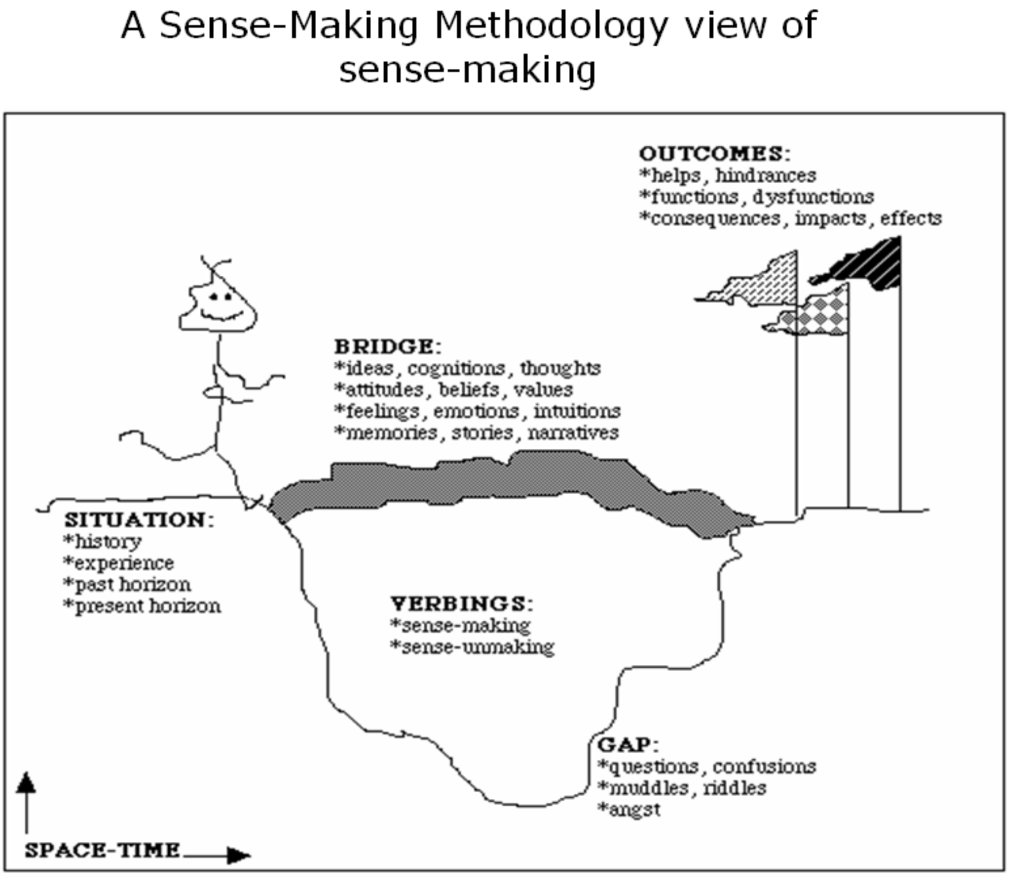

Figure 2.9 Dervin's Sense-Making metaphor (Dervin, 2003, pg 277)

As an example, the six categories of *Situations* are

i. two or more roads lie ahead (decision);

ii. something blocks the road (barrier);

iii. the road has disappeared (wash out);

iv. someone or something is pulling the user down the road (problematic);

v. the road is spiralled and has no direction (spin-out);

vi. the user blanked out (out-to-lunch stop)

Influences on the *Situation* include history, experience, past and present horizon.

The Sense-Making Methodology uses a 'Micro-Moment-Time-Line' interview technique. A template of questions is applied in a step-by-step recall interview; for example it includes a range of *Gap*-questions for any given context (*Situation*) and has been successfully applied to several hundred cases and has been shown to have wide applicability. For example, it has been applied to studies in communication, in information seeking of specific groups in health service, education, and many other contexts.

2.5.2 Russell et al. Sensemaking

Russell and colleagues were investigating another aspect of sensemaking - the costs of sensemaking, or specifically the cost of extracting information from located information resources, where extraction is taken to include the subtasks of finding, extracting and transforming the information into alternative formats. Such extraction is often judged to be the most time-consuming sensemaking task (Russell et al., 1993).
Costs can arise from any/all of the tasks involved and although the volume of information sources is ever-increasing and the cost of information itself has fallen, there are still costs to the 'sensemaker'. Any such costs are typically weighed in terms of perceived benefit or value of the information against time costs.

Russell et al. argue that sensemakers develop and refine representations e.g., they develop frameworks (schemas) to structure and organise the information being gathered and then when they believe that the framework is sufficient, i.e., that there is no significant data (residue) remaining from the searching, they fill-out or encode the representation with detailed content. They model this sensemaking as a core process which they call the 'Learning Loop Complex' which itself contains three loops and four processes or subtasks (Figure 2.10).

i. Search for representations: create representations (schemas or outline structures) that capture the significant concepts of the topic. This is the *generation* loop;

ii. Instantiate representations: repeatedly identify information of interest and encode it into the representation (Russell et al. called these *encodons*). This is the *data coverage* loop;

iii. Shift representations: this is prompted by the discovery of *residue* or relevant data that does not have a place in the existing schema and forces changes in the representational schemas. Changes could include expansion to accommodate new data or if the new data does not fit then the schema may need to be merged, split, or unused representations. This is the *representational shift* loop;

iv. Consume *encodons*: the instantiated representations are used in a task-specific information processing step.

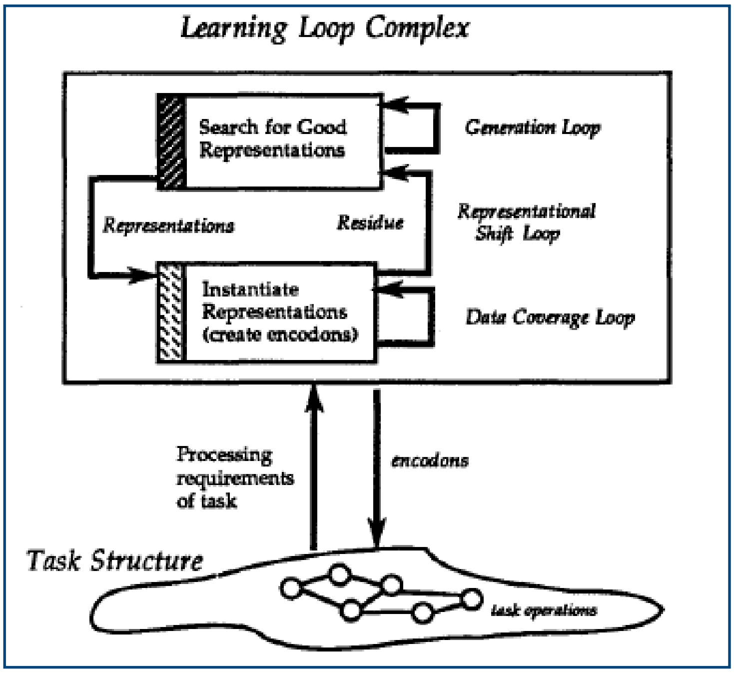

Figure 2.10 The 'Learning Loop Complex' Model (Russell et al., 1993, pg 271)

Sensemaking is considered a cyclic process which involves searching for a good representation (*generation loop*), enhancing that representation with further information *(data coverage loop)* until there is significant *residue* to prompt a search for a better representation (*representational shift loop).* Sensemaking iterates between the top-down representation instantiation and bottom-up search processes. Finally the resultant representation (*encodons*) is used in whatever way the task requires (Figure 2.10).

Russell et al.'s initial study (1993) was based on a single case study that observed how a group of commercial trainers made sense of information about laser printers whilst planning and developing a new training course. The course trainers used a hypermedia knowledge structuring tool, Instructional Design Environments (IDE) to capture and organise information for the course. Russell et al. later compared their results with other previous work to show that their findings held over many cases and argued that such sensemaking methods are essentially anytime algorithms i.e. the best solution is found within the given time limit but if more resources/time is provided, a better solution is sought.

The original 1993 seminal model has informed a considerable number of studies, e.g., Faisal et al. (2009), Sharma (2011), Butcher et al. (2011), and Attfield et al. (2011). Other studies have validated and extended the original model, e.g., Qu et al. (2005), Pirolli et al. (2005). Based on further empirical studies, Russell et al. (2008) extended the 1993 model (Figure 2.10) to explicitly capture an information foraging loop distinct from the core sensemaking loop (Figure 2.11).

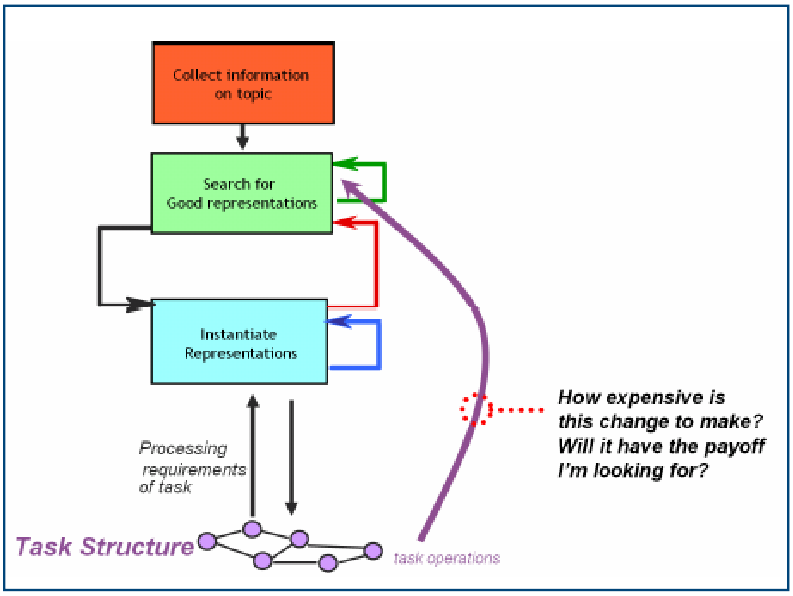

Figure 2.11 Russell et al. revised Model (2008)

It was also recognised that there was a clear evaluation process whenever the users considered a change in their representation structure, i.e., the users were seen to deliberate the benefits of making the representational shift. The model has also been extended to include this backlink (Figure 2.11).

2.5.3 Sensemaking: Empirical Studies Parallel to This Project

There has been renewed interest in everyday sensemaking in part as a consequence of the rapid development of WWW technologies, and much has been reported since this project began. Many of these studies report on sensemaking in alternative contexts, e.g., Dyrks et al. (2008) explored sensemaking practices of fireman, and Sharoda et al. (2008) investigated sensemaking in an hospital emergency department. Others investigate the design implications for sensemaking support tools, for example,

i. Faisal et al. (2009), suggest, in a position paper, that the approach to informing design should start with an understanding of representations. They offer an initial classification of representations as a first step in developing a design methodology for tools that support interactive sensemaking;

ii. Zhang et al. (2009) suggest implications from testing of their (previously presented) comprehensive sensemaking model;

iii. Russell et al. (2008) investigate how well readily available software supports everyday sensemaking and suggests some design implications from their results.

Others investigate sensemaking in collaborative working, e.g., Morris et al. (2008), Lee et al. (2008), Selvin et al. (2008) and Sharoda et al. (2009). A collaborative tool is a component in many of these studies and as such the studies also consider the performance of the tool itself.

However it is the empirical work of Qu et al. (2005, 2008) and Pirolli et al. (2005) that were of particular interest for this project.

2.5.3.1 Qu and Furnas (2005)

The Qu and Furnas (2005) investigation into sources of representations offers insights into the sources and strategies used in external representation construction during sensemaking tasks. In their study thirty participants were randomly assigned to one of two topic-comprehension-tasks; these tasks were deliberately chosen for their different characteristics e.g., one, entitled 'Tea' had many websites with large volumes of information available whilst the other, 'Everyday drinks for Old People', as a single concept lacked any specific websites. The comprehension-task was to be completed within two weeks as preparation for a one-hour presentation on their findings. Participants used a sensemaking-supporting information gathering system known as CoSen

> *"... which allowed them to easily search web, browse, bookmark, and organize searching results, take notes of web pages, and edit the talk outline in an integrated environment"* *(*Qu et al., 2005, pg 1990*)*

The system automatically saved the two external representations, namely bookmarks and a talk outline for all participants.

As with Russell et al. (1993), findings from Qu et al.'s study show that sensemaking structures come from iteration between top-down (e.g. from existing knowledge) and bottom-up (e.g. by induction of gathered facts). Qu et al. (2005) also identify that structures can be derived bottom-up by borrowing from discovered structures of others, e.g., from located web-page content. They also highlight a key difference from the Russell et al. earlier work; Russell et al. suggested that structural representations were completed separate from content encoded or added to the structures, whereas Qu and Furnas show that gathered information contributes to both the structure representation and the encoding in a more integrated manner. From this they conclude that the sensemaker gathers both facts and organisational ideas from the information gathered which aid the representational search in sensemaking. Whilst this is a significant finding, it is unclear as to what impact the use of a system such as (CoSen) may have had on the sensemaker's ability to complete as a more integrated activity.

Other findings from this 2005 study highlight some useful insights into how the information sources influence the representation construction:

- sensemaking and information seeking are intertwined; sensemaking uses information seeking as a subtask and, whilst in the process of information seeking, users try to make sense of what they find.
- in both tasks, participants borrowed from existing representations found in located content (web-pages) and search results to build their structures, e.g. headings, sub-headings;
- the volume of information held about a topic can influence the structure of an emergent representation. Representations were re-evaluated and adjusted to incorporate found information when the volume suggested it was important enough for inclusion.

Qu and Furnas (2008) report a second phase of this study that contributes to the growing body of Exploratory Search (2.2).

2.5.3.2 Pirolli et al. (2005)

As part of a large project at Palo Alto Research Centre (PARC), researchers in the User Interface Research Area have been studying a broad class of tasks known as sensemaking tasks. The goal is that the studies collectively provide insight into design for new sense-making technologies. In one study, Pirolli et al. (2005) applied cognitive task analysis and think-aloud protocol to examine the process two Intelligent Analysts adopted in their everyday problem-solving tasks. This study involved expert and experienced sensemakers using specialist systems and tools.

In line with their expectations about expert behaviour, Pirolli et al. found that the two expert Intelligent Analysts referenced a set of patterns built from their extensive experience of working in the field. These patterns, referred to as schemas, were used to organise incoming information into representations as aids to planning, evaluation and reasoning. The tasks the Intelligent Analysts undertook were recognised as sensemaking tasks and Pirolli et al. were able to draw out the similarities to Russell et al.'s 'Learning Loop Complex' model (1993).

One significant outcome of the study was their 'Notional model of the analyst process' (Figure 2.12) which extended the Russell et al. model (1993) and contributed towards their revised version (Figure 2.11).

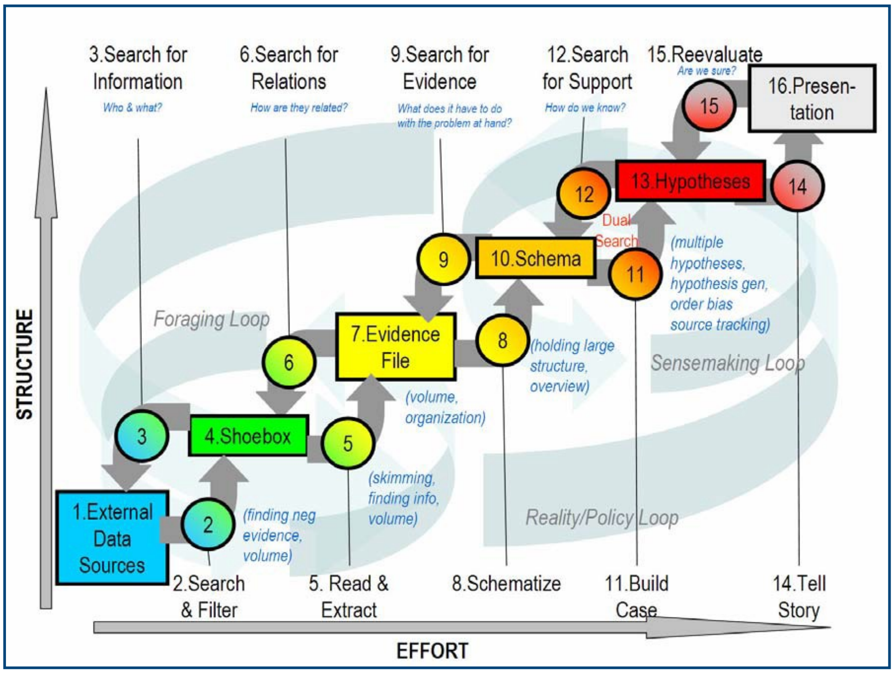

Figure 2.12 Notional Model of the Analyst process (Pirolli et al., 2005)

Legend:

Rectangular boxes are approximate data flow

Circles represent the process flow

External data sources hold the volumes of raw evidence

Shoebox is the subset of the external data

Evidence file holds the extractions from the Shoebox

The process is fluid with many back loops and two distinct, significant, cyclic loops:

i. an information foraging loop concerned with gathering and processing the data towards creating a schema

ii. a sensemaking loop concerned with the process of moving from schemas through (re) representations to the finished product. This is akin to the 'Learning Loop complex' model (Russell et al., 1993).

Findings showed that the processing was *bottom-up* (from data to theory) or *top-down* (from theory to data) and the processes appeared to be applied opportunistically.

Intelligence analysis typically involves large volumes of data and it is this focus that led Pirolli et al. to identify key leverage (pain) points that might benefit from technological support. The design implications identified for the foraging loop were concerned with the trade-off between:

- exploring: increasing the scope of the information space being monitored;
- enriching: filtering and narrowing the set of items collected for analysis;
- exploiting: improving the interaction with the items in the set

Those implications identified with respect to the sensemaking loop were suggested as:

- techniques and features to enable analysts to off-load information patterns onto external memory such as visual displays would aid the limitations of human working memory;
- generation of alternative hypothesis to combat the time pressures and adapt overloads that risk the analyst's ability to consider alternatives;
- new tools to address cognitive bias in the process.

2.6 Discussion and Conclusions

Information behaviour evolved from its initial focus on system-side information retrieval to a more user-centred focus. Researchers such as Dervin & Nilan, Ellis, Wilson, and Kuhlthau are frequently credited as influential in this switch, and their early models have proved to be a sound basis for ongoing research. In the main these models originally captured academics and professional users undertaking information seeking tasks using library or specialised databases. More recently, Kuhlthau and Ellis' models have been applied and validated for everyday users undertaking web-based seeking tasks: both continue to reflect general information seeking behaviour. That said, neither of them explicitly capture ‘use’ behaviour, although it could be argued, that information ‘use’ is implied in the ‘presentation’ stage of Kuhlthau’s model and in ‘extracting’ and ‘ending’ behaviours of Ellis’ model.

The literature reports many hundreds of empirical studies investigating various aspects of information behaviour. A critical mass to date has focused on the search engine and its interactions (query formulations), or located source relevance judgements. Many others document investigations into seeking behaviours with respect to user characteristics, for instance, gender, or experience, or report findings specific to particular aspects of the seeking behaviour such as navigation styles. Very few have investigated the ‘use’ of located information and those that have, apply their own interpretation on ‘use’. For example use of citations, use as organisation of ‘content clippings’ for later reuse.

A major criticism of information behaviour research is this lack of attention paid to ‘use’ behaviour. It is rarely explicitly captured in models or investigated in empirical studies. This aspect remains under-researched.

Information seeking and sensemaking have been inter-linked over time, and sensemaking is viewed from several alternate perspectives. For example Dervin models it as a broad communication process, with users active in the creation of their own sense, whereas Russell et al.’s model sensemaking as a representation process, bound by cost v benefit trade-offs.
Sensemaking research, particularly everyday sensemaking, has generated much interest in recent years and resulted in a growth of reported empirical studies conducted in parallel to this project. Nonetheless, everyday sensemaking is still under-explored as is the relationship between sensemaking and information seeking.

This project is interested in how users make sense of, i.e., how they gather, evaluate, understand, interpret, and integrate new information for their own specific problem/task needs. More generally, it is interested in the broad interactions that occur between the user and information sources during this sensemaking process.

Three information seeking models and five behaviour studies have been reviewed in detail and considered relevant to this project. They provide a comparative basis for findings for the first study which addresses Research Question 1 and informs Research Questions 3 and 4 (Study-1, Chapter 4). The three selected models are:

i. Bates' Berrypicking model (1989) captures the seeking process as a flow of recurrent search activities (queries) and points of document interaction. Although an early model, it captures the multiple-query concept and the interaction with sources and documents ongoing throughout the process. This concept is still applicable to current web-based seeking.

ii. Ellis' Behavioural model (1989, 1993) is a model suitable for general application and has been shown to be applicable for web-based information seeking. It defines seeking features that may occur in any order. As such the model is flexible and provides a comparative base for findings.

iii. Kuhlthau's ISP (1991) is another model that has been shown to be general and applicable for web-based information seeking. It illustrates progression (not necessarily sequential) through the seeking process and reflects personal construction and sensemaking. These two characteristics, i.e. progression and sensemaking, makes Kuhlthau's model particularly suitable for evaluating aspects of Study-1 results with respect to Research Question 1.

Five selected information seeking empirical studies each addressed an aspect of the user-information source interactions. This project bridges all aspects and to a certain extent these named studies helped shape this project. Furthermore, they provide some basis for comparison with this project's findings from Study-1:

i. Aula et al.'s (2005) study of 200+ participants offers insight into some general search (query) strategies. Whilst query interactions are not a focus of this project, the search is expected to be closely coupled to other behaviours. Hence these findings provide a recent and fairly general point of reference for the findings from this first Study-1;

ii. Ivory et al. (2004) suggest several results' features that users consider in their selection; this decision-making process is contributory to the user's developing understanding as they progress their seeking task. These findings offer another slightly different comparative basis, i.e., example strategies involving results interactions and evaluation;

iii. Rieh's research (2002) reports on both interactions with search results, i.e., information surrogates, and information sources. These are both fundamental to web-based seeking activity and judgements made suggest evidence of understanding and making sense.

This, coupled with a sound methodology are reasons why Rieh's empirical work is relevant to this project and useful for comparison with Study-1;

iv. Tombros et al.'s (2005) study is one of the few known to focus on utility evaluation with respect to which features are considered during users interactions with the located information source. As with both Aula et al. and Ivory et al. studies, Tombros et al. offers empirical findings that afford comparison with this first Study-1;

v. Wang et al.'s (1998, 1999) two phase study interprets 'use' of information to be citation usage. This interpretation does not resonate with this projects understanding of 'use' but nevertheless they document a pathway through the seeking process that reflects key decision points, e.g., points of understanding or making sense. These evaluations offer a potentially useful base for comparison.

This project's empirical Study-2 (Chapter 6) has a particular focus on users' sensemaking, their external representations and the relationship between seeking and sensemaking. As such, Study-2 addresses Research Questions 2, 3, 4. Dervin and Russell et al.'s models are both judged relevant to this second Study:

- Dervin's Sense-Making methodology is not judged applicable for this project. It uses 'Micro-Moment Time-Line' interviews to capture the <u>*reported*</u> situations and gaps that arise in user's time-space pathway, whereas this project is interested to <u>*observe*</u> how users interact with information sources and externalise their understanding through sensemaking. However, the concepts of *Situation*, *Gaps, Uses* and *bridging* are of interest;
- Russell et al's perspective on sensemaking (1993) is more in line with the focus on this Study-2's Research Questions. Their work reflects information behaviours and has external representation at the core of their sensemaking model. This model and findings provide a sound base for comparison.

Several of the relatively current studies into sensemaking offer some base for comparison with findings from Study-2. For example, the studies that investigated design implications for sensemaking technologies provide a useful comparison with the findings from Study-1 and Study-2 that inform Research Question 5 which specifically addresses design implications. Another investigation, Qu and Furnas (2005, 2008) is important to this project's second study. Their first phase investigated sources of representation structure in sensemaking which particularly resonates with this project's third Research Question. It provides interesting results but a significant difference is that their investigation used an integrated search/representation environment for participants. Nevertheless, their study is one of the few that currently investigate the micro-level sensemaking and their findings from phase-1(2005) provide a useful comparison. Furthermore their phase-II findings concerning the relationship between sensemaking and information seeking and their concluding design implications provide for comparison.

Another study by Pirolli et al. (2005) investigated Intelligence Analysts' sensemaking. Although their empirical work is based on experts (Intelligence Analysts) doing specialised roles and using specialist systems and tools, their 'Notional model' (Figure 2.12) highlights a relationship between sensemaking and information seeking and offers some implications for design. Their findings may show similarities to the findings of this project although both the user type and task are very different in both projects.

This Chapter has reviewed the literature to provide a context for this research and help situate the proposed empirical work. Furthermore, specific results and findings have been identified as sources of comparison with this project's findings.

Chapter 3 - Methodology

3.1 Introduction

Chapter 1 provided the context for this project, i.e., it highlighted the perceived lack of research into sensemaking in web-based information seeking environments, and introduced the five Research Questions devised to address the perceived research gaps. Next, Chapter 2, reported on relevant literature from the two broad areas that inform this research. This current Chapter 3 expands on aspects of the qualitative research methodology as first introduced in outline in Chapter 1(ref Chapter1.4). The overall outline design solution presented there was a series of small empirical studies, each devised to address or inform one or more Research Questions (ref Chapter 1, Figure 1.2). That is,

- Study-1 was devised to identify the broad range of typical behaviours & strategies deployed as experienced end-users interacted with information sources whilst undertaking information-related tasks in web-based environments, and determine where sensemaking was indicated as evident. It was specifically designed to address Research Question 1 and inform Research Question 3 and meta-questions 4 and 5;
- Study-2 was devised to investigate further web-based sensemaking behaviours and strategies as indicated by Study-1 findings, i.e., examine how such behaviours and strategies were deployed by experienced end-users whilst they undertook an everyday web-based topic-comprehension task. It was specifically intended to address Research Question 2, inform Research Question 3 and the meta-questions questions 4 and 5, as well as help validate Study-1's results.

This series of studies were intended to share a common, qualitative methodology although there were necessary differences in some aspects of its application, i.e., each Study had its own unique objectives.

This Chapter presents more detail about the overall design (3.2) and then reports on several aspects of the methodology. Although the detailed design of each Study evolved over time, the Chapter highlights the similarities and differences as applied to each Study, namely,

Section 3.3 discusses suitable elicitation methods based on consideration of the nature of evidence needed for each Study's Research Question;

Section 3.4 argues the environmental setting for each Study;

Section 3.5 details appropriate participant sampling and recruitment mechanisms;

Section 3.6 explains task design, considerations and decisions;

Section 3.7 provides an evaluation with respect to validity, reliability and limitations of the project;

Section 3.8 offers a Chapter summary.

3.2 Project Design

The project was originally devised as a preliminary feasibility Study, plus two main Studies and one further comparative Study, but only the feasibility Study and two main Studies were viable due to time limitations (Figure 3.1).

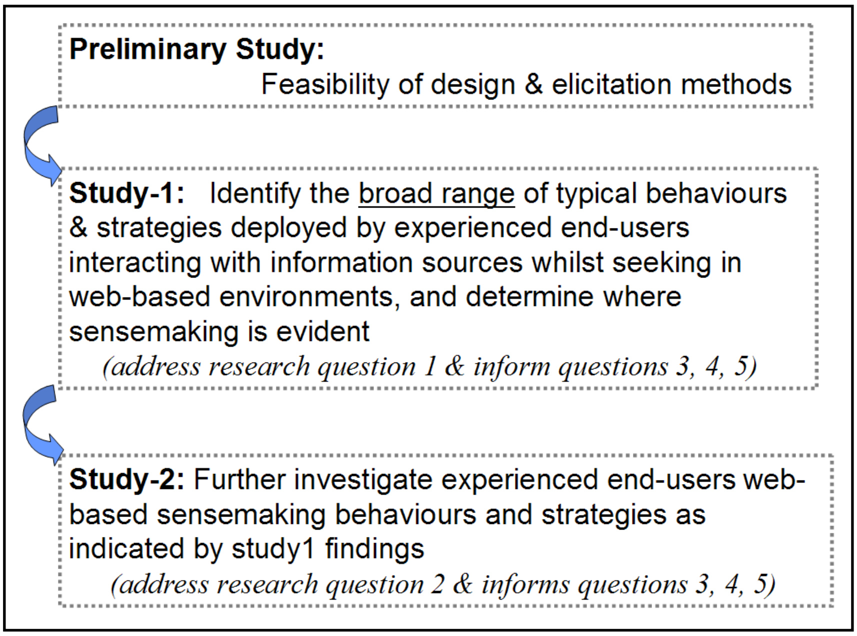

Figure 3.1 Project Design: a series of Empirical Studies

As a series of small Studies, the overall design was judged to have several benefits, namely,

- it provided scope for comparison and some validation within and between studies; for example, Study-2 would serve to validate Study-1 if examples of broad strategies reported by Study-1 were found in Study-2;
- the overall design needed to consider the known ‘task influence’ on information seeking behaviours (e.g., Bystrom and Jarvelin 1995); different studies with different tasks helped address this known influence;
- it facilitated the opportunity to refine each successive Study’s objectives, e.g., to further investigate selected findings from a previous Study;

- it provided a reasonably broad base of results for further extrapolation, e.g., across a range of participants and across different tasks.

The preliminary feasibility Study was specifically devised to test the practicability of certain aspects of the methodology, e.g., the appropriateness of selected data collection methods (3.3.2), and to help inform sample participant's characteristics. Details of this Study are reported next.

3.2.1 Preliminary Feasibility Study

A Feasibility Study was undertaken to

- determine the appropriateness of the identified subset of elicitation methods and collection techniques;
- provide some experience in observational work;
- uncover any unforeseen issues.

The specific aims of the Study were

- to gain insight into how and why participants start and finish seek activities as they do;
- to appreciate the range of observable seeking behaviours;
- to identify examples of external representation as evidence of explicit sensemaking.

Three representative adult learners of mixed background and experience were randomly selected; two self-assessed as experienced web-based information searchers, the third self-assessed as a novice. They were given an information seeking type task which was broadly within the domain of their everyday workplace, i.e. as authentic as possible.

> *'For a programming language or a software package of your own choice, investigate and gather the key functionality and features, as preparation for a five minute presentation'*

The task was intentionally customisable for a choice of computer programming language or software application in order to be sufficiently motivating for the participants.

Forty-five minute observations with think-aloud were audio-recorded and the researcher made additional notes. Participants conducted the web-based task at their normal workplace or at the researcher's workplace. They were encouraged to talk aloud as they collected and used any information found from located sources. A supply of paper & pen and software (e.g., *MsWord*) was made available for the task. Data was also gathered from post-session question & answers.

There were several key outcomes from this preliminary feasibility Study:

- it provided useful experience in observation data collection techniques;
- it showed that a time-limited observation for a search novice was unlikely to yield much useful data across the Research Questions. Thus it reinforced the decision to use only experienced information seekers for this project;
- the results suggest corroboration with some recent work completed by Rieh (2002), Ivory et al. (2004), Tsai and Tsai (2003), Tsai (2004), Aula et al. (2005), Tombros et al. (2005). This proved very encouraging.

3.3 Research Questions and Types of Evidence

The literature review (ref Chapter 2) identified that more needs to be understood about the range of behaviours and associated utterances that typically occur as end-users use any located information to help satisfy their information needs. Thus, the Research Questions were devised to address this gap, i.e., investigate how users made sense of information sources found when working in web-based environments, what resources and how and when these resources are deployed, and how & when they (end-users) externally represented their new found understanding (ref Chapter 1.3). These users' behaviours and their external representations, i.e., their explicit sensemaking artefacts, are significant primary data evidencing sensemaking within an information seeking context: such data was expected to be rich or multi-faceted, context sensitive, empirical, and overall qualitative, i.e., data not readily expressible in numerical form*s* (Sharp et al., 2007, pg 356).

Various elicitation techniques, applicable across many disciplines, are available for collecting qualitative data. A subset of these data collection methods has been shown to work in qualitative research namely, observations, verbal protocol, interviews and questionnaires (e.g. Ingwersen et al., 2005). Examples of application, singly or as multiples of methods, are evident in many information seeking and 'everyday sensemaking' studies. The advantages/disadvantages and strengths/weaknesses of each method are well reported in such as Silverman (2005), Rugg and Petre (2007), and other literature specific to these methods, e.g., think-aloud protocols: van Someren et al. (1994); Interviews: Keats (2000), Gillham (2000); Questionnaires: Oppenheim (1992).

There is much general advice as to how to choose between the varying elicitation techniques, e.g., Preece et al. (2002, pg 215), but deciding which is the most appropriate elicitation technique to deploy can also be informed through consideration of the evidence needed to answer the Research Questions; this approach is adopted by others, e.g., Rieh (2002). Indeed, Rugg and Petre emphasise how important it is to understand the type of evidence needed to answer Research Questions (Rugg et al., 2007, pg 37).

3.3.1 Research Questions and Elicitation Methods

Table 3.1 summarises the suitability of several methods as compared against the type of evidence or data needs of each of the five Research Questions:

3.3.1.1 Research Questions 1 and 2

The evidence (or data needs) of Research Question 1 and 2 (RQ 1 & 2, Table 3.1) were similar; they needed to capture data that conveyed experienced users' behaviours and strategies as they collected and used, i.e., made sense of, information sources whilst working in web-based environments. Observation is commonly recognised as one of the best means of capturing this type of behaviour as it occurs, although there is some debate that the mere act of observing might interfere with the natural actions of the user. Another equally suitable method, typically used with observation, is concurrent verbal protocol which captures their think-aloud thoughts as they enact, in this case, the seeking and sensemaking processes.

Interviews and questionnaires had some merit for RQ 1 & 2; interviews, particularly semi-structured with open ended prompting, were considered useful to capture participants' perceptions or recall of their seeking and sensemaking behaviours both generally or within a context. Similarly questionnaires using a variety of questioning techniques, e.g., open, closed and multiple-choice readily capture their perceptions of typical behaviours. Both of these methods were also considered suitable for pre and post-session aspects of the data gathering, e.g., participants' demographics.

Empirical Study (ref Fig 1.2):	Research Question:	Elicitation Method:			
		Observation	Verbal protocol	Interview	Questionnaire
Study-1	1. What is the broad range of typical behaviours and strategies deployed by experienced end-users as they interact with information sources whilst undertaking information-related tasks in web-based environments, and where is indicative sensemaking evident?	√	√	**O**	**O**
Study-2	2. How do experienced end-users make sense, i.e., collect, extract and organise relevant information from web-based information sources?	√	√	**O**	**O**
Study-1 & Study-2	3. How do users externally represent both the collection and the meaning being derived from the information sources?	√	√	**O**	**O**
Study-1 & Study-2	4. How does user's sensemaking relate to the seeking process?	**X**	**X**	**X**	**X**
Study-1 & Study-2	5. What are the implications for interaction design of sensemaking support tools and systems?	**X**	**X**	**X**	**X**

Table 3.1 Elicitation methods considered against project Research Questions

(Based on examples from Xie (2000) and Rieh (2002)

Legend: √ denotes **useful, O** denotes **somewhat useful,**

X denotes inferred from Study-1 and Study-2 findings

3.3.1.2 Research Question 3

This question (RQ3, Table 3.1) was concerned with behaviours related specifically to the explicit external representation of their sensemaking, i.e., as they made sense during the process. Again observation best captures their representation behaviours and utterances as they occur, with examples of emergent external representations a collectable by-product of the observed session, e.g., cross referenced to behaviour through timestamps.

Interviews and questionnaires was considered slightly less suitable for RQ3; whilst these methods suited the report or recall of types of external representations examples as used by participants, the precise stage of behaviour they emerged would be less easy to identify, i.e., less easy to contextualise. That said, this was not a significant issue for Study-1 as its aim was to identify a range of behaviours.

3.3.1.3 Research Questions 4 and 5

These two questions (RQ4 & RQ5, Table 3.1) were unlikely to be recognised by the end-user, but if so their responses would be participants own analysis of their perceived behaviours which might be difficult for them to articulate. These two questions were therefore considered meta-questions, i.e., better answered by the analytic process.

How each data collection method was applied in each individual Study was a further dimension of the design decisions and is discussed next.

3.3.2 Data Collection: Study Decisions

The previous Section considered the types of evidence needed from the Research Questions perspective. The data collection decisions were further corroborated by the feasibility Study (3.2.1) and the pilot runs for each of the two main studies. The selected elicitation methods as applied to each Study are summarised in Table 3.2

Selected method:	**Study-1:**	**Study-2:**
Pre-session questionnaire	√	
Observation with think-aloud	√	√
Post-session questionnaire		√
Post-session collection of external representations (behavioural artefacts)	√	√

Table 3.2 Summary: elicitation methods as applied to each Study

Questionnaire design was based on existing guidelines, e.g., Keats (2000); Preece et al. (2002); Rugg et al. (2007), and examples in the literature, e.g., Aula et al. (2005) and Tombros et al. (2005). Two questionnaires were devised, one for each main Study: a pre-session questionnaire in Study-1 was designed to ask data about demographics as well as some aspects of participants' typical information seeking and associated usage behaviours. Study-2's questionnaire, on the other hand, was devised for post-session collection of demographic data, some aspects of typical behaviours, and reflective thoughts about the observation.

Observation with think-aloud was well-suited to each Study but the different foci of the studies required a slightly different implementation. In line with typical practice (van Someren 1994, pg 44) a dedicated audio record device was secured to record participant's think-aloud throughout both main studies, thus enabling replay and transcription for analysis. Such audio recording was judged sufficient for the purposes of Study-1 but video recording with screen capture software was more appropriate for Study-2. These decisions were informed from the literature, as well as discussions with other experienced behavioural researchers, and reaffirmed by evidence from pilot runs of both studies. For example, a pilot run of Study-2 intentionally conducted without video recording confirmed its added value to the proposed Study. Screen capture software which was also available in laboratory demonstrations highlighted the advantage of the enhanced detail that was obtainable from both video camera and screen shot video streams. Further the merged video stream output offered a rich source of data for Study-2 analysis (ref Chapter 5).

Lastly, for each Study, the collection of any instances of emergent external representations, sometimes referred to as "behavioural artefacts" (Case 2002, pg 163), were designed to be gathered post-session.

Using a combination of data collection techniques provides different perspectives, e.g., observation with think-aloud plus pre or post-session questionnaires aids internal validation of the findings. Further details of these data collection methods as applied to each Study are found in the respective Chapters (Study-1: Chapter 4; Study-2: Chapter 5).

3.4 Environmental Setting

There is an ongoing debate as to when naturalistic (operational) or laboratory settings should be used for empirical studies, although the demarcation between naturalistic and laboratory settings has become more vague over time. For example laboratory settings are reported to be best suited to studies which need to control certain factors or variables which might influence results (e.g., Tague-Sutcliffe, 1992; Rugg & Petre, 2007). However, many studies use laboratory settings without controlling any variables (Tague-Sutcliffe, 1992), and Case (2002, pg 185) suggests that laboratories are often chosen as study settings for simply pragmatic reasons. Conversely, given physical space, privacy, access

permissions etc., might favour laboratory settings, Bystrom and Hansen (2005) warn that the setting could have an impact on the user's behaviour and performance; similarly Silverman (2005) suggests that it is always important to consider the consequences of the setting for the research project, but as long there is no significant effect it is acceptable to use laboratory or simulated settings.
Other factors that can inform the setting choice include,

- availability of suitable laboratory facilities;
- space for data collection equipment such as video/audio recording and screen capture software;
- additional empirical study facilities such as local printing.

Many suggest that these other factors influence selection of laboratory settings over naturalistic settings for empirical studies (e.g. Rieh, 2002; Ivory et al., 2004; Qu and Furnas, 2005; Tombros et al., 2005). Clearly if equipment dictates the setting, measures have to ensure that the research is not compromised in any other way. That is, whatever the setting, the environment layout needs to be planned so that there is no interference during the observation; interference could arise from the position of the observer as well as the placement of any data collection equipment being used, e.g., video and audio recording equipment (Preece et al., 2002).

Study Decisions

The environmental setting for these research studies describes the type of setting, equipment and types of information seeking resources *(i-s resources*). The latter term, *i-s resources,* is used in this project to refer to the collection of physical and software resources needed for each of the two studies. These types of *i-s resources* varied according to the study requirements but included a combination from

- a supply of paper and pens/pencils (*pen&paper*);
- hard-copy of a task-sheet;
- access to one or more internet browsers and search engines;
- access to *MsOffice* software including *Word*, *Excel*, *Access*, *Powerpoint* and *Notepad*.

The decisions as to which and how these resources were deployed within each Study are discussed in the respective Study Chapters (ref Study-1: Chapter4; Study-2: Chapter5).

In theory, given the primary elicitation methods, i.e., observation with think-aloud methods, both naturalistic/operational and laboratory based settings suited each Study. The decision was informed by several factors, namely, the literature, the elicitation methods (3.3.2), and pragmatic considerations. The setting arrangements were decided as:

Study-1: naturalistic/operational

Study-2: laboratory

Given Study-1's objectives, i.e., to investigate a range of seeking and sensemaking behaviours, it seemed appropriate to encourage users to be observed in their own workplace, in order to gather as natural a range of behaviours as possible. On the other hand a laboratory setting was preferred for the second Study which was investigating more in-depth seeking and sensemaking behaviours; the reasons for this decision are:

- a laboratory setting accommodated video recording and screen shot capture equipment;
- it enabled any potential requirement for local printing facilities;

More details re the settings and configurations are found in the respective Study Chapters.

3.5 Project Participants: Sample Considerations and Decisions

The preliminary Study highlighted issues related to participant's experience when conducting a time-constrained information seek-through-usage task, i.e., a naïve user proved to be insufficiently productive to provide a rich enough dataset (3.2.1). This finding is reinforced by the literature; for example, Holscher & Strube (2000) found completion rates for search tasks were lower when users had less technical and expertise knowledge;

Lazonder et al. (2000) found that novice users were less proficient at locating Web-pages but were able to find information equally well once they were in the Web-page, whereas Kim (2001) concluded that both performance and navigational styles are significantly affected by online novice information seekers lack of experience. This is similar to Calcaterra et al. (2005) who suggests that navigation behaviours may be more closely linked to computer rather than cognitive skills. Martzoukou (2005) also cites several studies which have shown experience to be a factor in information seeking behaviours.

Another consideration for this decision was the scope of the task-in-hand to be observed; the data capture needed to encompass all facets of the information seeking process, i.e., seek-through-usage. This, combined with the findings from the preliminary, feasibility Study, which also corroborated existing literature, influenced the decision about the key criteria of any sample participants, namely participants needed to be experienced and competent not only in terms of using the internet as information seekers, but they also needed to be able to process and use found information, as well as articulate the processes. In other words, participants across all main studies needed to be experienced information processors*,* but they did not need to be highly technical.

Another aspect is consideration of the sample size; this is typically more to do with satisfying the quality of the data captured rather than the quantity. By their nature, small samples in qualitative studies tend to offer less scope for extrapolation of findings, but in relative terms, a small sample of say 15-25 should offer more scope than a singleton sample. A guideline sample size for small studies is n:5-20 (Rugg et al., 2007).

A final consideration is recruitment mechanisms, of which there are several; these include personal contact, contact via professional bodies, email distribution via newsgroups, organisation's internal email lists. The mechanism chosen invariably depends on the target community, accessibility, etc..

Decisions: Sampling and Recruitment Strategy

For pragmatic reasons, two academic faculties of the university were selected to provide participants matching the criteria, i.e., experienced information processors. Internal email, supported opportunistic recruitment for each Study, but this was followed by some purposive sampling (Silverman, 2005, pg 129) to provide a reasonable cross-section of role types. Situational constraints, such as availability of volunteers, available time-span for each Study, and laboratory access issues (Study-2) guided the sample size for each Study, although the sample needed to be large enough to provide a comparative base for analysis whilst being manageable within the timescale. A sample size was nine for Study-1 and eight for Study-2. Non-overlapping groups between studies were sought as desirable and more detailed profiles of each Study samples are found in the respective Chapters.

3.6 Task Design: Considerations and Decisions

It is generally considered best practice to collect data from real users performing real search tasks (e.g. Martzoukou, 2005; Kim et al., 2005), although Martzoukou (2005) in her review of web information seeking research, cites the over reliance on simulated rather than authentic and owned tasks as a limitation of many empirical information seeking studies. Nevertheless, it is not always practical to study real life tasks, for instance, due to unsuitable work environment or longitudinal characteristics of the task. For these and other, often pragmatic reasons, simulated tasks may need to be studied instead. Indeed, Ingwersen (2005, pg 252/253) cites how Borlund's 2000 and 2003 research showed that simulated tasks can replace real tasks without detriment to the resulting behaviour. Furthermore, the research showed that such tasks have an additional advantage in that they can provide experimental control as the task can be applied to several subjects or users for comparative investigation.

Regardless of whether a task is simulated or otherwise, a sense of ownership is considered to be critical to task performance; Kim et al. (2005) in their review of the literature, suggest that one way of addressing this in simulated tasks is to incorporate actual task consequences for the task performers. This resonates with Ingwersen et al. (2005) who suggest that a simulated work task can offer an element of interpretation for the user and thus a degree of control assuming it includes the reason for the information need, the context of the situation, and the problem to be solved. There are other considerations:

- a good simulated task is one that is recognisable as realistic, of interest, and 'told' or presented within an imaginative context (Borlund, 2000);
- they need to be complex enough to challenge the subject/searcher (Kim and Allen, 2002) with sufficient context for them to be able to make decisions about the usefulness of found Web-pages (Tombros et al., 2005);
- the complexity of the task is significant: regardless whether real or simulated, there is known to be a direct relationship between task attributes and task performance (e.g. Bystrom and Jarvelin,1995). For example, complex tasks demand more complex types of information and, typically, higher order cognitive skills (Bloom's taxonomy) to understand and make sense of the problem domain.

Finally research showed that any perceived lack of ownership of simulated tasks can be addressed by such as borrowing from real life scenarios, considering topical or relevant scenarios for the task, ensuring that there is a clear task objective which is realistic and recognisable to the volunteer, rather than simply asking them to simply '*search for…*' during an information seeking related task.

3.6.1 Simulated Task: Characteristics

As well as the considerations raised by the literature, advice about and example task topics were sought from several academics, across two universities, who had considerable experience of setting information seeking tasks for course assignments and examinations. Based on this cumulative knowledge and the findings from the preliminary Study, the design criteria for this project's simulated tasks needed to have the following characteristics:

- authentic as possible and provide a sense of ownership;
- suitably relevant, engaging and motivating across a broad range of volunteers and disciplines;
- sufficiently complex without being too difficult;
- complex enough to warrant some representation strategies but not too complex that the search strategy hampers success;
- demanding specialist knowledge or both specialist and populist in nature;
- have a practical element or current relevance;
- manageable within a time limit e.g., 1-1.5hrs time span;
- demand some form of opinion or personal judgment.

3.6.2 Common Web-Based Task Types

Web-based task 'types' or 'task purposes' have been analysed and classified variously by many authors (ref Chapter 2.2). For example, a user might conduct a real web search to

- navigate, often directly, to a particular known web-page;
- conduct an information gathering exercise which could be for personal interest, work or educational related;
- purchase something or negotiate a download etc..

The most common task topic/subject domain is shown to include research, health, travel and e-commerce (shopping) (e.g., Morrison et al., 2001; Rieh, 2002; Toms et al., 2003; Spink and Jansen, 2004).

3.6.3 Task Design Decisions

The type of task chosen for each Study needed to best suit each Study's objectives and any simulated tasks needed to reflect the criteria as listed (3.6.1). The task decided for each Study varied.

3.6.3.1 Study 1 Task

Study-1 objectives were to investigate an example range of seeking and sensemaking behaviours used by experienced information processors; as such it would benefit from as wide a range of tasks being undertaken as possible. Moreover, observation of participants undertaking their own research-related task offered the best opportunity to elicit a realistic range of behaviours.

Accordingly, each participant was to conduct an owned research-related information needs task. Importantly, it follows that all observed tasks stem from 'real information needs'; in this respect they were

- naturalistic to best reflect typical seeking behaviours,
- authentic and owned maximising participant's engagement with the exercise.

In addition, an owned task was required to be relevant and demand some form of personal judgement, e.g., with respect to their particular needs. A pre-session guideline was devised to aid the selection process (ref Chapter 4.5.3).

Although this design decision resulted in a range of tasks that varied dependent on a number of factors, including the stage of their studies, etc., the tasks all shared the same information-type characteristics.

3.6.3.2 Study 2 Task

The second Study was to research further into the range of example behaviours found in Study-1 results, i.e., in particular it needed to focus on behaviours that reflected sensemaking behaviour during web based information seeking and sensemaking. In this case, the task needed to be a single simulated task which would prove suitable across a range of participants. A non-trivial 'information gathering' topic-comprehension task was chosen. Such tasks characteristically require intense information gathering, interpretation and (re)representation, and can often involve higher order cognition skills such as synthesis. This type of task is typical of everyday sensemaking tasks that exploit the ready availability of web-resources (Qu and Furnas, 2005). Determining the topic of the comprehension task was a complex decision process as reported in Chapter 5 (ref Chapter 5.1.1).

3.7 Evaluation: Validity, Reliability and Limitations

Using multiple data sources from a combination of elicitation methods, not only provided for different perspectives on the gathered data, but contributed to the validity and reliability of the results. Ingwersen (2005) argues that even partial evidence from multiple methods can together allow cross checking and increases the validity and reliability of results. Even so, there is often a need for a trade-off between the two concepts (e.g., Case, 2002) and on this point Cryer (2000) states that validity needs to be the more important consideration when a trade-off is necessary. The design is evaluated in terms of its validity, reliability and limitations.

Validity

Validity is concerned with "how closely results map on to reality" (Rugg et al. 2007, pg 226) that is, how suited the methodology is to the situation being investigated. Observation with think-aloud are very appropriate methods for behavioural investigations: observation as a data collection method offers 'real time' data collection, capturing a user's actions 'as they happen' and is recognised as very effective for capturing both behaviour and process (Maiden et al., 1996). Indeed, Wilson opines that all other methods are mere substitutes i.e., all others are essentially requiring recall about 'the event' (cited Martzoukou, 2005, pg 6).

The qualitative approach based on small groups of users, as used in this research, allows for an in-depth understanding of the behaviours of a specific type of end-user, i.e., an understanding of how experienced information processors seek and make sense in web-based environments. Further validation is provided by the comparative nature of the studies, i.e., comparison of behaviours within each Study and across the Studies. Any findings are readily comparable with other studies based on groups of similar user-types as well as other groups of different user-types – all undertaking the same task; other variables include the task context. The comparative studies framework offers the potential for some generalisable findings which in turn could inform theory.

Reliability

The question of reliability is essentially concerned with the repeatability of the results (Sharp et al., 2007). This, it is argued is difficult to achieve in qualitative studies for at least two key reasons, namely,

- the variances of human participants with respect to time, space and context;
- the interpretation aspect of the data, the analysis, or both.

One characteristic of research known to aid reliability is transparency of the process; the methodology and procedure used in this research is fully documented and thus intended to be transparent. For example, an archive of the data, elicited and analysed, is available to others for scrutiny and any direct comparison studies for verification.

The project addressed the issue of reliability in other ways,

- it was not possible to employ multiple coders for this project which is one mechanism reported to improve reliability of results (Silverman, 2005). Instead the coding schema was presented for regular scrutiny by two very experienced researchers, to help address any bias in the author's interpretation and offer verification of coding. During these frequent Q&A sessions the coding schema was defended and reviewed as necessary.
- emergent results were regularly presented for inspection and scrutiny;
- the key elicitation methods served different purposes and provided for some cross-checking and thus verification of reliability:
    - observation with video captured the visible actual behaviours whilst think-aloud gathered concurrent audio data about the cognitive process taking place during information seeking and sensemaking. Recording these elicited data streams for further and repeated scrutiny provided a rigorous data set of mutually supporting evidence;
    - questionnaire data, i.e., responses offered some insight into their perceived typical behaviour patterns which was comparable to the actual behaviours and provided a measure of robustness to the findings from the observation and think-aloud data sets.
    - the collected artefacts evidence or legitimise any claims of representation strategies when cross referenced to the observation sessions.

Limitations

The use of small samples of participants with detailed rich data sets offers greater validity but at the cost of less opportunity to generalise from the results. This limitation is part addressed through designing for a range of different research related tasks as Study-1. Generalisation could also be addressed through further studies based on different tasks and quantitative data, e.g., collecting large volumes of reported behaviours and examples of external representations. This is discussed later (ref Chapter 8.3).

3.8 Summary

All methodology and design decisions were taken after consideration of a number of factors pertinent to each aspect; relevant literature, the preliminary Study findings, and pilot runs for each Study informed each stage of the decision process. The key decisions for each Study are summarised in Table 3.3:

Aspect of Methodology:	**Study-1:**	**Study-2:**
Data collection methods	- Pre-session questionnaire - Observation with think-aloud - Post-session collection of external representations	- Observation with think-aloud - Post-session questionnaire - Post-session collection of external representations
Data capture equipment	- Audio recording - Researcher note-taking	- Audio +video+ screen capture - Researcher note-taking
Environment setting	- naturalistic	- laboratory
Resources available	A range of *i-s resources* (3.4)	A range of *i-s resources* (3.4)
Participant: criteria	Experienced information processors	Experienced information processors
sample size	nine	eight
recruitment mechanism	Internal email	Internal email
Type of Task	Individual own research related information needs task	Designated everyday information gathering type task: topic-comprehension task

Table 3.3 Methodology and Design: key decisions per main Study

Attention was paid to validity and reliability of the methodology, and the limited scope for generalisability of results was acknowledged as the trade-off in this approach.

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Chapter 4 - Empirical Study 1: Information Interactions in Web-Based Research-Related Information-Seeking Tasks

4.1 Introduction

This Chapter reports on the first investigatory, empirical Study undertaken to identify the range of seeking and sensemaking strategies exhibited by experienced information processors as they executed an authentic research task in web-based environment, i.e., it was designed to address Research Question 1 and to inform Research Questions 3 & 4. A variety of data were collected using various methods, and an iterative, inductive analysis was conducted.

4.2 Roadmap

Section 4.3 presents the rationale for the Study.

Section 4.4 details the Study design, including questionnaire design. The pilot run of the Study is then reported briefly.

Section 4.5, the '*Method'* section, describes the participant sample, procedure, observed task and session profiles.

Section 4.6 explains the analysis approach.

Section 4.7 presents the results in three main sub-sections, each detailing aspects of the participants' information interaction strategies to do with 'search' (4.7.1), 'evaluation' (4.7.2) and 'use' (4.7.3).

Section 4.8 provides an overall discussion which relates these findings to the relevant Research Questions and, in so doing, relates these findings to sensemaking more broadly, as well as considering an emergent framework in context of selected existing information behaviour models.

Section 4.9 summarises the Chapter.

4.3 Rationale for the Study

In every aspect of life, whether it is education, work or play, we encounter situations where we need to seek out information to understand a situation and solve a problem or complete a task. Examples include learning about a topic in order to complete an assignment, finding out more about a hobby, researching facts and figures prior to a purchase, generating a report as part of a work-task, and so on. These 'information needs' activate information seeking, which typically involves gathering, interpreting, organising and integrating new information, in order to make sense. Furnas and Russell (2005, pg 2115) explain this as leading to "the creation of new sense" i.e., the sensemaking process. Despite renewed interest in sensemaking, which is in part due to the impact of the web and its range of applications, little is known as yet about micro-level sensemaking behaviour and its relationship to the information-seeking process (e.g., Furnas et al., 2005; Takayama et al., 2008).

Information seeking and sensemaking have been closely coupled for many years, for example, Dervin 1983, Kuhlthau 1991 (ref Chapter 2.2). For example, Kuhlthau's Information Seeking Process (ISP, 1991, pg 361) portrays the "user's constructive activity of finding meaning from information …" through "a series of encounters with information over a space of time". As such, Kuhlthau considered information seeking as a sensemaking process, in which the individual is actively interpreting and constructing their own meaning to fit with what they already know.

Despite the existence of many information behaviour models, the literature review (ref Chapter 2) identifies that most reflect two core behaviours, *search* and *evaluation* and only occasionally, do they explicitly identify 'use' as a third core behaviour. Moreover, if captured at all, information 'use' is often only implicit in the models, e.g., Kuhlthau, 1991; Ellis, 1989 (Chapter 2). These two models have more recently, been validated and expanded for web-based contexts, for example Vakkari's (2001a or b) study based on Kuhlthau's ISP (1991).

Web-searching and seeking are different from both pre-web information retrieval (White & Iivonen 2001) and searching bibliographic database systems (Holscher et al., 2000). Web-based information seeking is concerned with interactions between the information user and a computer-based information system (e.g., Broder, 2002; Sutcliffe et al.,1998), and web-based searches have at least two types of associated interactions:

1. interactions with the search-engine interface (e.g., query input searches), and
2. interactions between the user and the information sources, e.g., evaluation, extraction and use from search results and web-pages).

However, in the main, empirical studies continue to focus on the *search* or the *evaluation* aspect of the process with little attention paid to the usage aspect; examples of more recent studies within a web-based context are set out in Table 4.1.

Who?	Key purpose and 'gaps':
Rieh 2002:	Rieh was concerned with judgments of 'quality' and 'cognitive authority'. She recognises selection decisions to be predictive judgments about the potential source, based on the search result entry information, and the decisions based on the actual source to be evaluative judgments. Her evaluative judgment findings are based on observations of participants' interaction with the selected source or web-page at the screen. Source usage itself was not explored.
Ivory et al. 2004:	They explored the decision making and performance of sighted and blind users. The aim of their lab-based study was to identify which features user's inspected to evaluate search results for relevance and which additional features, e.g., source word count, if added, might help users avoid following false-positive results. **The study did not pursue further than selection decisions about returned search results.**
Aula et al. 2005:	A large-scale web-based study, used web-based questionnaires to investigate the search and re-access strategies used by experienced users in web-based context**. It was only interested in the search aspects of the process.**
Tombros et al. 2005:	Tombros et al. conducted a time-controlled observation study in which users undertook a series of different search tasks to locate non-academic web-sources. They specifically probed for range of features in non-academic source content that influenced users' utility (relevance) judgements. They argue their contribution is the detailed breakdown of source features within categories, in particular the breakdown of Text features within the source itself. **This research did not examine other than participant's utility evaluation of the source.**
Wang et al. 1998, 1999:	Wang and Sorgel (1998) and Wang and White(1999) undertook a longitudinal study of decision making on document use. It examined the selection process as participants interacted with pre-gathered, printed search results. Wang's findings identified which aspects or elements of the result entries were being inspected (document information elements, DIE) as well as criteria that were influencing these decisions. Their second study (1999) gathered reflective data about why participant's chose or used a source. **However the study only considered usage from a citation perspective; it did not consider how source content itself was extracted and represented to help solve the information problem. There was no search context, i.e., results were supplied**.

Table 4.1 Studies of web-based searching and seeking

Each of the studies in Table 4.1 has examined one or more facets of the seeking process, but, whilst they helped scope this current empirical work, they did not specifically address how users extract and use located information sources.

This first Study was undertaken to address the first Research Question:

> *What is the broad range of typical behaviours and strategies deployed by experienced end-users as they interact with information sources whilst undertaking information-related tasks in web-based environments, and where is indicative sensemaking evident?* (Chapter 1.3.1)

This Study also aimed to inform, but not fully address, Research Question 3:

> *How do users externally represent both the collection and the meaning being derived from the information sources?* (Chapter 1.3.3)

and Research Question 4:

> *How does users' sensemaking relate to the seeking process?* (Chapter 1.3.4)

The main goal of the Study was to gain insight into the broad range of strategies that experienced users might employ as they conducted web-based searches to locate sources for authentic, research-related tasks. It focused particularly on the interactions between the end-user and the information sources (e.g., search results and web-pages/documents) and looked across different aspects of the sensemaking process:

- deciding which sources to use;
- collecting, extracting and organising relevant information from the sources;
- forming external representations, both of the collected information and of the meaning being derived from it.

Instrumental goals were:

- to understand what behaviours were evident as participants progressed from initial results evaluation to source usage; and
- to identify explicit evidence of sensemaking.

Sensemaking itself might be indicated by a user's utterance, by manifestations such as their manipulation of information or creation of a representation, or by observed user behaviour. End-users' specific search behaviour needed to be noted in order to appreciate its importance in the overall task, but was not of focal interest. Neither were the detailed relevance criteria they used for evaluation, which has been researched by others (e.g., Rieh, 2002).

The resultant range of typical behaviours and strategies would be used to scope further, more focused investigations into the sensemaking process and how it relates to information seeking.

4.4 Study Design

The Study was conducted in line with the overall project design decision and guidelines (Chapter 3):

- the search task needed to be naturalistic and authentic;
- the volunteers needed to be not only experienced internet searchers, but more specifically to be experienced information processors, able to consider and use found information;
- the environment/setting needed to be as natural as possible;
- the Study used suitable data collection via questionnaire, 'think-aloud' protocols and post-session evidence gathering;

Using a combination of data collection techniques provided different perspectives (e.g., questionnaire and 'think-aloud') and aided internal validation of the findings.

The user's articulation of their decisions and actions, as they proceeded through the web-based information search process, was the primary data sought. In addition, a questionnaire was devised to capture both demographic details and practical data about typical behaviours such as choice of search engine and query formulation, to provide a more informed context about their information searching behaviours. Samples of cited external representations were also gathered to support and verify participant's claims regarding usage.

4.4.1 Questionnaire Design

The questionnaire (ref Appendix A) contained a mixture of open-ended and 5-point Likert-type questions, to capture both demographic data and readily reportable aspects of typical search behaviours:

- section 1 sought demographic data and asked participants to gauge their own level of web-search expertise and the frequency of searches;
- section 2 asked about typical web-based search behaviours, and asked participants to rate their perceived success in information searches;
- section 3 gather data typical of their search-results evaluation;
- section 4 asked about typical information-usage behaviours.

The questionnaire provided a basis of comparison between some claimed typical behaviours and observed behaviours, and the design was based on existing guidelines (ref Chapter 3.3.2).

4.4.2 Pilot Study

A pilot run was undertaken prior to the full Study. As a result, the presentation of the questionnaire was altered very slightly to clarify an aspect of the participant's academic background and use of advanced search operators. The accompanying email text to participants was also reworded slightly for clarity. There was no negative feedback from the final version of the questionnaire (ref Appendix A).

4.5 Method

4.5.1 Participants: Sample Recruitment and Profile

In line with sample size guidelines, nine volunteers were sought from among PhD students at the Centre for Research in Computing (CRC), Open University (OU), a target user group identified as experienced information processors who would be most likely to be both successful in their search and able to articulate their use of the found sources.

Recruitment, via internal email, was initially opportunistic, but some purposive sampling (Silverman, 2005, pg 129) was used to provide a balance across the PhD levels of study, where year 1 of study maps to level 1 (reflected in the participant identifier as L1), year 2 maps to level-2 (L2), and year 3 onwards maps to level 3 (L3). The participant profiles are summarised in Table 4.2.

All participants were very experienced internet and computer users:

- all participants had at least 7 years of internet experience (column 3, Table 4.2);
- all participants had at least 8 years of computing experience (column 4, Table 4.2);
- eight out of nine judged themselves to be (very) experienced web-searchers (rating 1-5, column 5, Table 4.2). All conducted several searches per day, apart from p3-L2, who also reported the lowest self-rated search-success rate (rating 1-5, column 7, Table 4.2).

p-ID	PhD study-year	Gender	Internet experience (yrs)	Computing experience (yrs)	Self-rated Web-search expertise? (1-5)	Freq of Info searches	Self-rated Success rating? (1-5)
p1-L1	Year 1	Male	7	8	4	Several per day	5
p2-L1	Year 1	Female	9	9	5	Several per day	4
p3-L1	Year 1	Male	10	23	5	Several per day	5
p1-L2	Year 2	Male	10	10	2.5	Several per day	5
p2-L2	Year 2	Male	11	12	5	Several per day	5
p3-L2	Year 2	Male	10	10	5	Once per day	3
p1-L3	Final Year	Male	11	35	5	Several per day	5
p2-L3	Final Year	Female	12	16	4	Several per day	4
p3-L3	Final Year	Female	7	10	5	Several per day	4

Table 4.2 Participant profiles compiled from pre-questionnaire responses

Legend: p-ID is allocated as participant-number within Level of study

Self-Rating 1-5: where 1 is low and 5 is high

4.5.2 Environment and Setting

Participants were observed conducting their searches in naturalistic settings, with the addition of audio recording facilities, which could be placed discreetly within the workspace (ref 'Data Collection', Chapter 3.3). Searches were completed at either the participant's normal place of work, or if privacy or noise was a factor, conducted in a small meeting room in the immediate vicinity. Participants used their own PC (one participant), or own laptop (four participants) or, if they elected to be observed away from their workplace and did not have access to their own laptops, the researcher's laptop which they configured with their own bookmarks etc. They used tools of their choice, for example, their choice of internet search engine, internet browser, and access to *Microsoft Office* software including *Word, Excel, Access, PowerPoint* and *Notepad.* A supply of pen and paper and a print-out of the task-sheet (ref Appendix A) were also readily available.

4.5.3 Procedure and Execution

Data collection took place between November 2005 and January 2006. Each participant signed a 'Consent Form' (ref Appendix A) prior to any data collection. Questionnaires were issued via email attachment, one week prior to the observation. The accompanying email reinforced some preparatory information:

> *"Ideally I would like you to re-run (as near as possible) some recent examples of informational searches, talking me through what/how you searched including the tools used, the evaluation process with regards to the usability of a source, and finally but importantly, how you actually used (or would use) it."*

Thus the participants were prepared to execute a new (or re-run a recent) research-related information search for information about a new or relatively-unknown concept or topic. Whilst each participant's search varied in topic, each search was:

- a new or recently-executed search,
- based on a real information need,
- owned by the participant,
- serving a research-related task to gather and process information.

The ranges of tasks executed are listed in Table 4.3.
As Table 4.3 shows, seven of the nine participants elected to re-run a recently executed information search.

The semi-structured observations were guided by an open-question template and participants were encouraged to demonstrate their search and selection/usage activities as naturally as possible. The information search activity was not knowingly restricted, as participants were able to access typical browsers, search engines and personal bookmarks. Participants were encouraged to 'think-aloud'; each session was audio-recorded, and hand-written notes were taken. Only the participant and the researcher were present in these sessions. The average session length was 1hr18mins, although of course the session length varied:

p-ID	p1-L1	p2-L1	p3-L1	p1-L2	p2-L2	p3-L2	p1-L3	p2-L3-	p3-L3
Time:	***1hr07m***	***1hr17m***	***1hr20m***	***1hr22m***	***1hr06m***	***1hr33m***	***1hr30m***	***1hr23m***	***1hr05m***

p-ID:	Search Task Observed:	Needed for:	Currency:
p1-L1	Keyword search for concept	Literature Review	Re-run
p2-L1	Keyword search for concept	Literature Review	Re-run
p3-L1	Keyword search for concept	Literature Review	Re-run
p1-L2	1- Keyword search for parallel applications 2- Example of a non-web-based search	1 - Parallel, relevant research 2- Case study work, primary focus of work since last 6 months	Re-run
p2-L2	Keyword search for concept	Current research studies	Re-run
p3-L2	Keyword search for concept	Current research studies	New
p1-L3	1- keyword search for technical detail of interest to research and personal circumstances 2- keyword search for concept related to current research	1- General awareness 2- Justification of position in Thesis write-up	New but regular Monitoring activity
p2-L3	Search for background information to better understand a particular Research Methodology	Thesis Methodology write-up	Re-run
p3-L3	Search for Quotes to be used as Chapter introductions	Final presentation of Thesis write-up	Re-run

Table 4.3 Participants' observed 'research-related information task'

There were only minor technical hiccups. Some of the connections were slow during access/download to journal/conference websites; this was a frustration rather than anything worse. One participant was unable to configure the researcher's laptop completely to their own settings. Again this was not a major issue, because the participant reported working with multiple different browsers and machines and accepted this limitation as 'business as usual'.

Potential information sources were located successfully in all nine sessions. Seven of these were described as re-runs of recent searches, although participants pointed out that query results themselves might vary, even within one hour of a re-run.

Within the sessions, it was only possible to observe the user's interactions at the screen-interface with the found sources, although participants were prompted and encouraged to ‘talk-aloud’ about how they might continue to make decisions about, and use, the sources further. If they talked about external representations they might generate, then examples of such representations were collected post-session.

4.6 Analysis

The focus of this Study was to capture evidence of the participant’s sensemaking by observing their behaviours as they conducted an information-seeking task. Qualitative, inductive and iterative analysis was applied to categorise any emergent strategies employed by the participants, and to identify any significant influences underlying their decisions and actions as they searched, selected and integrated the information they gathered from the web.

4.6.1 Coding and Tools

Each of the nine ‘think-aloud’ recordings was transcribed, then annotated with field notes; reference points regarding any reported external representation were noted for the collection of such artefacts post-session. The transcriptions were captured as documents within *Nvivo,* a qualitative analysis tool. The ‘think-aloud’ protocols were representative of the participants’ own searching strategies, and the ‘free flow’ nature of the transcriptions suited an ‘open-coding’ approach, as described by Gibbs (2002). The process of open-coding allowed development of an analytic to capture emerging ideas and concepts.

Initially a course-grained analysis of the transcripts was conducted to determine the range of web-based information-search strategies being used. From the codings, several emergent interaction groupings were evident:

- interaction with the query interface (search engine and query representation);
- interaction with the search engine feedback (search results lists);
- interaction with the information content (selected source, usage).

A more fine-grained analysis on these ‘interaction groupings’ highlighted further emergent, recognisable categories of interactions, each distinguishable by its interaction properties and purpose. These categories together provided a framework from which to better understand the more detailed information-seeking and sensemaking behaviours.

The nine completed and returned pre-session questionnaires were also imported into *Nvivo* and coded. Specific examples of each participant’s own external representations, identified from their ‘think-aloud’, were gathered as soon as possible after the session and held ‘on file’ for cross reference during analysis. Thus, as the coding developed and became more complete, questions about reliability of reports were addressed by:

- comparative analysis across ‘think-aloud’ and questionnaire data, checking whether actual behaviours reflected behaviours reported as typical; and
- verification of participant’s claims regarding source usage through reference, where possible, to samples of external representations (which had been collected post-observation).

The coding schemas were exposed to some validation through regular presentation and justification to the supervision team.

4.7 Results

Nine PhD students, all experienced information processors, successfully executed one or more tasks related to their current research. During the observations, they were encouraged to recall behaviours that they were unable to demonstrate. The results presented in this section were informed primarily by analysis of the data collected during the ‘think-aloud’ observations; data from the pre-observation questionnaires and sample evidence gathered post-observation reinforced or refined some findings. Mention is made of these other data sources where they inform the results being discussed.

Participants’ behaviours and strategies were identified as a series of information interactions. Initially, three broad groupings of these interactions emerged from the initial transcript analysis: interactions with the query interface; interactions with the search engine feedback; and interactions with the information content. Each of the observed information interaction groups had its own purpose and set of characteristics. These groups were broadly comparable to *search*, *evaluation* and *use* information behaviours reported in the literature (as represented in Figure 4.1):

- *search* information interaction strategies involved choosing a search engine and formulating query(ies) to locate relevant information sources;
- *evaluation* information interaction strategies were to do with determining the value of an information object from inspection of one or more of its features or content;
- *use* information interaction strategies were concerned with interpreting, extracting, organising and integrating the found information into an existing body of knowledge.

Figure 4.1 Initial categories of information interaction strategies

The emergent *evaluation* interaction strategies were complex and multi-faceted. For example, they occurred at several different points in the seeking process, e.g., when the information object being evaluated could be a surrogate source from a results list, or it could be a target information source itself. Consequently, this broad category was resolved into three different categories of *evaluation* information interaction strategies: evaluation for *selection*, for *utility*, for *personal fit* (Figure 4.2).

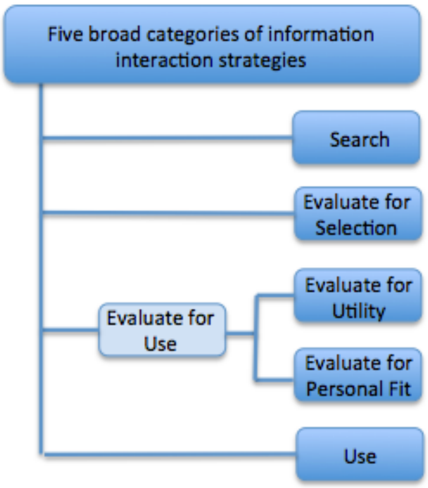

Figure 4.2 Emergent categories of information interaction strategies

The resultant five broad categories, *search*, three types of *evaluation*, and *Use*, each had a recognisable purpose, plus its own set of characteristics and complexities. The overall information-seeking process is seen as a framework combining these five broad categories of information interaction strategies. This empirically-grounded framework provides insight into the complexity of *evaluation* and information *Use* behaviours rarely captured in other models, as well as reflecting the main two behaviours captured in many existing information seeking models, *search* and *evaluation*. The broad categorisation of information interaction strategies offers additional value; each category can itself be investigated for evidence of specific sensemaking behaviours during the seeking process.

Such findings contribute to understanding the relationship between search, evaluation and use.

The five types of interaction strategies are discussed in this section. However, *search* and some aspects of *selection evaluation* behaviours are well-documented in the information behaviour literature, and those aspects are of less interest to this Study, with its focus on sensemaking. Hence only selected findings from those categories are reported here to provide:

i. context for the other findings that are of greater interest;
ii. a basis for further investigation and discussion with respect to any associated sensemaking;
iii. a basis for comparison with any future Study's findings.

4.7.1 Information Interaction Strategies Associated with *Search*

Data related to *search* interactions were gathered and analysed mainly to provide context for the sensemaking process as a whole. Information interaction strategies associated with *search* are concerned with finding and locating information via some type of query interface. Two aspects of these strategies are of broad interest to this project: the choice of search engine, and the query formulation.

4.7.1.1 Choice of search engine

A general search engine was the preferred choice of seven out of nine participants, because of the broad scope of results returned by applications such as *Google* compared to a more specialised academic database:

> *"So Google is what I use everyday for everything I do. I really like it and find that it is very useful."*
> *p3-L3, 04.26*

Eight from nine participants indicated that a typical next step in their search strategy was to follow a general search using *Google* with a more specialised search using tools as an academic database. Examples included seeking out specific sources from a conference or author, and following a 'lead' or useful alternative keyword located through the initial *Google* search:

> *"It usually gives me a list of words then I can search in more specific way; it gives me a broad overview."* *p2-L1, 2.31*

Another participant, p3-L1, undertook their searches using an academic database but discussed how they commonly used a mix of these with *Google* searches.

The observed practice was consistent with their pre-session questionnaire responses, in which they expressed a preference for Google and explained that they typically used tools such as an academic database for subsequent searches or for finding specific academic papers.

4.7.1.2 Query (re)formulation

All participants applied keyword queries successfully, finding at least one source worth further consideration. This was consistent with the participants' own expectations, as expressed in the questionnaire (Table 4.2). There was only one instance of query re-formulation:

> *"So at this point I am in trouble; let's come back to search terms, instead say: 'How do I start at the beginning?' OK let's look for a survey. Let's go for something that will lead me into it let's try 'xxx Survey'."* *p1-L3, 37.47*

Advanced search operators were evident in only one case (*p2-L1, 08.41),* although several participants expanded their action with explanations as to when they might normally apply advanced operators, e.g.:

> *"…then I'll start playing with keywords and negation words and phrases" p1-L3, 28.26*

Another participant exhibited their use of academic database filter tools to filter the search results *(p3-L1, 18.59)*; this feature has a similar functionality to advanced operators used in general search engine queries.

The pre-questionnaire responses suggested more regular use of advanced operators by seven of the participants, who claimed to use speech marks operators more than 5% of the time. Only two participants, *p1-L2* and *p3-L3* claimed less than 5% usage of any operators.

4.7.1.3 Discussion: strategies associated with *search*

Generally, these findings showed participants' *search* behaviours and strategies to be deliberate and informed. Participants' query executions were deliberate and generally successful; although it could be argued that these were likely to succeed given that some of the observed searches were re-execution of previous searches. However, search *per se* was not a focus of this Study, and thus the possibly artificially-high success rate is not of immediate concern.

The limited use of advanced query operators for initial search merits further comment: the most likely explanation, given the utterances accompanying their *search* behaviour, is that many of these experienced users preferred to return potentially large volumes of results providing a broad picture, rather than filter or limit results too early and possibly miss a result that might offer a useful or significant lead. The mix of utterances and questionnaire feedback provided evidence of the participants' recognition of situations where these operators could be applied. Further, their reported usage corresponds to selective application of advanced operators. Although this finding is not significant to this Study, it would need further investigation.

These finding are consistent with the literature as well. The observed, typical preference for a general search engine such as *Google,* is consistent with findings reported in literature reviews (e.g., White et al., 2001), and by other studies including Fast et al. (2004), Aula et al. (2005), and Tombros et al. (2005). Other studies reported web queries to be short (Jansen et al., 2000) and concept based (Wildemuth, 2004).

Many of the earlier studies which considered and reported operator usage during web searches were based on analysis of search engine logs (Jansen et al., 2001). Such studies also found selective use of advanced operators during search. For example, a large-scale study based on transaction-log analysis of 18,000+ Excite users showed that only 6% of the users used any of the Boolean capabilities, and these were used in less than 10% of the 51,473 queries, with similar results for the use of the three modifiers '+', '-' and '()' (Jansen et al., 2000, pg 218). Similarly, another smaller-scale study conducted by Aula et al. (2005), based on 236 completed web-based questionnaires from experienced users, found that experienced users do not generally employ advanced operator techniques. On the other hand, in another small-scale study into the effects of web expertise and domain knowledge on search behaviours, Holscher et al.(2000) found that experts used some form of query formatting in over 90% of submitted queries when domain knowledge was low and in over 80% when domain knowledge was high. Non-expert web-users were found to apply formatting 58% and 37% respectively.

The observed behaviour from this Study appears to align with the findings from Aula et al. (2005). However, if the observed behaviour is combined with utterances and questionnaire responses, it would suggest that this Study's participants might align more with the expert users observed by Hoscher et al. (2000). Regardless, there is sufficient evidence from utterances and questionnaire response to disagree with Aula et al.'s argument that these advance facilities are not used because they are not understood.

4.7.2 Information Interactions Associated with *Evaluation*

Participants' *evaluation* activities occurred at several different points in the seeking process, and the associated complex information interactions evolved into three distinct groups, in two reflective steps. First, a discrimination was made between evaluation for *selection* and for *use*. *Evaluation for selection* strategies involved interactions with surrogates for information objects in results lists. These were discernable from the interactions with the sources themselves, *evaluation for use*. Second, interactions within *evaluation for use* were separated into two further categories on the basis of the question the evaluation addressed. *Evaluation for utility* was concerned with asking 'Is this information source of use?', whereas *evaluation for personal fit* was concerned with asking 'Is the information what I want to use?'. *Utility* to *personal fit* strategies were further distinguishable by:

- a typical change of medium from screen to paper;
- a trend towards more intense, in-depth reading of sources, sometimes iterative; and
- emergence of examples of participants' external representations, both 'on source' annotations including highlighter and margin notes, and some 'off-source' representations, e.g., hand-written/electronic descriptive notes to provide quick recall of main points.

The recognised fuzziness between *personal fit* interactions and *Use* interactions is discussed later (4.7.2.4).

4.7.2.1 Information interactions associated with *evaluation for selection*

Evaluation for selection interactions, with surrogates of information objects from search engine results lists, almost always occurred at the screen interface. They were concerned with selecting information sources worthy of further investigation, based on a prediction of the usefulness of the source from the limited information available in the surrogate. Such 'relevance judgments' have been well researched (4.7.2.4). Nevertheless, two facets of the participant's selection strategy or decision making process are worth scrutiny: *what* features were looked at, and *why* the result was selected.

These two aspects of the selection decision offer the most insight into the sensemaking process, regardless of what features were inspected; however the features are briefly described for completeness. These findings offer the context, rather than adding to the sensemaking understanding *per se*.

What: features inspected

The results returned from different search engines vary in their presentation style. For example, general search engines, such as *Google,* typically list source surrogates, containing *Title*, *Summary* and *URL* features*,* whereas academic databases more often present *Abstract*, *Title*, *Author* and *Source-origin,* at a minimum*.* In the main, participants preferred to search with *Google*.

From the *Google* result-pages, three key features, namely *Title, URL*, and S*ummary* text with keywords were inspected or referred to, often as combinations. Evidence examples include:

> *"Basically I look at the Title of the URL. It says a lot as it is. The next thing I look for is, I don't normally go straight away to the short description. I normally look at the site where it comes from."*
> *p1-L1, 17.20*

> *"So what I normally do is look at the titles first, and if there is nothing useful I look at the BOLD words, and if I find the words, all the keywords ... within a particular summary, I stop there and read further to see if it is relevant for what I am looking for."* *p2-L2, 05.29*

> *"So I start by scanning the blue titles because they are the most ... but I know that does not tell me enough, so I scan the URLs if it makes sense to me."* *p2-L3,16.51*

On the other hand, the features inspected from the academic database results pages were *Title, Abstract, author, source origin* (institution), and *reference* (p3-L1).

At least one participant checked statistics to give them some context for the volume of keywords matched in returned result set

> *"It returns all the URLs that have got this, but looking at the numbers here (top RHS) there is 10,000 +, so I look at this information first. In this case, it did not find a single phrase that had the four Keywords together"* *p1-L1, 14.40*

Questionnaire responses indicated some 'order of importance' of the features; for example, *Title* was judged to be the primary feature by seven participants, with *Summary* judged to be the primary feature by another two participants.

Corresponding features from different result sets (from *Google* or *Academic Databases*), were apparently treated as equivalent with respect to the way they were used. For example, *Summary* and *Abstract* were both inspected to grasp the contents of the source, and the *URL* was seen to provide information about *author/source/institution:*

<u>Google feature</u>:		***<u>Academic Database feature</u>:***
Summary	*------ equates to -----*	*Abstract*
URL	*------ equates to -----*	*Author/source/institution*

Why: reasoning about selection

Utterances indicated that *evaluation for selection* was more complex than simply inspecting this combination of results features, engaging additional information such as prior knowledge, awareness of purpose, and expectation in making selections. Entries in search results list were evaluated with respect to *topicality*, *origin* and *authorship*, as well as other factors. Essentially, the source's usefulness or worthiness was judged on the basis of the surrogate's features.

<u>Topicality</u>

Topicality is a subjective relevance judgment, which is often expressed in such as "of interest", "on topic", "keyword matches", and "relevant/not relevant". Examples of utterances describing topicality are listed in Table 4.4.

<u>Source origin and authorship</u>

The origin of the source (e.g., a named academic institution), or where it was published (e.g., name of journal or conference), contributed to assessments of the source's worthiness; for example:

- the author was known within the discipline or community:

> *"The process of picking a paper to read, it does not have to be Quantum Computing - it could be anything, is relatively complicated. It's a decision based on who wrote it, first, second and third author decisions there. If it is a journal paper or something more complicated … if I don't know anything about them … net Citeseer is great for that - can pick up what the community thinks of a paper …"* *p1-L3, 11.33*

- the site of origin was known for its good research reputation:

> *"… I normally look at the site where it comes from. For example this is the University of xxx. They do lots of research in xxx, so I know already that this is very good stuff that I can use. So if I go here [choose this link] I am sure it is a research paper."* *p1-L1, 18.06*

- the conference or journal was recognised for its status:

> *"And what I also look out for sometimes is a link to the URL, [looking at example] If I look at this, I see that it is an xxx Conference, … so that looks good" …[12.30] " But in the general case, where I don't have any idea about a paper, what I do is use the link to give me an indication e.g. if it is ACM.org / blabla, then I know that it has peer reviewed"* *p2-L2, 15.04*

Sources that originated from a commercial source such as a computing magazine were typically dismissed, although this varied dependant on their research task; for example, sources from commercial organisations proved useful to one participant for their e-commerce related research *(p2-L3, 57.54)*.

Indicators of Topicality:	**Example:**	**p-ID:**
"of interest"	*"OK so I have found this thing 'xxxx'. Sounds interesting."* *"An xxx - this is description of what an xxx is, so that would be something **of interest** for me to know."*	*p3-L2, 20.38* *p2-L3 18.20*
"on-topic"	*"So it has 2 main ideas …so it should be **related with my topic.**"* *"OK, that looks a reasonable starting point – so click on there … it was the title, **on topic** and I was happy with the journal and the author…"* *" … or another one, like this xxx which is not on-topic for me…"*	*p2-L1, 14.20* *p3-L1,18.13* *p3-L2 50.52*
"keyword matches"	*"So I will be looking at anything that is talking about xxx [matching keywords]"* *"Each of these titles have keywords related with the keywords of my study"*	*p1-L1 29.20* *p2-L1, 09.40*
"relevant/not relevant"	*"I stop there and read further to see if it is **relevant** for what I am looking for"*	*p2-L2 05.29*

Table 4.4 Indicators of *topicality*

Other influences

The file type of the source was remarked on repeatedly as influencing participants' selection decisions. The file types specifically mentioned were *.pdf*, *.html*, and *.ppt* files. Both positive and negative remarks were associated with all types. For example:

- ***.html** files* were considered good for easy/fast loading but poor for layout/formatting (e.g., *p3-L2, 30.04);*
- ***.pdf*** files conveyed 'previous publication' (*p1-L3, 37.47*) but occasionally caused technical difficulties for access (*p3-L3, 52.31*);
- **.ppt** files (i.e., *Microsoft PowerPoint* presentations) were thought both 'useful' as a summary/report of a presentation (e.g., *p2-L1, 38.52*), but 'not useful' in as much as the interaction was missing (e.g., *p1-L1, 29.40)*.

Other factors were also reported as influential in their selection process; examples are presented in Table 4.5.

Influence examples:	**Associated p-ID:**
multiples of sources raised concerns about integrity, for example multiple formats, locations	*p3-L2, 50.30*
avoid/dislike search result entries with no obvious link	*p1-L2, 18.30;* *p3-L2, 17.09*
currency was an important consideration	*p3-L1, 35.42*
citation status within the community	*p1-L3, 13.00*
poor structure and spelling was a negative influence	*p1-L3, 13.40*
negative influence where URL indicates commercial, e.g., ".com" or "not serious" type of site	*p2-L3, 16.16;* *p3-L3, 05.57*

Table 4.5 Factors reported as influential in the selection process

4.7.2.1.1 Cues for further searches from evaluation for selection

New searches were typically activated during *selection* evaluation because the current returned results set had been used/exhausted. Another common reason was that the returned set of sources proved to be 'off-topic', suggested that a different set of query keywords was needed:

> *"... So at this point I am in trouble; let's come back to search terms; instead say: 'How do I start at the beginning?' ... Let's go for something that will lead me into it. Let's try xxx Survey."*
>
> *p1-L3, 37.47*

The type of task influenced the number of pages of returned results that some participants might be prepared to scan (e.g., *p3-L1, 28.94*). Although participants scanned through a few pages of search results under observation, associated utterances indicated that they typically limited the number of pages of results they were prepared to scan/browse before they decided to reformulate or enter another query:

- five were prepared to scan/browse five or fewer results pages before undertaking another search;
- two were prepared to scan/browse up to 10 pages of results *(p1-L2* and *p1-L3);*
- one was prepared to scan/browse up to 18 pages of academic database results pages *(p3-L1);*
- one was prepared to scan/browse an unlimited number of pages of results *(p1-L1).*

4.7.2.2 Information interaction strategies associated with *evaluation for utility*

Utility evaluation typically occurred at the first interaction with the actual information source, which would have been selected from the search engine results lists as discussed in a previous section (4.7.2.1). Strategies in this category were concerned with determining if the actual source had enough useful content to be worth storing and/or printing for further examination. A variety of strategies were deployed. Characteristically *utility* evaluation was executed as a screen-based examination of selected sections of the source, seeking relevant content. For example, the *Abstract* might be scanned for its conceptual content; sections of the source might be scanned for methodology or findings. As a result, a range of concepts might be recognised within a source and conceptual connections might be made between sources. The task in-hand invariably helped to shape the focus of this evaluation; in addition, sources were sometimes chosen in anticipation of future or anticipated tasks as well as current needs. Other features such as authorship and references/citations were also significant to this *utility* decision. Sources were discarded when they did not fulfil selection expectations.

4.7.2.2.1 Basis for utility decisions: scanning strategies

A source was not necessarily read as a whole; instead, sections of the source were inspected, e.g., 'Abstract', source attributes such as 'author', 'bibliography/refere*nces'*. These are collectively referred to as the source 'elements'. Typically, combinations of these 'elements' were inspected in order to gather sufficient information about the source to judge its *utility* for the task. Reading selected source 'elements' was often considered sufficient to make a quick decision about the usefulness of a source; however, utterances indicated that participants were prepared to invest effort to ensure that they made a sound decision about a source's potential usefulness.

Eight discrete 'elements' were inspected or identified for inspection, as set out in Table 4.6; however, only the 'Abstract' was common across all participants. The 'Abstract' was generally considered reliable and sometimes sufficient in itself to make a judgment about the utility of the source. Although there was no discernable pattern to the ordering or the importance of the other seven 'elements', the relative significance of each is suggested by the number of unique inspections or mentions.

Source 'elements':	**Number of unique mentions by participants:**
Abstract	9
Author/ Institution/ Publication	3/1/3
Introduction	4
Conclusion	4
Existence of Keywords (content)	3
Bibliography/references	3
Presentation/structure	2
Language	1

Table 4.6 Source 'elements' inspected for *utility* evaluation

The list of citations or references was occasionally checked for usefulness, even if the source itself was not judged to be of use (e.g., *p3-L2, 28.24*). Poor presentation or structure suggested poor quality and could be a reason to halt the evaluation (e.g. *p1-L3, 14.27; p3-L1, 52.44*).

Whilst a selective inspection strategy was generally adopted, participants were prepared to put in the effort needed to ensure a sound decision about a source's potential usefulness:

> *"... I would rather spend qualitative time to read the Abstract* ***three*** *times, than read it quickly and then lose time reading the whole paper and then after words say 'this is not very useful' "*
>
> *p2-L3, 1.04.21.*

In contrast, another participant was confident about their previous selection decision based on the results lists, and decided not to conduct a *utility* evaluation (p2-L1, 08.00).

Task influence

The search task clearly influenced behaviour. For example, where the observed search was part of a broader task such as a project literature review, the source content was evaluated with respect to multiple factors, whereas for more specific tasks, such as a search for a specific methodology, the evaluation was more focused and selective.

> *"Where it is a different task or different issue and I were doing this search for the first time, or looking at this area for the first time in which case I would want to survey as many different sources as possible and explore as many different avenues as I could … Whereas in this task that I am doing now probably more selective. How substantial is the state-of-the-art, how good is the stuff out there already?…"* *p3-L2, 47.00*

Task also affects how much of a source they actually inspect when making utility decisions:

> *In the first year1 stage of my research, … I had to read the whole thing, tried to digest the methodology and see what contribution they had. But now what I do is I just read the abstract, quickly go through the various sections … Sometimes what I do is that I look at some references that they would have provided."* *p2-L2, 28.01*

One participant was only interested in how the key concepts were argued, as their task was to find corroboration for their own thesis:

> *"So specifically what I would be looking for is hard reputations or hard support. Stuff in the middle is of interest but not for chapter 6! … for example … So I'd like to read this [***found***] to balance his views"* *p1-L3, 57.10*

A located source might not match the task-in-hand needs, but might still be judged useful for a known future task:

> *"So I'll also be keeping my eyes open on these other relevant subjects. Like when I am looking for, searching for particular key words, for particular subject area of the research … I am also keeping my eyes open."* *p1-L1 36.55*

> *" This is in the interesting category and will get filed away, as it isn't part of my search at the moment."* *p3-L1 21.20*

Authoritativeness influence

Seven of the nine participants considered the authoritativeness of the source, as evidence by Author/ Institution/ Publication. This was evident across all task types and levels of PhD experience:

> *"The other thing I look for is this [pointing to bottom of page] 'Has it been published?' … as much as possible I want to read something that has been published in journals …Where has it been published or this guy gets up one morning and puts it on the web!"* *p1-L1, 23.24*

> *"OK there might be 10 instances … but they are all in insignificant sources or not in a peer review journal, and I'd want to be able to cite related work in important sources… at this point I'd make decisions based on those cues rather than just noting what they are saying."* *p3-L2, 49.0*

> *"OK the question now is where is it published? or is it published?"* *p1-L3, 42.15*

This indicates the relative importance of this authoritativeness on *utility*; it was also evident as an influence in previous *selection* decisions.

Concepts perceived within the located source: examples

Participant's scanned or read their preferred source elements such as 'Abstract' to determine whether one or more concepts explored within the source were relevant, usable or useful:

> *"So it is basically about content now. Whether it exactly fits what I am looking for…" p1-L1, 36.55*

From this activity across all participants, three key threads emerged: 'methodology', 'treatment of keyword concepts' and 'conceptual argument'. These are illustrated in Table 4.7.

These concepts were being judged in terms of utility, quality and importance, as well as relevance; the emphasis was on how the content could be used/useful:

> *"Every time I look at something I am thinking "how important is it to my work"* *p1-L2, 22.59*

Critical to these judgments is the recognition of the original context of the source itself:

> *"… sometimes you have to read between the lines as to what is the context, where are they coming from"* *p3-L1, 50.48*

> *" …again I'll start reading through the Introduction; it is hopefully giving me a bit more of the context …"* *p3-L1, 54.56*

Utterances suggested that connections were being made at this initial point-of-contact with the source. Connections were identified with their own and other work. Participants attended to the use of terminology and methodology, in order to help them position their own work within the community (*p2-L3, 55.06)*.

Example of Concept:	Supporting statement:	p-ID:
methodology	*"What problem are they solving, what is their approach, if their problem is close to my problem it might be useful … but first I would like to know which approach"*	*p2-L1, 19.18*
	"so what is it? Mentally fitting it in the picture; how have they done it? What sort of methods"	*p3-L1, 50.02*
	"So that kind of gives me the power to my justification in my work; …someone who has done research … and says yes it is really important to … So that kind of gives more validity to what I am trying to show as my rational of my work"	*p3-L3, 31.47*
treatment of keyword concepts	*"Again what I did with the journal, checking if I can position myself in this literature if I can recognise where am I , if the words I am using … so I can check if I am using the right words"*	*p2-L3, 55.06*
	"I was looking for quotes that would have the Word 'xxx' in it - because I am interested in xyz … So when I found …, then it talks about how the eye reflects what is in our mind"	*p3-L3,10.36*
conceptual argument	*"This is slightly different, I am looking for a paper by a reputable author, in a reputable venue that supports the claim that I am trying to make".*	*p1-L3, 16.21*
	"… whereas the what and the how I am quite interested in and then their conclusions i.e. what is there argument"	*p3-L1, 50.32*
	"I am looking [at the Abstract] to see the match between the questions that they are answering and the kind of questions I am asking in my research"	*p3-L2, 21.54*

Table 4.7 Examples of concept types associated with p-ID

4.7.2.2.2 Extracting from located sources

During *evaluation for utility*, participants occasionally extracted detail from the located source; in the main these were citation details:

"… whenever I get a paper the first thing I do is save a copy and put details into EndNote"
p1-L3, 46.24

Bibliographic tools such as *EndNote* were seen as the preferred tool for citation representation purposes, but *Copernic* was deployed in one case (*p1-L3, 1.00.38*), and Adobe reader was used for making brief annotations on the source (*p1-L3, 1.02.32*).

Less common extractions included taking a copy of the *Abstract* and storing it alongside the citation, and extracting references to use in further searches (e.g., *p2-L1, 30.49). Bookmarks* or *Favourites* were used (e.g., *p3-L1, 04.08*), but another judged them problematic when switching between computers and places of work (*p2-L3, 57.15*).

Screen versus paper preferences

Under observation, all nine participants interacted with the actual source at the screen interface; and questionnaire responses confirmed their preference for evaluating for utility at the screen, with eight out of nine reporting that they '*often'* or '*almost always*' did so. Only one, *p2-L2,* indicated some preference for paper versions of sources at this stage*,* responding that they '*sometimes'* made *utility* judgments whilst interacting with the source at the screen interface but *'almost always'* preferred to do so using a printout.

4.7.2.2.3 Cues for further searches from evaluation for utility

Single sources or batches of sources might be evaluated at this stage. The default cue for a new search was the completion of this *evaluation for utility* activity; a new search might be undertaken if further information sources were needed, although it might not be executed immediately. Other reasons for further/new searches being initiated included:

- something within the source, e.g., author/conference, keywords, reference, etc., proved interesting enough to be followed through with a further search (*p3-L1, 45.33*);
- the source was no longer relevant and was discarded:

"… if it is not too relevant then I just discard it" *p2-L2, 09.44*

At this stage an information source might be discarded for a number of reasons. For example, it might not live up to expectations:

"There a few criteria which really turn me off something … One is when they have a really good title and then turned off by paper … because … they either have a different or rubbish definition of what they claim to be investigating. … [or] *p3-L2, 22.34*

"Another one would be if they claimed a really big space to be addressed or answering a really important big question and then they do things very specific without telling a good enough story."
p3-L2, 22.39

Another strategy adopted was to look at random chunks of source text in order to eliminate sources which had a poor writing style:

"... I would find the couple of paragraphs that had those words in them. I understand that jumping into the middle of a paper may not make sense, but if the style is absolutely disgusting then it is going to take a lot more to make me read it. I don't have enough time to go through somebody's poor writing".
p1-L3, 14.27

4.7.2.3 Information interaction strategies associated with *evaluation for personal fit*

Evaluation for personal fit is the second of two categories identified within *evaluation for use* (Figure 4.4). In *personal fit* evaluation, the user interacts with the actual information source, usually repeatedly in order to answer the question: **'**Is the information what I *want* to *use'***?** These strategies are concerned with digesting the source content in order to determine what the content offers and, importantly, how it fits with their perceived task-needs.

The source under consideration would have already been judged for *utility*. The concepts identified at the *personal fit* stage might differ from those that informed the previous *utility* decision. There is a noticeable media switch for this *personal fit* activity. These interactions are normally paper-based; they are seen as the first in-depth reading of the actual source document and might involve repeated reading. Some external representations emerge, and although considerable effort might have been invested by this stage, a source might still be discarded.

4.7.2.3.1 Basis for personal fit decisions: reading strategies

One objective of *personal fit* interactions is to conduct an in-depth examination of the source to evaluate, more precisely, what conceptual or verbatim extractions it offers, and how these might fit the participant's perceived needs:

"I sort of scan first looking out for highlights, … then think 'Does it relate to the question?', go back and read it in more detail, picking things out …" *p3-L1, 48.05*

Their reading strategies were variously described as:

- 'in detail' (*p1-L1 35.32*),
- with more scrutiny (*p2-L2, 25.52*),
- in 'more detail' *(p3-L1, 48.05*),
- looking for 'deep learning' (*p1-L2, 52.15*),
- 'goal directed'… I am reading to know something to write *(p1-L3, 1.07.44*).

What was read varied between the complete source document (e.g., *p1-L1, 40.49*) and selected sections (e.g., *p2-L2, 28.24*), and this could vary on any subsequent reads (*p1-L1, 57.03*). Indeed, some participants indicated that they might adopt both approaches, scanning sections first and then going back to read in detail (e.g., *p3-L1, 48.0*).

More often than not, reading generated some form of external representations, whether on-source or off-source. However, representing their developing understanding is a labour-intensive activity and has to be worthwhile:

"I never read in detail until I am sure it is worth it. Because I have read a couple of things, and I made these summary … it takes a lot of time to make this one-page summary … So I try to just read the things that are very related very close, has good findings" *p2-L1, 41.46.*

An overall preference was expressed for paper-based sources at this stage of the process. The reasons for this preference included the flexibility of using a paper-source in terms of being able to readily move around the source for the more in-depth reading (*p3-L1, 1.06.35*). Paper supported their own emergent external representations, readily allowing annotations and notes:

"When I am reading in detail, like those 25, I read only from paper because when I read detail I like to do margin notes" *p2-L1, 23.49*

Only one participant stated a preference to always work with screen-based sources, based on their personal dislike of managing volumes of paperwork; this participant also used *Abobe Reader-writer* tools for note-taking (*p1-L3*).

Task influences

'*Task'* influenced reading strategies. For example, if a concept needed to be understood in the broader context of a literature review, then the source might be read more than once; whereas, for a more focused task such as supporting an argument, the participant might restrict reading to only certain key sections of the source for contribution:

> *"The first year of my research, I had to read the whole thing, tried to digest the methodology and see what contribution they had. But now I just read the Abstract."* *p2-L2, 28.01*

The task can also influence the number of sources read: a broad task might involve reading many sources, whereas a more focused task might involve scanning a reduced batch of sources:

> *"It depends on where I was, on the precise nature of what I was trying to achieve. With this search, it is an area which I am fairly comfortable with … And where it is a different task or different issue and I were doing this search for the first time, or looking at this area for the first time in which case I would want to survey as many different sources as possible and explore as many different avenues as I could"* *p3-L2, 46.32*

> *"But if I have a keyword search results, … for instance for a literature review when I had to compare a lot. Now I just tend to get 3 papers and read them and think this is enough for now … but then I had to do massive amount, so then what I did was print all of the first pages with the Abstracts…"* *p2-L3, 1.05.28*

Reading batches of paper sources

Participants generally read paper sources for *personal fit* decisions in batches:

> *"I tend to get a big stack [of papers] together that I know that I am going to read, which I carry around in my bag."* *p3-L2, 55.00*

> *"… so once I see them [6-10] piling up on my desk I stop; that is for me the check the point where I say OK enough - that is it."* *p3-L3, 48.32*

> *"… I'll collect several. I have a time for searching and a time for reading. I will collect several and then sit down and start browsing through them to see if there is anything I can take which is useful."* *p1-L1, 35.40*

This preference was corroborated by their questionnaire responses. The reported time delay between *utility* judgments about a source and actually reading it for *personal fit*, seemed to vary, dependant on task deadlines, preferred style of working, etc..

Organising sources pre-reading

Several participants explained the strategies they used to organise or group paper sources to help them prioritise their reading. A number of example approaches were identified, for example:

- clustering papers based on the 'Abstract', and then prioritising the reading order for the groups (*p2-L3, 1.05.41*);
- arranging into three piles, namely '*now*', '*supporting work'* and '*peripheral/wider reading'* piles, according to the perceived importance of the source in relation to their own research (*p1-L2, 23.02*);
- a classification system based on *faces* allocated against sources during *utility* judgments, based on the *Abstract* held in a bibliographic store from (*p2-L1*). This system helped prioritise the reading:

  a *sad* face signalled that the source was too detailed and should be read later,
  an *attention* face indicated that the source had to be kept 'in sight',
  and a *happy* face indicated that the paper was to be read.

Organising sources after reading

Two participants reported that the understanding gained from iterative reading allowed them to categorise their sources after reading:

- one reported a sophisticated strategy, whereby sources were categorised into a series of themes within subjects, and the categories were adjusted to suit the dimensions of the research itself:

  > *" ... after reading several papers ... I think, 'Are all talking about a similar theme?', then I ... categorise that as subject area within the subject. And I also do it based on my dimensions of my research."* *p1-L1, 45.20*

- a second case reported a simpler, two-level classification:

  > *"Once I read them, then I classify them in what I call the peripheral and the focused"*
  > *p3-L3, 48.44*

4.7.2.3.2 External representation strategies

External representations emerged during these more intense *personal fit* evaluations. Different strategies for expressing both on-source and off-source representations were reported. Many used a combination of representations; for example, *p1-L1* used on-source underline, highlighter, margin notes, and off-source hand-written and electronically-generated structures. Various representations were recalled by participants, and evidence of these artefacts was gathered post-observation.

All participants, at some stage, store some aspect of their notes in a bibliographic tool such as *EndNote*. They perceive such tools as a single storage point for organization and access. Participants both transferred their notes from elsewhere into *EndNote*, and took notes directly into *EndNote* (e.g., *p3-L1*, *p1-L3)*.

Representation is seen as an ongoing practice, and only examples of representations emergent during, and reflective of, *personal fit* activities are detailed here. Other examples of representations which might be enhancements of initial artefacts emergent at this stage, are left aside until the later discussion within *Use* strategies, but it is recognised that there is no clear division between what can be classified as *personal fit* and subsequent *Use* representation strategies.

On-source representations and associated strategies

Marking the source promoted a better understanding whilst reading (*p2-L1, p1-L2, p3-L2)*. All types of common on-source representations were seen to be widely deployed during *personal fit* interactions. Different representations appeared to serve different purposes, for example:

- highlight/underline were typically used to capture significant points, ideas, concepts and sometimes act as an aide memoir for later recall;
- margin notes often expressed participants' own interpretation of content, and captured connections with the participant's own and other authors' work;
- hand-written front-page notes could contain a very brief summary, opinions of the paper, and useful references, as well as citation details for later usage of the source.

Types of representations and their purposes are summarised in Table 4.8.

Type of representation:	**Purpose:**
Highlighter, underline, pencil marks	- important points, - keywords, - preparation to build other notes, - make connections, - memory aids, - easy re-locate later;
Margin notes (paper and electronic)	- make associations, - reinforce ideas, - own interpretation, reminder/alert;
Front page summary notes	- summary of significant aspects, - tracking citation and filing details

Table 4.8 On-source representations and the purposes to which they were put

Both manual and electronic tools were deployed to generate the on-source emergent external representations. For example,

- seven out of nine participants marked the paper source in some way, e.g., underscore, highlighter, margin notes, keywords. Of these, only one preferred to mark electronically; this was consistent with their preference for reading from electronic sources (*p1-L3*). All others expressed a preference for pen-and-paper;
- the two other participants expressed a strong preference to keep the source pristine, either for sharing with others (*p3-L3*), or because markings were distracting when reading *(p3-L1)*.

<u>Off-source representations and associated strategies</u>

During *personal fit* interactions, off-source representations were less common; only two types were reported: descriptive notes and bullet-point notes. Each had a purpose: the former to describe the source contents in the participant's own words, and the latter to note the key/relevant points. Table 4.9 offers an overview.

Type of representation:	Purpose:	Example p-ID
Descriptive notes, hand-written and electronic formats	- Description of source on initial read, - Capturing relevant points, questions arising, etc.	- *p1-L1, 41.38* - *p2-L3, 1.07.42*
Bullet points, hand-written and electronic formats	- Capturing important points	- *p2-L2, 33.32* - *p3-L1, 1.08.54*

Table 4.9 Examples and reasons for *off-source* external representations

Examples (collected post-observation) varied in terms of content and structure, reflecting personal preferences, particularly in the case of hand-written notes.

Both pen and paper and electronic medium were used for representation. At this stage, two used only electronic means for representations of the source *(p3-L1, p1-L3*), two used only pen and paper annotations *(p3-L2 and p3-L3)* and the remaining five participants used a mix of both. The most common reason for paper-based representation was portability, whereas the most common reason for electronic notes was search and retrieve facilities. Other reasons for chosen medium included:

- hand-written notes support better memory/recall (*p1-L1, 43.29*).
- notes in *EndNote* allow for everything kept in one place for easier administration (*p3-L1);*
- *word* documents provide easy re-access and copy-and-paste facilities for later use (*p1-L1, p2-L3);*
- mobile phone text alerts are useful for reminders in the near future *(p2-L2, 36.01)*.

<u>**Verbatim physical extractions from located sources**</u>

If not already extracted, citation details and 'Abstracts' are often extracted and stored at this point during *personal fit* evaluation *(e.g., p1-L1, p2-L1, p3-L2),* although at least one participant (*p1-L2*) expressed a preference to re-write the Abstract in their own words. Other chunks of text that could be extracted for future use included quotations:

> *"The only thing that I extract is the Abstract … into EndNote, but I don't normally for any other text; I just read it and try to present it in my note form. Also if someone has said something really exciting then I can pick that as a quote - but only of really classic quote."* *p1-L1, 51.27*

The most common tool for this purpose is *EndNote*. However, it is more likely that quotations will be extracted at the *Use* stage (4.7.3).

Representation influences

The contents of the representation are, in some instances, influenced by the authority of the source. For example, it was thought important to ensure that representations were very clear if the source was known to be from a good and trustworthy origin:

> *" … sometimes there are authors that you trust but there are also authors which you don't really trust … So the note taking is influenced by the people authoring the paper, where is it coming from? Which genre is it coming from? Which conference is it coming from? So if I am reading a paper from a very good conference or very good journal, then I make sure I take as clear notes so that I understand each and everything that they are trying to say. Because I am sure that it has come through lots of people"* *p1-L1, 49.26*

'Good quality' sources need more comprehensive notes (*p3-L1, 1.08.54*).

4.7.2.3.3 Cues for further searches from personal fit evaluation

There are several reasons why a new search could be initiated at this stage in the process, although new searches were less common than in previous phases. Triggers include a new or related concept or keyword(s) and new authors/references:

> *"… if a paper mentions something and …. I think it is very important, then I am going to follow that reference. … and I am going to start my search again to look for that paper …"* *p1-L1, 47.09*

The source might have raised questions concerning existing knowledge:

> *"On the other hand there might be something that I read but could not understand technically that would cause me to go away and look for more background understanding"* *p3-L2, 1.11.05*

Alternatively, a source might raise questions that it does not address, provoking a new search to find authors who do address these questions:

> *"…if I have read a paper and I find so many open issues that the paper has not addressed, so I start looking… So directed by open issues that may come from the previous papers…"* *p1-L1, 58.00*

4.7.2.4 Discussion: information interaction strategies associated with *evaluation*

Much of the literature on evaluation behaviour reports on the range of criteria and influences on users' relevance judgments. The definition of what exactly constitutes *subjective relevance* has been often debated. For example, Mizzaro (1998) argued relevance was a poorly understood concept and proposed a relevance pool of many kinds of relevance including topicality and utility. Others have investigated relevance criteria or influences: one example is Tang et al. (2001) who found *topicality* to be an important criterion for relevance judgments across the seeking process. Tombros et al. (2005) suggests there are two main views of relevance, namely, *topicality*, and *user-utility*.

In this Study, evaluation proved to be a complex and multi-faceted activity, with three recognisable sub-processes clearly evident, namely *evaluation for selection*, *evaluation for utility* and *evaluation for personal fit*, each with its own purpose and characteristics (and each discussed in the sections that follow). *Evaluation for personal fit* is not distinguished by earlier studies.

The literature describes two key evaluation points in the information seeking process:
1. *selection* decisions based on the lists of returned search results, and
2. decisions about the *usefulness* of the source, based on judgments about the source document or webpage itself.

Many investigations have concentrated on only one phase of this evaluation process, e.g., Ivory et al. (2004) investigated selection, whilst others have investigated across both selection and evaluations of usefulness, e.g., Wang et al. (1998, 1999), Tang and Solomon 2001, Rieh 2002.

In this Study, there was no common pattern across *evaluation* as a whole and behaviour patterns evident within each sub-group are discussed later in this section. Influences on decisions changed, for example, as evaluation progressed, topicality-based *selection* decisions changed to judgements about the usefulness and quality of the concepts stated within the located source. On the other hand, a few influences remained important across the process; for example, task played a significant role across *evaluation*, influencing:

- how many pages of search results were scanned (*selection*);
- the volume of the sources retained for current and/or future use (*utility*);
- how selectively the source was read and how many sources were read (*personal fit*);

Similarly, authoritativeness played a role throughout *evaluation*. It was influential in the *selection* and *utility* judgments, as in the quality of the representations produced during *personal fit* evaluation. During the *personal fit* phase, utterances concerning how participants used their off-source and on-source representations suggested what was important about the source: concepts contained, connections with own and other work, etc.

The task influence, as evident in this Study, has also been reported by researchers such as Vakkari (1999). Their findings examined the changes in relevance judgments at different stages of the task. A few recent studies have examined particular facets of relevance judgments in a web-based context, which makes them suitable for comparison to this Study's findings, as summarised in Figure 4.3.

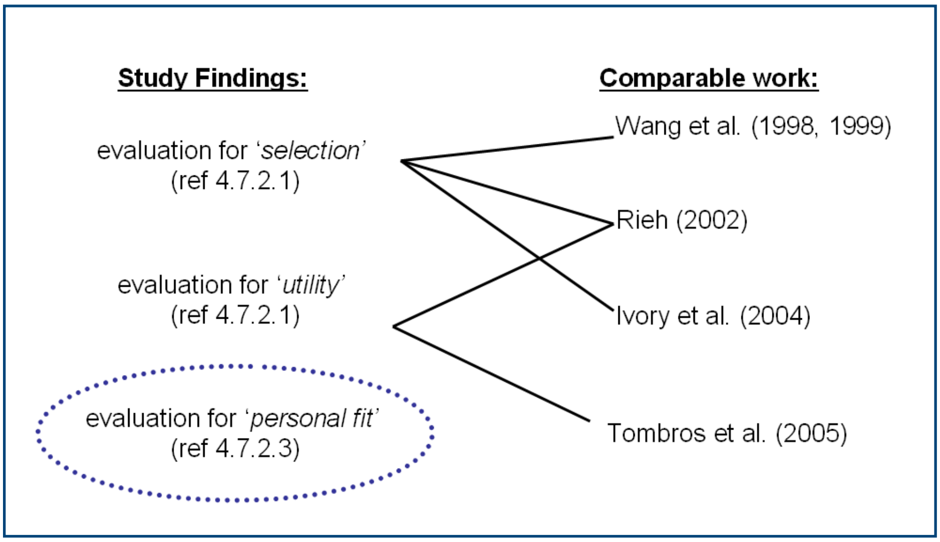

Figure 4.3 Study findings on *evaluation* mapped to related literature

Some verbatim citation details were extracted during *utility* evaluation, although users' own external representations were not evident until the *personal fit* phase of evaluation. The primary purpose of external representations was to capture the user's understanding and interpretation of the source before it was used. Despite the user effort into *evaluation*, sources were discarded at any stage if deemed unsuitable for whatever reason, whether off-topic, not fulfilling expectations, lacking authority, etc.

<u>Discussion: *evaluation for selection*</u>

The prime focus for *selection* was the search engine results lists, in whatever format. Interestingly, during *selection* activities, participants scanned/browsed multiple pages of results to filter for sources which had high academic authority. Given that most participants preferred to use a general search engine to return a broad range of results (4.7.1), this level of filtering would appear to be a duplication of the automatic filtering they could achieve via the use of an academic database search engine; this indicates that this group of experienced information processors were prepared to apply effort to gain the broadest range of results returned and suggests they were particularly confident in their query keywords and their ability to search and evaluate/filter pages of results.

The reliance on subject and domain knowledge during *evaluation for selection* was also evident in other studies (e.g., Rieh 2002).

The three key features of the search results actually inspected during observation, namely *Title*, *Text* summary and *URL*, were consistent with participants' reported typical practice. They also corresponded to those used initially by participants in Ivory et al. (2004) study. This is not surprising given the limited features of a result entry returned by general search engines. Both Wang et al.'s and Rieh's criteria lists for selection were more comprehensive and of a different granularity to those identified in this Study, but the results are broadly consistent. *Title* was explicit in both. 'S*ummary text'* is broadly equivalent to *Abstract,* and *ToC* (DIEs, Wang) is broadly equivalent to *Content* of information object (Rieh). *URL* is explicit in Rieh's findings, although Wang et al. talk of a 'geographic location'.

Participants appeared to consider a combination of influencing factors, with *topicality* and *source origin/authorship* being two of the most significant, whilst making selection decisions as to the potential worthiness of the source based on the surrogate information held in the search-result-entry. These two criteria were both recognised as influential by participants in Wang et al.'s and Rieh's work.

Other contributing influences were also broadly consistent with Wang et al. and Rieh. For example, utterances about 'structure and spelling' resonate with Wang et al.'s findings about 'quality' and Rieh's mention of 'presentation'; availability of types of file formats such as *html*, *pdf* etc., echo Wang et al.'s mention of 'availability'; and currency (based on date) was also consistent with Wang et al..

Discussion: *evaluation for utility*

Evaluation for utility is the first interaction with the actual located source, typically at the screen. It is concerned with asking 'is this information source of use?'. The source was judged primarily on its conceptual content:

> *'methodology', 'treatment of keyword concepts', and 'conceptual argument'.*

Typically, located sources were scan-read rather than subjected to any in-depth reading, and more often than not, only selected sections or elements of the source, such as the *Abstract,* were read to inform this *utility* decision. This suggested minimised effort for maximum gain, although participants were prepared to apply more effort when necessary. The source's authoritativeness was an important influence on the *utility* decision – as it was for *selection* decisions. This is consistent with Rieh (2002),who investigated the information 'quality' and 'cognitive authority' of *evaluative* judgments which are seen to be akin to this Study's *utility* evaluation behaviours, and with Tombros et al. (2005), who specifically investigated 'utility' judgments.

The document features used to decide document *utility* in this Study are consistent with, although fewer than, those identified in other studies. '*Text*', '*Structure'* and '*Quality'* coincide with three of the five categories of features identified by Tombros et al. (2005). Rieh (2002) identified six categories of criteria for evaluative judgment of 'quality' and 'cognitive authority', of which two were in evidence in this Study: characteristics of the sources, and characteristics about the source, e.g., where it comes from. The comparison between studies is summarised in Table 4.10.

Topicality was no longer apparent as a criterion at this stage; instead, decisions were influenced by the quality, importance and general usefulness of the source content. The nature of the task influenced behaviours. Extraction of citation details into bibliographic software appeared to be the only extraction from located sources at this stage of the seeking process. Despite the increased effort needed to *evaluate for utility*, sources could still be discarded at this stage, should the content not prove useful.

Abraham (thesis, 4.7.2.2.1)	**Tombros et al. (2005)**	**Rieh (2002)**
The located source content was wholly or selectively inspected, e.g., Abstract, existence of keywords, etc.. to offer clues about its *utility;*	The located Text with several named features was found to be the most valuable for *utility* decisions;	Located source content was explicitly identified as one criteria to inform their *evaluative* judgment;
The presentation/structure was identified as significant to any such decision;	Structure was identified as the second most important category of features to influence utility;	Organisation/structure and presentation of information objects were recognised criteria;
Authoritativeness, e.g., author/institution/publication was an important factor in utility judgments.	Authority and source origins etc., were features contributing to overall Quality.	Type of source, author/creator credentials and type of source were all criteria that were identified as important for judgments about the source.

Table 4.10 Comparison of three main document features referenced with respect to *utility* judgments

Discussion: *evaluation for personal fit*

There was a clear demarcation between *utility* and *personal fit* evaluation; *personal fit* was a more intense, in-depth paper-based activity focused on answering the question **'**Is the information what I want to use?*'***.** The purpose of these interactions was to identify concepts or verbatim material that could be usable for the participants' needs. The activity might involve iterative readings of the paper source. These *personal fit* activities were not observed, instead recalled as typical; pre-questionnaire responses and relevant artefacts gathered post-observation were used to validate and support where possible. This provided a rich picture of the facets of reading and representation strategies used in *personal fit* judgements.

Information interactions to do with *evaluation for personal fit* (4.7.2.3) are not known to be addressed elsewhere as a distinct phase of the evaluation process. Participant comments regarding the purpose of their external representations offer some indication that sources were identified for the concepts they contained and for the connections the source made to their own and others' research.

The demarcation between interaction strategies concerning *evaluation for personal fit* and those for *Use* (reported below) is not strict. The two are distinguished by evidence of a recognisably different purpose, the former to do with evaluating the potential and desirability for use, and the latter to do with actually making use of the material, but it is acknowledged that the behaviours are not strictly distinct. For example, making connections to other sources may begin during *evaluation for personal fit*, and continue during *Use*. Similarly, representations made for *personal fit* are also made during *Use*. In both cases, the effort devoted to the representation was influenced by the perceived quality of the source. Despite the acknowledged 'fuzziness', the distinction is useful in drawing attention to the shift of purpose and hence to understanding the behaviours observed. Hence it is maintained throughout this research.

4.7.3 Information Interaction Strategies Associated with *Use*

Strategies in the *Use* category were concerned with deciding 'how to best use' the located information for the participants' own purposes. *Use* strategies were concerned with interpreting, extracting, organising and integrating the found information into a body of knowledge. Participants made sense of located sources using a mix of iterative strategies, typically involving higher order skills such as analysis and synthesis. Reading and representation (including writing) strategies were two *Use* strategies common across all participants. For the purposes of this Study, writing strategies are treated as examples of representation strategies, i.e., drafting outputs such as notes or narratives is considered to be representation of material. Both paper and electronic tools (e.g., *Word*), were deployed for extraction and representation.

The demarcation for the *Use* category was evidenced by participants':

- claimed shifts in understanding;
- trend towards multiple source interactions e.g., comparisons across sources;
- integration of new-found information into their own body of knowledge e.g. integrating extractions into their own diagram, report, etc.;
- interactions with their own external representations.

Representations and subsequent re-representations were much in evidence during this *Use* phase. These representations were often complex (e.g., analytic concept maps) and could be influenced by both the source structure and/or the source contents. Apart from material such as quotations and citation details, content was rarely extracted verbatim. Participants interacted with both the located information sources and their own representations as interpretations of those sources.

Initial reading interactions with an actual paper-based source were identified as *personal fit* activities in this Study (4.7.2.3.1), but these *personal fit* activities might be iterative. Further, participants might identify possible extractions during this initial in-depth reading, although not necessarily use them immediately. This boundary between *personal-fit* and *Use* strategies is fluid, but any strategy that indicated conceptual extraction was treated as a *Use* strategy.

The results presented in this section were derived from participants' reports of their typical *Use* behaviours; where appropriate, reported claims were corroborated via reference to questionnaire responses and to external representations gathered post-observation.

4.7.3.1 Basis for *Use* decisions: reading strategies

Participants' primary focus was deciding how to use the extracted information, i.e., to represent their own interpretation of a found concept, physical text/diagram or other material in a (developing) solution structure:

> *" ... I'd have taken all the literature in, made some sense of it myself ... and out of it would come my own interpretation ... Then I would have established my own narrative and then would factor in the bits of literature I needed to support my view to tell the story."* *p3-L2, 1.14.56*

Typically, only selected, significant or key sources identified in the evaluation phase were read at this point. Iterative reading was evident, with some source contents re-read many times over the lifespan of the task:

> *"... up to this point of my PhD, there hasn't been one single paper that I have seen only once ... it is going back again and again and again – it is endless."* *p3-L3, 49.55*

Re-reading sources numerous times was common; reasons include:

- the source is being re-read or re-checked to ensure understanding (e.g., *p1-L2, 56.25*);
- to deal with a previously-noted extract (e.g., *p3-L3, 34.47*);
- to investigate another/new conceptual extraction (e.g., *p2-L2, 51.26*).

At this stage of the process, there is more comparison across and between multiple-sources to help inform participants' *Use* decisions:

> *"First I read the paper from beginning to end, completely. Then I start ... linking it to other papers. ... if somebody says he has used the xyz for abc, ... who could have used the xyz ... and how is this approach different from the other one ..."* *p1-L1, 40.49*

"So, because I have an idea, these small ideas have collated from the publications which helped me come up with a clearer picture of what I want to do…" *p2-L2, 54.24*

Some look for connections as reassurance; for example one participant was looking for connections to determine how mainstream the source was or whether it was 'outside the norm' in their discipline:

"…if it is something of major importance, I would [look] in other resources [to] find something relevant, [to] compare … what other people say … [to see if] this paper … is standing on its own … it is like confirming that what I have read is representative of the norm" *p3-L3, 38.56*

Despite the effort expended up to this stage in the seeking process, an information source could be discarded at this point, e.g., simply because it could not be accommodated in the final representation.

" I might choose not to include it, but that would probably be for more practical reasons - like not having space or relates to some sort of side argument that I was desperate to make but could not justify doing it" *p2-L2, 1.20.53.*

Iterative reading: enhanced source value

Typically sources were read many times, driven by the participant's need to understand source concepts, because the concept is new, because their better understanding identifies a new 'need', or because of something said by another:

"I have read this (paper) maybe 8 or 9 times so; I read these in the summer but read again last week because of something my supervisor said to me." *p1-L2, 52.45*

Re-reading enhances value as they find new concepts and contributions during subsequent readings:

"Maybe initially, you are reading it for just the methodology aspect of it, but later on you saw the contributions to be interesting so you'd concentrate on the contributions or vice versa." *p2-L2, 1.04.49*

" … over time, you tend to take different things out of them" *p2-L3, 1.16.20*

"… and when I go back to the very first one that I read, I can even pick more stuff." *p1-L1, 57.50*

Similar gains resulted from comparison between sources:

" So it is like comparing the sections of the papers between them to see what added value you can get from each of them." *p3-L3, 41.15*

'Reading' their own external representations

'Reading' interactions are not confined to the source; they include reading its re-presentation in summary notes, synopsis, diagrams, etc. Such reading is often iterative:

> *"... If it is on one page of [summary] notes it will be a core reference, so I will go back to compare with all the others for reference."* *p2-L1, 47.00*

> *"If I would go back later I would first go to EndNote, to see what I wrote and there would be a few notes and then I would go to the WORD document first and then the original."* *p2-L3, 1.09.56*

Indeed representations are often intentionally drafted to help their understanding:

> *"... there are two kinds of papers that I write. The first one ... is a teaching paper. I write that because I don't understand. I am really teaching myself ... if I can compose that then I understand it."* *p1-L3, 1.08.11*
> *"A lot of what I do is go back and re-read my own papers, as those are summaries of things that I have read. ... It gives me a chain of reason as to how I got there."* *[p1-L3, 1.10.33]*

4.7.3.2 Shifts in understanding

A number of reported reading behaviours indicated some shift in participants' understanding. This could have occurred for a number of reasons, e.g., concepts previously identified during *utility* evaluation might be more comprehensively absorbed from the source material during this later in-depth reading phase. Their developing understanding was recognised and articulated in terms of:

- positioning themselves within the community;
- changing perspectives;
- making connections.

These are now discussed in turn.

Positioning within the community

Several participants reported that the source helps them to 'position themselves in the community'; this might be in terms of its arguments, citations and thematic groupings, and how these related to their own perceptions, for example,

- positioning with respect to the community discourse, including the terminology, methodology and analysis (*p2-L3, 55.06)*;

- positioning themselves in terms of support for their rationale by other researchers (*p3-L3, 35.41)*;
- positioning in terms of 'mentally fitting in the picture' (*p3-L1, 50.02)*;
- providing a firm foundation from which they can convince the community of their personal rigour and comprehensiveness (*p1-L2*, *1.10.41*).

The source citations and references play a significant role in this positioning activity (e.g., *p3-L1, p3-L2, p3-L3*).

Changing perspectives and developing arguments

Several participants reported how each iterative reading of the same source, or reading of different sources, helps develop their understanding and open up their thinking:

> *" ... my thinking changes over time; the way I was looking at it initially, may not be exactly the same way that I am going to look at it next time. Because after the first paper, it should give you an insight, which when you read the next paper, you'll understand it in more different way that you did the first one."* *p1-L1 57.03*

Their perspectives changed:

> *"I have to go back and look at it again ... or because when I read the first lines I've got a different perspective from what I have got written in my notes and it is scary."* *p3-L3, 50.03*

> *"And every time you look at this information ... you are getting added information ... and building the foundations for your work and ... feeding the development work ... because it is giving you another view of it"* *p1-L2, 1.11.10*

Each iteration brought further insight and better understanding:

> *"I might have discovered an angle or facet which I had not seen before, maybe because my knowledge or experience had increased."* *p3-L2, 1.20.20*

With better understanding, there was more clarity:

> *" ... it was providing me clarity , providing additional information but it wasn't something new that I haven't come across ever before"* *p3-L3, 35.24*

This in turn enabled them to formulate and refine their arguments:

> *"I carry whole lot around but all the time, as I am going through and formulating my arguments and refining my arguments, I am picking up the papers that support my arguments or contrast my argument are rising to the top ..."* *p3-L2, 57.10*

Making connections

Participants recalled identifying connections and associations with their own task as they iteratively read the sources:

> *" ... what I am looking for is deep learning ... trying to find connections with ... either something I know or something I want to know; that is the first thing I highlight. ... when I have found them, and I do go back over the papers, they are going to lead me to something more fine grained."*
>
> *p1-L2, 52.15*

Connections and associations were often made between and across multi-sources, for example building mental models from several sources (*p1-L1, 45.20*).

Cognitive skills descriptors

Participants' utterances indicated that higher order cognitive skills (Bloom's 1956 Taxonomy, cognitive domain) were being applied during *Use*. Sample evidence of recalled keywords is shown in Table 4.11.

Keyword:	**Example:**	**p-ID:**
Analysis	*"... that is the sort of thing I am looking for ... that is when I suppose you start to get into **cross source analysis**".*	*p3-L1, 1.13.55*
	*"So it makes sense if I did a **comparative analysis** between two case studies ...";*	*p1-L2 50.18*
	*"... after reading several papers and those papers, ..., are all talking about a similar theme, then I decide to **categorise** that as subject area within the subject. And I also do it based on my dimensions of my research"*	*p1-L1 45.20*
Synthesis	*"... in my review I end up with a model where I sort of **synthesise** ...".*	*p2-L3, 47.40*
	*"The story would very much be a result of my own **synthesis** of the research literature."*	*p3-L2, 1.16.01*

Table 4.11 Participants' example keyword descriptors of higher-order cognitive skills

These types of activities are recurrent, as participants engage iteratively with the located information and their understanding develops.

4.7.3.3 External representation strategies

Representation strategies capture their understanding and contribute towards the integration of new knowledge into existing knowledge frameworks. Emergent strategies included:

- compilation and updating lists;
- conceptual mapping using graphical representations;
- drafting/re-drafting of narratives.

Reported examples are shown in Table 4.12.

Another common representation strategy is to update or enhance existing representations which emerged either during the previous *personal fit* stage or at this *Use* stage of the process. Participants enhanced existing on-source markings/highlights. Over time, this could result in every text-line being highlighted/marked in some way; time-stamping (dating) was often used to differentiate their changing perspectives (e.g. *p2-L3, p2-L2, p3-L3).* Participants also enhanced their emergent off-source representations. Examples included highlighting their own notes (*p2-L2*, *38.21)* and using *post-its* as a means of updating existing notes and drafts (*p2-L3, 1.10.52).* Examples of representations associated with these varied strategies are discussed further in the next sub-section.

Example Strategy:	Example statement:	p-ID:
Creating structures with headings, bullet points, etc.:	*"Once I have a clear idea-ish in my head then I start writing … the only time I write … would be attempts to classify titles for my sections of the document and bullet points of what I would like it to look like."*	*p3-L3, 45.05*
	"… it is so good for me to always put in bullet points… The next stage is to add some flesh to these points …"	*p2-L2, 57.42*
	" … [It] would actually be some kind of structure … e.g., headings … and these are the headings that I am going to break it down into." [These headings are informed by] "… my synthesis… then break that down into different bits; as I broke it down into parts I might cite, annotate it … "	*p2-L2, 1.26.05*
Conceptual mapping using graphical representations	*"Idea then is convert it into a diagram so I'd worked right from the synopsis to the main paper, read it again thoroughly … Then I create a diagram which is linking the Case Study to my own work".*	*p1-L2, 42.28*
	"I have my thesis here – see chapter 7 - 'Note - a picture of a whiteboard because I wanted to erase the whiteboard. But what that means is that I am confused. Well I am still confused, because I have not been able yet to translate that into a structure, so instead I will just leave it there and one will come to me eventually."	*p1-L3, 1.14.55*
Drafting/re-drafting of narratives	*"What is it you are trying to say and how do you support those arguments and draft, after draft, after draft …"*	*p1-L3, 1.16.3*
	" …drafting/redrafting …"	*p3-L3, 44.44*
	"… I do drafts … it takes a long time, but what I do is I make a preliminary draft …" … "And then once I add flesh to it… and then I refine it."	*p2-L2, 53.12*

Table 4.12 Participants' recalled example representation strategies

Emergent off-source representations

Utterances during *Use* suggested that emergent off-source representations were typically more analytic than previous or earlier representations. This range, as shown in Table 4.13, was compiled from both reports and examples gathered post-observation.

	Number of participants:			
Example representations:	**Pen&Paper:**	**Electronic:**	**Both Technologies:**	**Total Participants:**
Summary/Synopsis	1	2	2	5
Tables	1	3	0	4
Lists/Bullet points	2	1	3	6
Diagrams	4	1	1	6
Concept maps	1	2	0	3
Structure, e.g. TOC, Outline headings etc.	0	3	3	6
Drafts	0	5	2	7
Bookmarks	0	3	0	3

Table 4.13 Participants' *off-source* representations, grouped by type and medium. The counts are mutually exclusive.

Summary notes and synopsis are typically derived from previous on-source representations created during a *personal fit* evaluation phase; they are often a more coherent, structured representation which might contain pointers to the source's significant aspects:

> *"Then once I have read it and understood, I make a summary which is like my own notes as to what I think the paper is about and what I think it is contributing. So my notes are basically in 2 sections … "* *p1-L1, 41.38*

> *"… but for my own work, instead I write summative survey, e.g., ' xy said this and j said that, here is an area where they don't seem to meet together, etc.'"* *p1-L3, 1.09.41*

One (*p1-L1*) stated that they generate this type of representation on paper before generating an electronic version of a summary/synopsis. These representations often contain other representations such as lists/bullet points, etc..

The most common off-source representation was narrative 'drafts'. Again, these often contain other representations.

Participants claimed to work in a mix of pen and paper and electronic formats, often with a preference for pen-and-paper as an initial activity. Electronic representations were preferred for 'drafts', and those who chose to work in pen and paper also worked with electronic tools. In contrast, pen and paper was the clear preference for diagrammatic representations, with only one participant working in both media. However the choice of medium was more evenly distributed for Tables, Concept maps, Lists/bullet points. Electronic representations were preferred for representations of structure, such as Tables of Content (ToC) and outline headings.

Tools as aids for representation (& extraction)

The electronic tools that participants reported using included:

- *Internet Explorer* and *Firefox* browsers for bookmarks;
- Word processing package (*Microsoft Word*) for summary/synopsis, lists/bullet points, outline structures, and narratives;
- *Google Scratchpad* for outline structures;
- Spreadsheet (*Microsoft Excel*) for tables such as those used in comprehensive comparative exercises;
- *Brainstorm* and *MindMap* for concept mapping; and
- *Visio* for diagrams.

All nine participants reported the use of bibliographic tools to store citation details, although only seven actually indicated their use in their questionnaire response.

Influences on representations

There was no new strong evidence of influences on external representations, although *authoritativeness* and *task* were mentioned by a few participants. However several participants mentioned how their emergent representation is influenced by the structure and contents of the information source, for example,:

> *"They [headings] are influenced, but I try to make sure once I write the headings … I try to write my dissertation in the same style but then again, I don't want it to be identical" p3-L3, 45.37*

Participant *p2-L2 (1.26.05)* explained how their headings were informed by their synthesis of what they had read; another explained similarly, but emphasised that the representation was their own (*p3-L3*, *1.12.12).*

Extractions from sources

Participants reported several examples of verbatim extractions from information sources during observation and in their questionnaires. Table 4.14 details examples.

Example	p1-L1	p2-L1	p3-L1	p1-L2	p2-L2	p3-L2	p1-L3	p2-L3	p3-L3
Reference Details	√ s	√ s	√ s	√ s	s	√ s	√ s	√ s	√ s
Structure/headings					√			√	√
Quotes	s	√ s	√ s	√ s			√ s	√	√ s
Abstract	√					√		√	√
Diagrams/Images					s				√
Tables					s				

Table 4.14 Participants' examples of extractions from located sources

Legend: √ denotes questionnaire response; *s* denotes statement made during observation

At some point-in-time during the information-seeking task, all participants tended to extract citation details from selected sources. Another common extraction is quotations; however general consensus was that the quotation had to be good enough to be worth taking (*p1-L1, 51.27, p1-L3, 58.50*). *Abstract* extraction refers to copying the *Abstract* directly into *EndNote*. Diagrams and tables are extracted occasionally *(p2-L2, 52.04)*. Three out of nine questionnaire responses indicated that participants do extract structure and headings although it is unclear how much these were edited at a later stage.

4.7.3.4 Cues for further searches from *Use* interaction strategies

At the *Use* stage, further searches were fairly specific and less common. Several reasons were given for further searches:

- new sources were cited in current information sources. Further search might be undertaken to track down other relevant literature (e.g. citation based searching , *p3-L2 41.28, p3-L3 40.59*), or to locate an original and possibly seminal source to establish credibility and rigour in the final task deliverable *(p2-L2 1.01.10, p2-L3 1.21.19);*
- a new concept (keyword) arose, typically from cross-source analysis *(p3-L1, 1.13.59*);
- a search was undertaken for the latest publications, as part of continual monitoring of a community (*p2-L3, 121.19).*
- additional information was needed to provide further material or perspectives, either because existing (gathered) sources may be deficient in some aspect, or because they do not support understanding and evolving argument adequately *(p2-L2 1.03.12, p3-L2, 1.28.06).*

4.7.3.5 Discussion: information interaction strategies associated with *Use*

Many of the strategies presented in this *Use* section could be considered to be extensions or expansions of those exhibited within *evaluation for personal fit.* However, these *Use* strategies were characteristically more concerned with deciding **'***how to best use'* the located information for the participants' own purposes: how to make sense of, organise and incorporate newly-found information into their existing body of knowledge. The findings in this section offer some insight into *Use* of information not known to be reported elsewhere.

Very few information seeking behaviour studies have specifically investigated the characteristics of *Use* behaviours, which may in part be due to there being so many interpretations of what 'use' in information seeking means (ref Chapter 2.2). There are however several studies reporting citation analysis; one recent example includes Wang et al. (1998, 1999) who devised a well-cited 'Document Use Model' (1999). Wang et al. interpret 'document use' to encapsulate reading decisions and document citation. They found that 10 of the original eleven criteria that influenced participant's earlier original selection decisions continued to be relevant at the usage stage, but a further 14 new criteria were identified as influential at the reading and citation stages, i.e., their defined interpretation of 'information use'.

Another empirical study undertaken by Qu and Furnas (2005) considers the use made of source content in a sensemaking context. Their research is pertinent to this project as a whole but any comparison is left until the second Study (ref Chapter 6).

In this Study, the *Use* category signalled a change of focus: rather than searching for sources, or searching the located sources for *potential* conceptual and verbatim extractions, the focus was on deciding how the content might be used purposefully for 'writing' such as preparing a 'task deliverable'. This distinction between *evaluation* and *Use* is not clear, because both activities require some reading and understanding; hence the fuzziness between the *evaluation for personal fit* and the *Use* categorisations. When individuals read to understand, they are extracting concepts from the source, building mental frameworks, making connections, and so on. Such actions may or may not lead to some external representation, and whilst usage/construction behaviours are evidenced by emergent representations, the absence of such representations does not exclude conceptual usage of source content. Given this observation, activities were distinguished by purpose. Initial interactions with the located source (which sometimes indicated some extraction for usage, conceptual or physical) addressing potential were categorised as *evaluation for personal fit.* Apart from these initial interactions, any other interactions with the source were presented as *Use* strategies in this section (4.7.3). The demarcation between *evaluation for personal fit* and *Use* was further differentiated by strategies that reflected:

- integration of newly-found information into participants' own body of knowledge;
- shifts in understanding informed by conceptual extractions, that build towards task needs;
- interactions with their own external representations;
- multiple-source comparisons, e.g., comparisons across sources prior to verbatim extraction.

Reading and representation strategies, were seen to be the two key *Use* strategies; they encapsulated participants' interactions with sources and with their own interpretations and representations of these sources' contents. Participants read and re-read to understand and make sense of the content, and represent/re-represent to capture this sensemaking. The iterative nature of the reading reinforced and extended their understanding; for example iterative reading helped them to make sense of where they were with respect to the community, allowed them to make connections with related work and to change perspectives as they developed their arguments. These 'read and representation' strategies broadly correspond to 'reading and citation', as identified by Wang et al. (1999).

Decision influences were not a key focus of this first Study, and results pertaining to influences have been reported only if they have been uttered during undirected talk-aloud. The only two influences explicitly identified during *Use* were *task* and *authoritativeness*. Nevertheless, it is interesting to compare the results to Wang et al.'s (1999) criteria for reading and citation decisions (summarised in Table 4.15).

Cognitive requisite, which Wang et al. describe as only relevant to reading activities, is not readily recognisable, although it might compare to the cognitive descriptors, concepts and cognitive shifts that occurred through iterative reading of sources during this Study's *Use* phase. Criteria associated with located source documents such as *quality* and *depth* are recognisable, if not explicitly stated and captured in this Study; given that poor quality and incomprehensible or excessive jargon were reasons given for discarding a source, it could be argued that these were implicit criteria. Other criteria associated with the author and origin do compare. However, the relationship between task influences and those Wang et al. associate with the written research product is tenuous.

Criteria:	Associate with:
Cognitive requisite	the participant's knowledge
Actual quality Depth Classic/founder Publicity	his/her judgment of document characteristics
Reputation Prolific author Journal spectrum	his/her perception of the agents of the document
Peer review Standard reference	the evaluation of document content by the field
Judge *Norm* *Target Journal* *Credential*	the written research product

Table 4.15 Wang et al.'s five categories of judgment criteria
(Table derived from Wang et al., 1999, pg 103ff)

The results of the physical extraction strategies (4.7.3.3.4) highlighted some mismatches between the questionnaire responses and the articulated general recall (Table 4.14). This could be due to a number of factors:

- the recalled 'talk-aloud' was the participant's own story of their actions, and there was little directed questioning, thus it is likely that some detail was simply not stated;
- it may be that there was a misunderstanding in the scope of the questionnaire questions, for example, the evident contradiction in *p3-L3's* response to extraction of 'structure and headings' (Table 4.14) could be due to their interpretation that these are conceptual extractions from the source, whereas the intended interpretation was looking for actual physical extractions;

These mismatches are not considered significant in this Study, which was looking for evidence of the ranges of strategies across the information seeking process; the mismatches have not been investigated further.

4.8 Overall Discussion

The main goal of this Study was to gain insight into the range of strategies that the participants, all experienced information-processors, might employ in the context of their research-related web-based activities, as they seek to interpret and integrate gathered information, i.e., it was designed to address Research Question 1. In addition, the results help to inform Research Questions 3, 4, and 5. A discussion is offered against each of these Research Questions in turn, followed by a discussion comparing these findings against other relevant research.

4.8.1 Addressing Research Question 1

Through iterative inductive analysis, three broad categories of information interactions emerged:

i. information interactions associated with *search*

ii. information interactions associated with *evaluation*

iii. information interactions associated with *Use*

Evaluation proved to be a complex category and was resolved into three categories with distinct purposes and characteristics: evaluation for *selection*, *utility* and *personal fit*.

These five broad categories of information interactions combine to exemplify:

> *the broad range of typical behaviours and strategies deployed by experienced end-users as they interact with information sources whilst undertaking authentic information-related tasks in web-based environments (as asked in Research Question 1).*

The categories form a framework (Figure 4.4) that represents the participants' information seeking process. The framework is iterative, rather than linear; typically, participants iterated around the *search*, *evaluate for selection* and *evaluate for utility* behaviours, until they had gathered a body of sources for further in-depth reading, and hence for *personal fit* evaluation sometime later. The participants were opportunistic in their interaction behaviours, which varied depending on task, timing and other factors.

	Categories of Information Interaction Strategies				
	Search	**Evaluation for Selection**	**Evaluation for Use**		**Use**
			Evaluation for Utility	**Evaluation for Personal Fit**	
Purpose:	*Finding/ locating* information	*Selecting* sources to look-at	*Deciding* what source/ document to read (examine in depth) & store or print	*Digesting* the content and determining which content to extract, synthesise, use	*Organising* and *incorporating* into a body of knowledge
Characteristics:	interaction with the *query interface*, search engine, tools, etc.	interaction with the *results lists* at screen	interaction with the *information source* at screen	interaction with the *information source* predominantly using paper-based source	interaction with the *information source(s)* and with its (their) *representations*

Figure 4.4 Empirical Framework:
categories of information interaction strategies in web-based information seeking

Much is known about *search* and *selection,* but less is known about *evaluation for personal fit* and *Use* strategies; these findings offer considerable insight into these strategies and associated behaviours. The boundary between the *evaluation for personal fit* and *Use* categories remains fuzzy; for example, participants might generate representations during *personal fit* but only integrate them in later *Use*. However, the categorisation is sufficient for this Study, which was interested to gather evidence of how users make sense in web-based learning environments. In future work, this demarcation will need to be better defined.

The five categories have each been presented in detail in this Chapter (4.7.1-4.7.3), and each associated discussion is offered alongside those results. However, there were a few notable relationships between the categories and hence across the process that warrant comment. For example, with respect to influences on strategies:

- *topicality* was a significant influence during *evaluation for selection* but was replaced by *utility* thereafter;
- the *authoritativeness* of the source was an important influence throughout the process; for example, a source that was judged authoritative enough to be selected and used to inform conceptual understanding may have not been deemed credible enough to be directly represented in a new representation;
- the nature of the task was influential throughout the process; it shaped participants' evaluation in terms of the number of sources selected from the search results lists, and

it later influenced how they interacted with the actual source itself, e.g., the level of reading effort and intensity. This was often discussed with respect to a broad or finely focused type of task.

The cues for further searches arose at any point of the seeking process, although new searches were less common in the later phases. The reasons for further searches varied. For example, in the earlier phases of *search* and *selection*, new or more on-topic sources were often required, whereas in the later phases of *personal fit* and *Use* and to a lesser extent *utility* evaluations, additional searches were more to do with sensemaking needs, e.g., mention of a new concept or a promising citation in a previously located source. These additional searches evidenced the iterative nature of participants' activities.

4.8.2 Addressing Research Question 4: Indications of Sensemaking During the Information-Seeking Process

The categorisation into information interaction groupings provided a useful basis from which to discover sensemaking activities, addressing Research Question 4:

> *How does users' sensemaking relate to the information seeking process?*

Sensemaking, in its everyday interpretation, can be considered as actions that

> *"involve finding the important structure in seemingly unstructured situation"*
>
> *(Qu & Furnas, 2005)*

Or

> *"the strategies and behaviours evident when users collect, evaluate, understand, interpret, and integrate new information for their own specific problem/task need"*
>
> *(Abraham et al., 2008)*

Both of these interpretations would suggest that sensemaking is more readily recognised when it is explicit, as evidenced by actions involving structuring or organising information for a purpose. Indeed during the *personal fit* and *Use* stages, external representations emerged as artefacts of participants' sensemaking, encapsulating the participants' own interpretation of located information. Looking across all stages of the empirical framework (Figure 4.4), findings indicated that some internal structuring and organising of newly-found information occurred at other phases of the seeking process as well; for example, users seemingly referenced implicit knowledge to interpret and make evaluation decisions at key points during the seeking process. The following three sub-sections consider the evidence of any sensemaking where sensemaking can be discussed in terms of both participant's think-aloud utterances and their emergent representations as artefacts of their sensemaking. The evidence is mapped against the empirical framework in Figure 4.5.

Sensemaking Indicators:	**Categories of Information Interaction Strategies**				
	Search	**Eval for Selection**	**Evaluation for Use**		**Use**
			Evaluation for Utility	**Evaluation for Personal Fit**	
Think-Aloud/ Reported	Exp-ression of needs	Relevance judgement	Source content identified as useful	e.g., Concepts identified as useful, connections to own/known work, raising questions	e.g., analysis, synthesis, integrate, changing perspectives
External Representations	*Query*	Very few e.g. *bookmark*	Very few e.g. Citation extracted	*On-source:* e.g. highlighter *Off-source:* e.g. Summary notes	evolving, *e.g. Conceptual maps, Diagrams, Tables, Drafts*

Figure 4.5 Empirical Framework annotated with indications of sensemaking

4.8.2.1 Sensemaking during *search* activities

The query is considered to be the explicit representation of the user's understanding of their need (White et al., 2001), which may not necessarily be an accurate expression (e.g., Belkin et al., 1982, Anomalous States of Knowledge (ASK project). Further, the action of query expression has been shown to be complex, for example, influenced by such as the type of question/task, search engine's features etc. (White et al., 2001). Due to the nature of the tasks demonstrated, it cannot be claimed that the high success rates seen in this Study indicate their queries were necessarily accurate representations of their task needs, but the findings do suggest that they are making informed decisions about both the task and the choice of search engine; as such they are referencing their own tacit knowledge, i.e., mental model of their existing knowledge and identified 'knowledge gap'. Indeed Vakkari & Hakala (2000) suggest that users have a vague mental model of the task.

4.8.2.2 Sensemaking during *evaluation* activities

Each *evaluation* category exhibits evidence of sensemaking.

Evaluation for selection from results lists is about making best decisions as to the value or worth of the result based on given information, i.e., its relevance. *Topicality* was seen as one of the significant influences on result entry selection; making judgments as to whether information is on topic implies that participants have some understanding of what the topic is about (as captured by Schamber's *aboutness* factor (1994)). Thus these decisions indicate that some mental framework or implicit knowledge was being referenced in order to help them make sense of the results returned from the search. This would likely expand as their understanding of the problem domain develops; as Kuhlthau (1991) and others have suggested, the seeker is learning through the seeking process.

During *evaluation for utility* interactions, there was little external representation to provide explicit evidence of sensemaking. However the mostly 'concept based' evaluation judgments indicate that participants were considering the source content against their existing knowledge to help fill their knowledge gap; again seekers are making sense, referencing their implicit knowledge as they try to interpret the concepts they find. Capturing citations at this stage suggests that information has been identified as worthy of future effort, e.g., a concept or argument has been mentally identified, although the citation detail was likely verbatim rather than interpretation.

It is during *evaluation for personal fit* that conceptual extractions are identified by the participants; evidence of making implicit knowledge explicit appears through emergent external representations of the new information and how it could integrate (link) with the existing knowledge framework. At this stage participants are concerned with 'best fits' for their knowledge gaps. The emergent representations were artefacts of the ongoing sensemaking: mapping, showing associations and connections, developing ideas, etc.

4.8.2.3 Sensemaking during *Use* activities

Participants' primary focus during the *Use* stage is to develop the task solution through iterative interactions with the actual source and their own representations. Many *Use* behaviours are evident sensemaking; it can be seen in the emergent representations, and is expressed in the participant's own utterances.

Emergent representations were typically more analytic than descriptive, and were often informed from multiple sources rather than a single source. They generally consisted of a mix of conceptual abstractions; rarely, they included verbatim extracts such as quotations and diagrams. Various degrees of analysis and synthesis were being applied as the analytic representations evolved; through iteration, the information made more and more sense to the user.

Participants themselves made frequent references to 'making sense' and spoke of analysis, synthesis, categorisation, etc.. They also commented on how their knowledge developed to allow them to position themselves within the wider community; change their perspectives and develop their arguments; make connections between and across the information sources and their existing knowledge; and add intelligence to their organisation strategies due to the enhanced understanding. In other words, they were explaining how they were making sense in the context of their tasks.

4.8.3 External Representations: Informing Research Question 3

The findings from this Study informed Research Question 3:

> *How do users externally represent both the collection and the meaning being derived from the information sources?*

A number of representations were identified, as were the tools employed to generate them. The representations were consistent with other literature: on-source annotations such a highlighting and margin notes; off-source representations such as lists, concept maps, diagrams, narrative notes, and outlines. Participants extracted citation details in order to keep track of found sources; citation extraction occurred at any stage of the *evaluation* or *Use* process.

Typically, representations that emerged during *evaluation for personal fit* included on-source annotation, highlights, margin notes, whereas more off-source representations were produced during *Use.* The representations produced during *Use* were often more analytic; examples included lists, narrative notes, summaries, diagrams. The representations became more refined, complex and analytic as a result of ongoing interactions with both the sources and the emergent external representations.

Comparing the tools used for representation across the process offers some insight into the role paper-based and electronic media played in these representation strategies. Overall, the choice of medium is personal and varies among individuals. Figure 4.6 is a snapshot based on examples reported and generally evidenced. From this, participants can be approximately positioned in the 'preference' space as shown (this positioning has been verified with the participants).

Figure 4.6 Each participant's approximate relative positioning with respect to their preference for medium of representation

The participants placed at the extremes of the continuum indicated a strong preference for either paper-based or electronic tools. Those participants placed near the centre usually choose a medium dependent on representation with a switch in medium often triggered by evolving representation needs, typically from pen and paper to electronic forms. For example, one participant *(p2-L1),* used both paper and electronic media for early representations, but preferred electronic tools for their more analytic representations; thus they are placed right of centre on the continuum.

4.8.4 Relationship to Relevant Literature

Each category of information interaction has been compared to the literature at the relevant points throughout this Chapter (sections 4.7.1.3, 4.7.2.4, 4.7.3.5). Suffice to recall that *search*, evaluation for *selection* and *utility* each reflect rather then extend the existing literature on these topics, whereas evaluation for *personal fit* and *Use* categories of information interactions offer some insight that is not previously reported elsewhere, and that is worthy of further investigation.

The emergent empirical framework and other overall findings are now compared to the literature regarding information-seeking models, sensemaking, task influence, and information foraging theory.

4.8.4.1 Empirical Framework and other information-seeking models

The empirical framework (Figure 4.4) is a representation of the information-seeking process from an interaction perspective that can be compared readily with other relevant information-seeking models. The three models identified in Chapter 2 as significant to this research are:

- Bates' Berrypicking model
- Ellis' Behavioural features model
- Kuhlthau's Information Process Search model (ISP)

Each will be considered in turn.

Bates: Berrypicking Model (1989)

The iterative nature of the information interaction behaviours, and the ongoing gathering and usage, suggest similarities to Bates' Berrypicking model presented in Chapter 2. Bates argues that users' information needs evolve as information is found, that they apply a variety of strategies on different information sources, and that they select from the information they locate, hence the '*Berrypicking'* metaphor. Her model (reproduced in Chapter 2 as Figure 2.5) is recast and mapped against the empirical framework with vertical alignment between the categories and the multiple queries (ref Figure 4.7). The sample pathway shown in the mapping illustrates Bates' user's Berrypicking search: the search progresses as far as the *evaluation for personal fit* phase, when some information is extracted from the document and the user's thought process develops and changes. This causes a return to execute another query, which progresses as far as evaluation for *utility* and rejection. This pathway continues for two further queries until the user eventually integrates all found information to their task.

The mapping highlights similarities between the empirical framework and Bates' model:

- both recognise shifts in the user's thought process as the task progresses, i.e., evolving task needs are triggered by discovered information or developing understanding as the task progresses;
- multiple sources are used;
- iteration over successive queries to the point of use with extraction from documents as an ongoing activity.

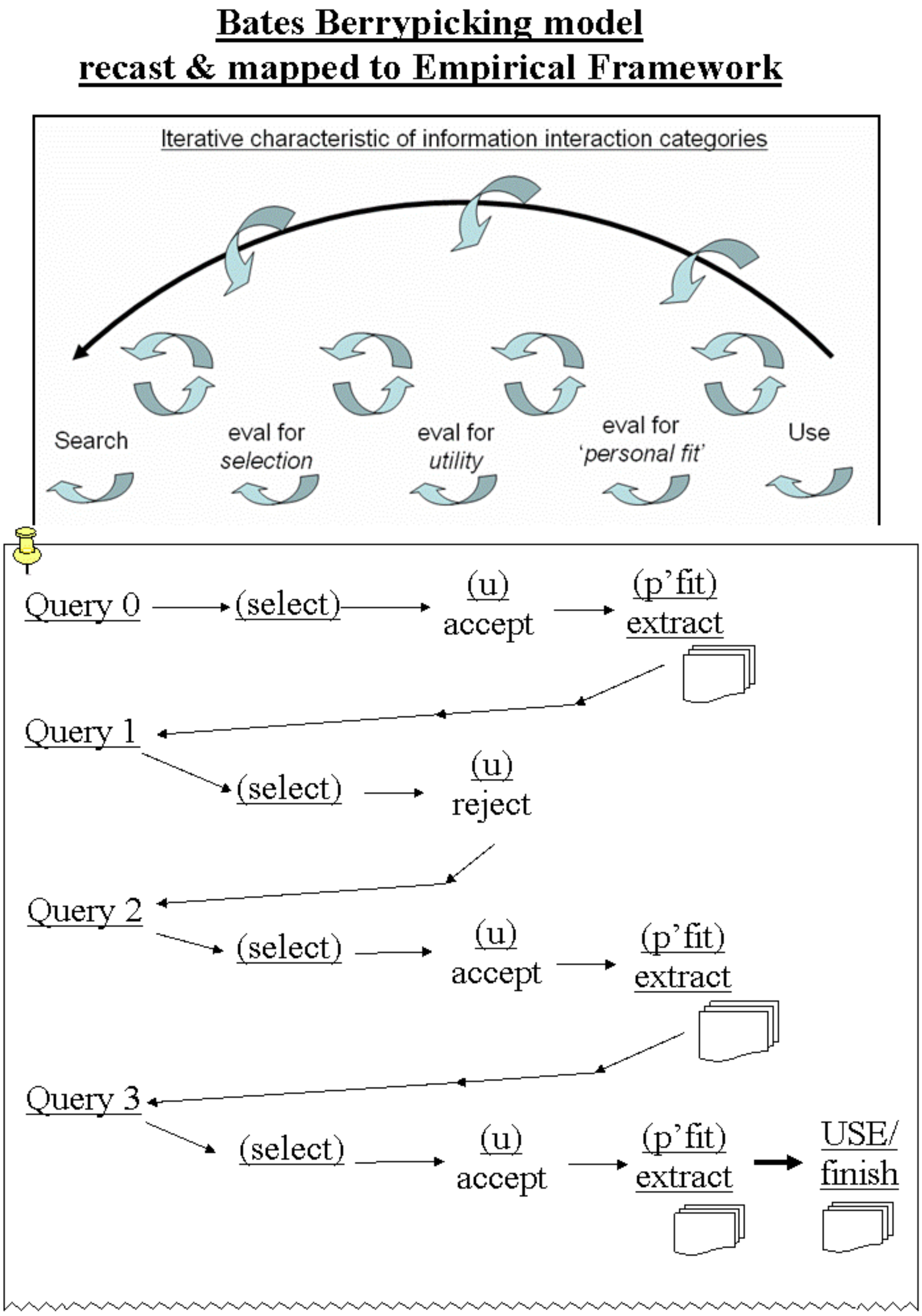

Figure 4.7 Bates' Berrypicking Model mapped to Empirical Framework

Legend notes as per Bates (1989, pg 410):

"Changes in direction of the arrow illustrate the changes of an evolving search as the individual follows-up various leads and shifts in thinking".

Ellis' Behavioural features model (1989, 1993)

Ellis' model (1989, 1993), which was devised from studies of groups of professional online database users, has more recently been applied and validated in online and web-based contexts by Choo et al. (2000), Meho et al. (2003) and Shanker et al. (2005). In each of these three studies, some or all of Ellis's features were seen in the user's activities (with four extension features offered by Meho et al.). A comparison of Ellis' eight features with the emergent empirical framework, recast as an iterative representation, highlights where there are similarities (Figure 4.8).

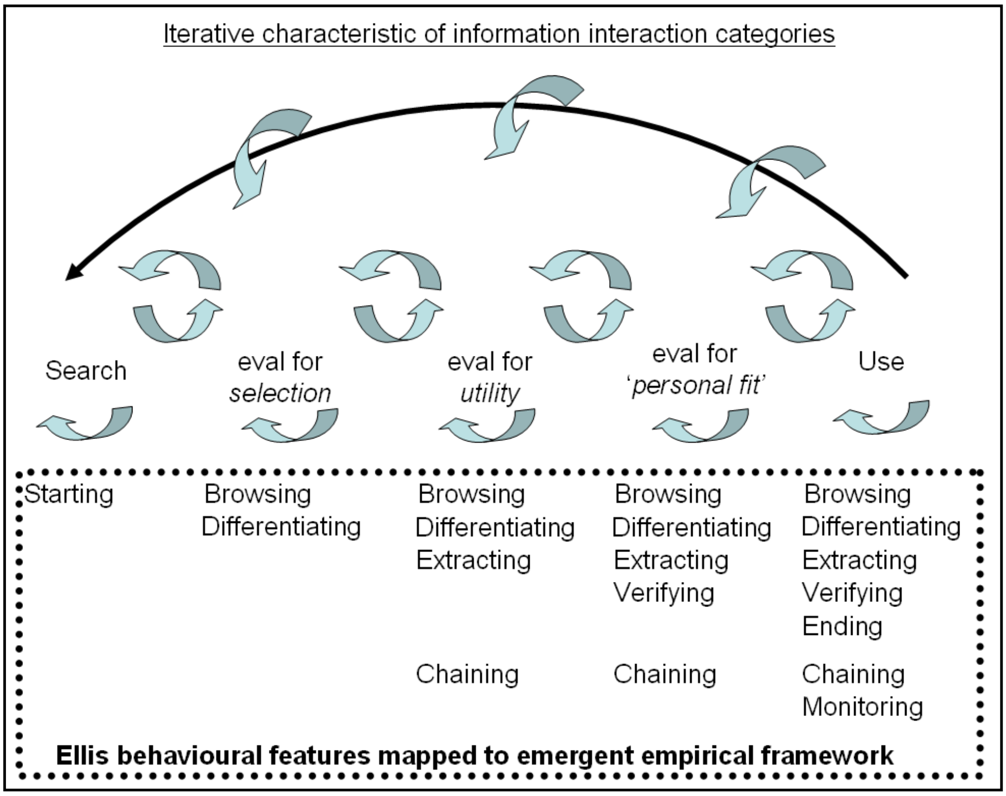

Fig 4.8 Ellis' eight behavioural features mapped against the Empirical Framework

Each of Ellis' features can be placed against the interaction *category* during which they typically appear. For example:

- Ellis' *differentiating*, exploring the differences between sources, is a behaviour that can be readily associated with the *evaluation* phases as well as the *Use* phase of the framework.
- *extracting* was seen as citation extraction during *evaluation for utility,* and as conceptual (and sometimes verbatim) extractions during *evaluation for personal fit* and *Use*.
- *chaining* was seen to occur directly from references or links found during *evaluation for utility*, *evaluation for personal fit* and *Use*. This in turn may have led to further browsing.

- utterances that indicated users' recognition of need to keep-up-to-date or monitor the literature were commonly heard when describing *Use* interaction strategies, consistent with Ellis' *monitor* feature.

This mapping (Figure 4.9) emphasises the iterative nature of both the empirical framework and Ellis' set of behaviour features.

Kuhlthau's Information Search Process (ISP) model (1991)

Kuhlthau's model was originally based on groups of library users and has been validated and shown to be robust, e.g., Vakkari 2001a and 2001b; Kuhlthau 2001. However, it has not been established that Kuhlthau's six stage ISP is wholly representative of a web-based information seeking activity, although Vakkari does identify Kulhthau's '*formulation'* as the ISP stage equivalent to the *'task performance process'* start point in his own 'Theory of a task-based IR process' (Vakkari, 2001b). On this basis together with the author's own understanding:

- Kuhlthau's *formulation* corresponds to the *search* phase of the empirical framework.
- Kuhlthau's *collection* corresponds to all *evaluation* behaviours
- Kuhlthau's *presentation* corresponds to *Use* behaviours.

4.8.4.2 Sensemaking findings compared to the literature

The external representations emergent at both *personal fit* and *Use* phases of the seeking process, are evidence of the user's sensemaking that develops and become more complex and assured as the user progresses the task. Whilst the results concerning specific sensemaking behaviours need further investigation, the empirical framework can be compared to Dervin's Sense-Making model (1983), with its three basic concepts: "Situations – Gaps – Uses" (or outcomes). The empirical framework captures various alternative pathways across the categories, which are readily comparable to Dervin's sensemaking model. A more detailed comparison will follow the second empirical Study (Chapter 6).

4.8.4.3 Findings on the influence of task compared to the literature

This Study showed that the needs of the task-in-hand were influential throughout the seeking process. This is broadly consistent with the literature regarding task and task context. Amongst others, Bystrom conducted a range of task focused studies including Bystrom and Jarvelin (1995) that showed the relationship between task complexity and facets of the seeking process; they determined that, as task complexity increases, the complexity of the information needs increases, and the success of information seeking decreases. Vakkari (2003) reviews the literature pertaining to Task based information and cites Belkin et al., 1992 as another who has also argued that the state of a user's information seeking is influenced by their individual task or problem.

4.9 Summary

This Study used a combination of data collection instruments to elicit the range of typical behaviours and strategies exhibited by experienced end-users as they undertake web-based research-related seeking tasks. The findings offer some detailed insight into the seeking process from an information interaction perspective; they are expressed as an emergent empirical framework. The framework (Figure 4.4) is duplicated here for easy reference:

	Categories of Information Interaction Strategies				
	Search	**Evaluation for Selection**	**Evaluation for Use**		**Use**
			Evaluation for Utility	**Evaluation for Personal Fit**	
Purpose:	*Finding/ locating* information	*Selecting* sources to look-at	*Deciding* what source/ document to read (examine in depth) & store or print	*Digesting* the content and determining which content to extract, synthesise, use	*Organising* and *incorporating* into a body of knowledge
Characteristics:	interaction with the *query interface*, search engine, tools, etc.	interaction with the *results lists* at screen	interaction with the *information source* at screen	interaction with the *information source* predominantly using paper-based source	interaction with the *information source(s)* and with its (their) *representations*

Figure 4.9 Empirical Framework: categories of information interaction strategies in web-based information seeking (duplicate of Figure 4.4)

The category headings intentionally reflect similar behaviour groupings identified in other information models. There are three broad categories of information interaction strategies: *search*, *evaluation* and *use*. *Evaluation* was further resolved into evaluation for *selection,* for *utility* and for *personal fit*. This framework accommodates the highly iterative nature of the seeking process across and within the five categories.

The outcomes of this Study are:

- the empirical framework depicting the information-seeking process as a range of information interaction strategies;

- the insight offered into the complexity of evaluation activities, and the novel identification of *evaluation for personal fit*;
- the insight into source usage; although *Use* behaviour is explicit within several other information behaviour models, it has received scant attention, and little is known as yet about how content is used from located or found sources;
- indications as to the relationship between the seeking process and sensemaking.

Sensemaking could be argued to be evident in every interaction category, although it was only explicit during *personal fit* and *Use* categories. Participants' external representations, i.e., the artefacts of their sensemaking, grew more complex and analytic as participants worked through their task-in-hand and made more sense of the source material. The framework suggests relationships between the information-seeking process and sensemaking, which can be explored further. The findings from this Study provide a basis from which to design and conduct more detailed investigation into sensemaking in web-based environments.

Chapter 5 - Empirical Study 2:
Detailed Design, Method, and Analysis

An empirically based framework from Study-1 provided insight into the range of interactions deployed by experienced information processors as they worked with information sources across all phases of the information seeking process during a research related task. Furthermore

- evaluation was seen to be a complex process with several stages that blended into the use of the information;
- evidence of explicit sensemaking (external representations) emerged during source evaluation and use (ref Chapter 4.8.2)

Study-1also found sensemaking to be evident as utterances in the early stages of the process, and as complex, explicit behaviour during the latter stages of information seeking.

The main goals of empirical Study-2 were to

i. further investigate web-based sensemaking behaviours,
ii. and in so doing validate the empirical framework.

In particular, the focus was to observe how such behaviours were deployed by experienced information processors whilst they undertook an everyday web-based topic-comprehension task, i.e., to address Research Question 2 and inform Research Questions 3, 4 and 5 (ref Chapter 3, Figure 3.1).

The remainder of the Chapter is structured as follows:
Section 5.1 reports on Study-2's detailed design decisions, namely

- the topic-comprehension task (5.1.1)
- the closed-corpus Google-collection of search results (5.1.2)
- the questionnaire design (5.1.3)

Section 5.2 details the research method

- pilot runs (5.2.1);
- participants: sample recruitment and profiles (5.2.2);
- environment laboratory configuration and resources (5.2.3);
- the procedure (5.2.4).

Section 5.3 provides an overview of the five-step analysis approach used in this Study-2. A Study evaluation is offered in Section 5.4 and the Chapter concludes with a summary in Section 5.5.

5.1 Study 2: Detailed Design

This Study was designed with reference to the overall project design decisions and guidelines presented in Chapter 3 (ref Chapter 3, Table 3.3) and the overall decisions with respect to Study-2 are extracted here (Table 5.1):

Aspect of Methodology:	**Study-2:**
Data collection methods	- Observation with think-aloud - Post-session questionnaire - Post-session collection of external representations
Data capture equipment	- Audio +video+ screen capture - Researcher note-taking
Environment setting	- laboratory
Resources available	A range of *i-s resources* (ref 3.4.1)
Participant: criteria	Experienced information processors
sample size	eight
recruitment mechanism	internal email
Type of Task	Designated everyday information gathering type task: topic-comprehension task

Table 5.1 Study-2: methodology decision guidelines

It is worth reinforcing that the participants needed to be experienced not only in terms of using the internet as information searchers, but more specifically they needed to be experienced information processors, i.e., able to process and use found information. More detailed aspects of Study-2's design are now discussed.

5.1.1 Topic-Comprehension Task

Study-2 needed to further investigate the behaviours found in Study-1 that specifically indicated sensemaking behaviour, i.e., a subset of behaviours observable during web based information seeking. This task was to be a single simulated topic-comprehension task which would prove equally suitable across a range of volunteers (ref Chapter 3.6.3.2).

Determining a suitable comprehension task topic was a complex decision process: eighteen potential topics, some taken from previous academic course assignments and amended for this context, were assessed against the previously reported generic criteria (ref Chapter 3.6.1); a short list of six current topics were then used in a straw poll exercise to identify

- the most suitable topic
- the most suitable task context, i.e., to prepare either an outline essay or an outline slide presentation.

The straw poll targeted a random group of university staff and students as they relaxed in refectories over coffee. Two topics emerged as the most engaging

i. "sustainability of oil supplies"

ii. "identity cards in UK".

After due consideration as to the structure of each of these topics, i.e., how well defined the topics were, and how topical and current they were, the actual task chosen was:

> "Prepare, in outline, a 15-minute slide presentation for a mixed local community audience on the given topic:
>
> *Determine and discuss the key issues with respect to the implementation and the implications of ID cards in the UK"*

With respect to the task output, the straw poll showed a slight bias of preference towards an outline essay, however, the pilot studies (5.2.1) demonstrated that a slide presentation was the more appropriate task output. The straw poll working sheets are found in Appendix B.

5.1.2 Closed-Corpus Google-Collection of Search Results

The term Google-collection is used in this thesis to refer to a closed-corpus of *Google* search results specifically generated for use by the participants in Study-2. Several factors influenced the decision to generate a pre-determined collection of search results for information sources relevant to the topic. These factors were:

- this Study was not focused on query formulation;
- there was a necessary time constraint;
- the collection needed to be contained, i.e., to enable user's interactions with the listed results to be broadly traceable;
- in theory the Google-collection could be regenerated by re-running the keyword queries, however, given the same search query and the same search engine, there is no guarantee that it will return the exact same result-set over time. .

To this end, a collection of *Google* generated search results was pre-gathered by unbiased means. This set or collection of relevant search engine results was obtained from two independent search sessions. The first was conducted by the researcher (author), where the search query term used was "ID cards in UK". The second session was conducted by an independent research fellow (RF); this involved three different searches, i.e.,

i. "ID cards UK implementation";

ii. "ID cards UK implementation rationale";

iii. "ID cards UK".

The final set of sixteen search results were collated from inspection of the first two pages of each of these four search result sets; there were eight matches across all sets, two results (non-current newspaper articles) were included as having limited usefulness, and the remainder was collated from a mix of results from all search results. This Google-collection was contained in an *MsWord* document with all results clickable to live web-pages; both a printed and an electronic copy were made available to participants throughout the task. An extract is shown in Figure 5.1.

A copy of the complete Google-collection results sheet is held in Appendix B. The sources covered a range of styles and authority: some were formal (e.g., Home Office documents); some were from news media (e.g., BBC and newspaper sites); some were general-knowledge sources (e.g., Wikipedia). Some (e.g., the Identity and Passport Service site) were detailed and well-structured web resources containing live links. Most sources extended over several web-pages with breadth and depth hyperlink navigation whilst others (e.g., the Daily Mail source) were just single-page articles.


NO2ID:stop **ID cards** and the database state
From April 2007 the **UK** Identity & Passport Service begins to open **ID ...** the National Identity Register (NIR) that is the main aim of the '**ID cards**' scheme. **...**
www.no2**id**.net/ - 19k - 26 Mar 2007 - Cached - Similar pages

BBC NEWS | **UK** Politics | Blunkett backs **ID card** plan
Everyone in Britain over the age of 16 could be issued with a form of **ID card** under plans outlined by Home Secretary David Blunkett.
news.bbc.co.**uk**/1/hi/**uk**_politics/2084860.stm - 48k - Cached - Similar pages

Identity **Cards** Bill
This is the text of the Identity **Cards** Bill, as amended in Standing Committee D in the House of Commons on 21st July 2005. Identity **Cards** Bill **...**
www.publications.parliament.**uk**/pa/cm200506/cmbills/049/2006049.htm - 11k - Cached - Similar pages

ID Cards - **UK's** high tech scheme is high risk - News archive **...**
ID Cards - **UK's** high tech scheme is high risk. The likely cost of rolling out the **UK** government's current high-tech identity **cards** scheme will be £10.6 **...**
www.lse.ac.**uk**/collections/pressAndInformationOffice/newsAndEvents/archives/2005/**ID**Card_FinalReport.htm - 26k - Cached - Similar pages

Figure 5.1 Extract from Google-collection of search results

5.1.3 Questionnaire Design

The questionnaire to be used post-session, contained a mixture of open-ended and 5-point Likert-type questions, designed to capture

- readily reportable aspects of typical web-based interaction behaviours relevant to topic-comprehension type tasks;
- minimum demographic data;
- participant’s reflections and comments on their session experience.

The design was based on existing guidelines as cited in Chapter 3 (ref 3.3.2) and a copy of the questionnaire is found in Appendix B.

5.2 Method

5.2.1 Pilot Studies

Two pilot studies were conducted to test the robustness of the data collection. One pilot observation was laboratory based with both audio and video recording whereas the second pilot observation, which was primarily to check the feasibility of an outline essay as a task deliverable, was conducted outside laboratory conditions, i.e., off-campus, audio recorded and notes taken. Both pilot participants matched the overall sample criteria.

The Study, as reported in this Chapter, incorporated the changes made as a consequence of the pilot runs, namely

- the task description sheet was modified to explicitly mention the audience characteristics for the task presentation (ref Appendix B).
- the order of the questions in the de-briefing post-session questionnaire was altered. A question asking for self-assessment of their expertise was moved from the third position to the fifth position out of eight questions, in the belief that new order questions 3 and 4 could help them better prepare to answer the new order self-assessment question 5 (ref questionnaire Appendix B).
- the outline essay deliverable option was eliminated; it was evident that participants might spend considerable time editing sentence flow and might only deliver a single detailed paragraph, as did the pilot volunteer. The task context was defined as preparing for a slide presentation to a mixed community audience (5.1.1).

5.2.2 Participants: Sample Recruitment and Profiles

In line with sample size guidelines, eight participants were recruited from the pool of staff across two academic faculties. The single criterion, i.e., that volunteers should be experienced information processors, was explicit and examples of what constituted "experienced information processors" were offered (ref 'Call for Volunteers text' in Appendix B.

Recruitment, via internal email to a range of user groups, was initially opportunistic but some purposive sampling (Silverman, 2005, pg 129) was used to provide a reasonable cross-section of role types. Eight respondents were selected, based primarily on their availability match with laboratory availability, but some attention was paid to the mix of the group, i.e., to provide a balance across both the PhD student year groups and staff roles. The mix of participants is shown in Table 5.2.

Participant role-type characteristic:	Numbers:
PhD students	4
Academic staff	2
Research Fellow	1
Academic related staff	1
Total in sample:	**8**

Table 5.2 Participant numbers across different role types

All years of the PhD programme and broad generic groupings of academic and academic related staff were represented. The full summary of participant profiles is shown in Table 5.3.

p-ID	Role:	Internet exp(yrs):	Computing exp(yrs):	Self-eval of experience:	Success rating:	Frequency: web-based searches	Purpose of searches:
P1	PhD final year	12	33	4	3	Several times per day	W, R, P
P2	Senior, Academic-related	10+	20	4	3-4	Several times per day	W, R, P
P3	Academic	4+	30	5	4	Couple times per week	W, R, P
P4	Academic	20+	25+	4	5	Several times per day	W, R, P
P5	Research Fellow	11+	20	4	4-5	Several times per day	W, R, P
P6	PhD year2	10	10+	5	5	Several times per day	W, R, P
P7	PhD year1	8	8	4	5	Several times per day	W, R, P
P8	PhD final year	12+	14+	3	3	Several times per day	W, R, P

Table 5.3 Summary of participants' profiles

Legend: purpose of search: W → work, R→ research, P→ personal

All volunteers presented themselves as experienced information processors: based on a scale of 1 (low) to 5(high) they self-rated their experience as 'above average' in all apart from one case, and all rated their success-rating, i.e., how successful they were in locating sought information as typically ‘average’ or ‘above average’. Other questionnaire responses confirmed their self-ratings; they all appeared to have considerable computing and internet experience and used the internet at least a couple of times per day to seek information for work, research, or personal use. The participant-ID (p-ID) was allocated in the order of the observations and volunteers’ identities were kept confidential.

5.2.3 Environment: Laboratory Configuration and Resources

The laboratory was set up in accordance with overall design decisions (ref Chapter 3.4). Within the room constraints, it was configured to ensure that all recording equipment was as unobtrusive as possible, and that the ‘note-taker’ (researcher) was seated outside both the video-recording arc and the participant’s line-of-vision. The layout can be seen in Figure 5.2

Figure 5.2 Study-2 laboratory configuration

The layout needed to discreetly accommodate both video and screen shot capture equipment. The laboratory equipment included

- a movable video camera and fixed video recording equipment;
- screen shot capture software with screen stream recording equipment;
- a locally connected printer;
- a laptop with a range of relevant pre-installed software.

Video recording equipment can be very disruptive and intrusive; the video camera was positioned out of the direct line of participant’s vision, but poised to view over their right hand shoulder, to ensure capture of both participants’ behaviours and the concurrent image they were viewing on the monitor. However, the monitor image was a relatively small proportion of the video frames; to address this, the available screen capture software was utilised to separately capture the screen images directly from the monitor. Later in processing, the video and screen image streams were merged to generate a single DVD output with the screen (monitor) image enlarged and overlaid into the main video frames.

Other resources

A laptop computer was set up with internet connection and a range of software, *MsWindows*, alternative search engines, browsers, and a standard selection of software packages including *MsOffice*. The types of information seeking resources identified for this Study and collectively referred to as *i-s resources* (ref Chapter 3.4.1) are listed in Table 5.4.

Type of resource:	**Resource example:**	**Comment:**
resource-T/S	Task-sheet	Paper version of the task description was supplied and available throughout the session; the task-sheet held a full description of the task and its requirements (ref Appendix B)
resource-G	Google–collection of results	Both electronic and paper versions of the collection of sixteen Google search results, merged from four previous searches, held as an *MsWord* document, were supplied. All of these search result entries were clickable to live WebPages of information content (resource-S);
resource-S	Web-based Information source	Live, electronic version of source, directly accessible via clickable hyperlinks in results Google-collection. Some paper versions of web-based sources also readily available;
resource-IW	Intermediate workspaces	Top-level categorisation of intermediary working/scribbling tools, such as: - *(resource-IW-p);* - *(resource-IW-w*).
resource-IW-p	Pen-and-paper as instance of intermediate workspace	pen and numbered sheets of blank paper (*pen&paper*) offering personal workspace
resource-IW-w	Instance of *MsWord* as instance of Intermediate workspace	Electronic facilities offering personal workspaces, such as *MsNotepad, MsWord, MsExcel, NotesView* of *MsPowerpoint*
resource-D	Slides for task deliverable presentation	Software package *MsPowerpoint* was available to capture their task deliverable representations, i.e. an outline slide presentation

Table 5.4 Types of supplied laboratory resources and examples

A locally connected printer was made available throughout the session, but to minimise potentially wasted time waiting for printouts during the observations, a pre-printed set of the sixteen website's homepages was available to be used as needed, i.e., in the event that a participant requested a printout of any of the known sixteen information source' *WebPages*. Hard copies of second-level *WebPage(s*), e.g., located during the task via a drill-down or clicked hyperlink, could not be anticipated and were to be printed during the session if/as required.

5.2.4 Procedure

All observations were conducted in the configured laboratory. A combination of audio, video, and screen capture facilities captured participants 'think-aloud' and their physical actions as they completed the task. Each session began with an introduction; the purpose was to

- explain the session with respect to expectations, e.g. participants were asked to think-aloud as they completed the task, and the data collection processes;,
- conduct a set up routine with each participant to ensure all equipment worked effectively and was able to detect participant's normal speaking voice;
- issue a paper & electronic copy of the task-sheet (task description) and answer any queries arising;
- obtain a signed consent form from each participant (ref copy in Appendix B).

Data was captured in accordance with the design guidelines for this Study (ref Chapter 3, Table 3.2). The specific types of data and the precise method of collection are summarised in Table 5.5.

Participants' think-aloud utterances were transcribed and annotated with timestamps (ref 5.3).

Type of data:	Method of Collection:
Evidence of participant's sensemaking, i.e. utterances and behaviours throughout the task:	
	Laboratory based observation with -Think-aloud protocol & audio recording; -Dual stream video capture of participant behaviours & screen interaction with all electronic resources; -Researcher note-taking;
Evidence of explicit external representation, i.e., what & when:	
	- Audio and video recording; - Researcher note-taking; - Post-study gathering of (any) generated representations;
Demographics, such as experience etc. & general debriefing:	
	- Post-session questionnaire

Table 5.5 Study-2: types of data and methods of collection

Each session was scheduled to last no longer than 1hr 30mins, including set-up, briefing and debriefing activities. The length of the actual recorded sessions, excluding briefing and debriefing, are listed in Table 5.6.

Participant:	p1	p2	p3	p4	p5	P6	p7	p8
Duration(mins):	50.15	57.54	75.23	44.22	74.44	75.33	82.24	82.38

Table 5.6 Observations: duration of individual participant's sessions (in minutes)

Where possible, participants were allowed to progress to a natural end, but there was no pressure to continue once they had signalled that they were ready to stop. This flexibility within the 1hr 30mins session guideline accounts for the variation in the actual session lengths. The sessions concluded with a short debriefing exercise based on a post-session questionnaire (5.1.3) during which participants were encouraged to reflect on their session. Any external representations, e.g., presentation slides and any working notes generated during the session were captured and retained.

5.3 Analysis

The primary unit of analysis for this Study was an individual's behaviours and associated utterances as they interacted with each of the supplied resources during the defined topic-comprehension task. The dual stream data capture was transcribed and the transcripts were time-stamped regularly for general ease of access; other annotation and timestamps included relevant references from the video, screen captures, and field notes at points of interesting activity. Activity considered interesting included

- a participant's first and returning interactions with electronic resources (video);
- screen capture reference points identifying their interactions with instances of information sources;
- a participant's non-electronic interactions with supplied resources.

Annotating the transcripts provided both a richer base data set and a verification mechanism.

Open coding was adopted (Gibbs, 2002, pg 167ff). Coding was inductive and iterative, with the initial raw action coding based on two aspects:

i. the evidence of interactions with the resources provided, namely *resource-T/S, resource-G, resource-S, resource-IW (various), resource-D* (Table 5.4).
ii. the empirically based framework of search, evaluation, and use actions (ref Chapter 4, Figure 4.4).

The mechanisms used to validate and verify the coding schemas are discussed in Chapter 3, (ref 3.7) and the specific coding approach adopted is discussed in more detail in this Section.

The analysis was qualitative, inductive and iterative and consisted of five steps; each step generated one or more outputs which were often subject to a further step of analysis (Figure 5.3).

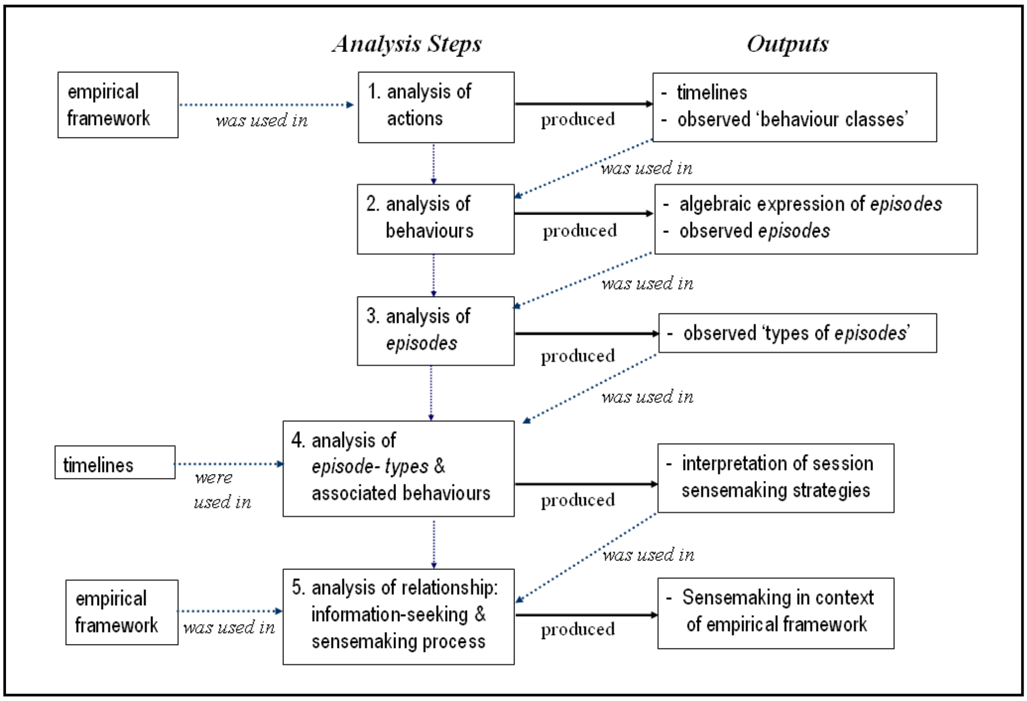

Figure 5.3 Five-step analysis and associated outputs

These outputs together provided the basis for an interpretation of participant's sensemaking. The individual analysis steps and their respective outputs are now discussed in detail (Sections 5.3.1 – 5.3.5) and where possible participant p3 is used to illustrate the analysis steps.

5.3.1 Analysis Step 1: Identifying Interactions and Behaviour Classes

There were two outputs from this analysis of actions, the first step of the process:

i. individual participant timeline graphs representing participant's interactions with the various supplied resources (5.3.1.1);
ii. observed behaviour classes (5.3.1.2).

5.3.1.1 Output: individual timeline graphs

Individual participant timeline graphs visually represented each participant's interactions with the supplied resources during the task, i.e., interactions with instances of

the task-sheet (*resource-T/S*),	}
the Google-collection *(resource-G*),	}
web-based information sources (*resource-S*),	} (Table 5.4)
various intermediate workspaces (*resource-IW*)	}
slides (*resource-D*).	}

An extract from an annotated timeline is shown in Figure 5.4. Colour coded one-minute cells reflect resource interaction occurrences during that one-minute time interval, however filled cells do not differentiate between a 'one second' duration or a full 60 second duration interaction, i.e. they simply indicate the presence of an interaction behaviour. Any interactions longer than one minute show as blocks of contiguous colour-fill, for example, two contiguous cell-fills highlight interactions which last more than one minute; three contiguous cells highlight interactions which last longer than two minutes. Interactions lasting two minutes or longer, are termed 'long' interactions, whereas 'short' is used to describe interactions which typically lasted less than two minutes.

The interactions are enriched with timestamps, e.g., these are used to indicate start behaviour or an important/interesting behaviour, and additional annotations identify relevant or significant aspects of the interaction, such as a first switch to a particular resource or a change of an information source.

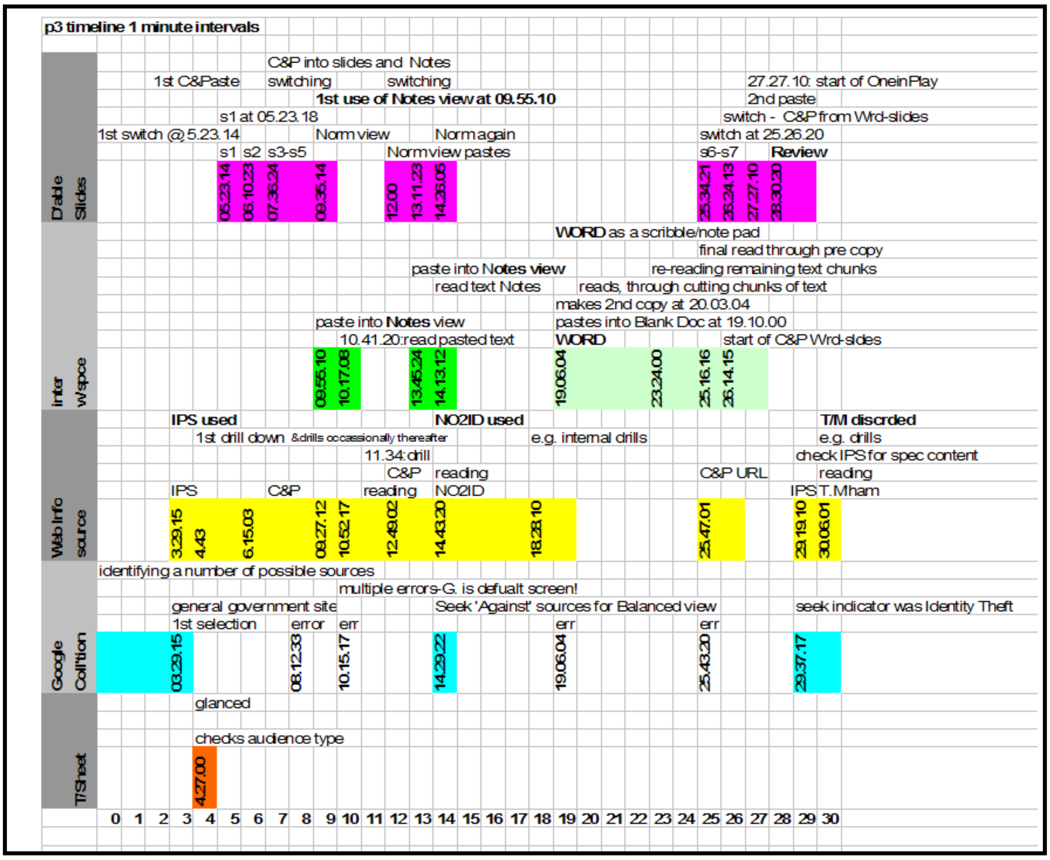

Figure 5.4 Extract from participant p3 timeline: timeslots 0.00-30.00

This extract shows interactions across all supplied resources and highlights how instances of web-based sources are 'in-play', i.e. visible and in use for much of this time period. It also highlights the many timeslots when multiple resources are 'in-play', e.g., 3rd, 14th, 29th minute. The full set of timelines is found in Appendix D.

This analysis was iterative; the first two available transcripts, participants p1 and p4, were analysed initially to determine the feasibility of the coding scheme. These were manually 'chunked' and colour-coded with respect to the different resource interactions, and timelines were generated. Originally, a baseline of two-minute intervals for the timelines seemed reasonable and was applied to these two cases; however, most of the interactions proved to be only a few seconds or more duration, thus a one-minute time interval was chosen as a more suitable baseline and these first two timelines were regenerated.

The next two cases, participants p2 and p3, were then analysed; no further issues were encountered although it became evident that each participant had their own preferred 'intermediate-resource', some using a mix of two or more instances. These interactions were initially coded at the generic top-level categorisation (*resource IW*), to be further investigated between the different types of these resources later, e.g., *pen&paper* (*resource IW-p*), etc.. The remaining four transcripts, for participants p5, p6, p7, p8 were analysed to determine further emergent groupings and initiate further questions of the data. Apart from case p4 and p1, all cases were analysed and coarse coded in the order they were observed. Participant identification codes (p-ID) were allocated in the order they were observed.

Overall timelines provided valuable insight into participants' interaction behaviour; they provided a key into the detailed transcripts and an insight into behaviours which underpin participants' problem-solving or sensemaking activity. As such they provided the baseline for further analysis into the nature of a participant's interaction behaviours with the separate resources, and allowed questions to be asked about the significance of different interaction patterns.

5.3.1.2 Output: observed behaviour classes

The second aspect of the initial coding was to analyse participants' interactions with reference to the empirical framework from Study-1 with respect to previously identified *search*, *evaluation* and *use* interaction behaviours (ref Chapter 4, Figure 4.4).

Preliminary attempts to code at a lowest level of detail proved over complex and the approach was revised. Further analysis showed many of the behaviours broadly mapped into the information interaction categories previously identified in the empirical framework, namely

- searching, (looking for sources)
- selection, (potentially useful sources are identified)
- evaluation, (a decision is made about the source, an action may be taken)
- use, (the gathered information is compiled or interpreted – evidence in utterances and external representations)

A fifth behaviour, i.e., planning behaviour, emerged from the iterative application of the coding schema. This was an important behaviour which relates the other behaviours to the task.

Identified behaviours were renamed from those named in Study-1 to distinguish them as Study-2 observed actions, i.e., *seek*, *eval(s), eval(u), compile*. The coding schema raised several issues and challenges which were resolved through continuous clarification and iteration; for example,

- in the first empirical Study (Study-1, Chapter 4), the search behaviours were observed interactions with the 'search engine query interface'. Whereas in this second Study, searching for results involved interactions with a supplied, pre-determined, Google-collection of search results. Thus, in this Study-2, searching or 'looking for sources' was considered on the boundary between inspecting the offered results (from the Google-collection) and identifying those potentially useful. That is, it was considered on the boundary to '*evaluating for selection*';
- typically the information sources were selected from the supplied Google-collection but occasionally participants drilled-down to seek for new or different information sources by navigation, i.e., following hyperlinks contained in sources. These hyperlinks were usually held as embedded links within the source or as an out-of-line separate list e.g., margin or end-of-source reference lists. When a selected hyperlink led to a different source and it was an in-line hyperlink action, it was coded as *eval(s);* a similar out-of-line action was coded as a *seek + eval(s)* to reflect the move/intent to locate an alternative source. These hyperlinks can be considered as internal & non-significant if they drilled-down into the existing website and were thus not coded;
- another challenge was the mapping of evaluation behaviours to either *utility* or *personal fit* judgments. The demarcation between the two types was not clear enough at coding stage, thus a decision was taken to code as a single *evaluation for use*

behaviour and investigate the properties when more was understood about the behaviour (ref Chapter 6.4.4).

Instances of behaviours were further informed from the timeline capture and the five classes of behaviour are defined thus:

seek:	looking for sources, i.e., accessing the supplied Google-collection, the transition into *evaluation-for-selection*
eval(s):	evaluate for selection (potentially useful sources are identified)
eval(u)*:*	evaluate for use (a decision is made about the source, an action may be taken)
compile:	use (e.g., the gathered information is compiled, transcribed, paraphrased, ordered/tidied, or interpreted)
plan:	planning relates the other actions to the task; it is implicit in the framework, but explicit in participant's behaviours and utterances. Planning has four distinct purposes: i. gather requirements ii. decide 'what to Do' iii. decide 'what to Use' iv. review, such as progress, set or revise goals, etc..

Each behaviour class had its own complexity and characteristics that varied within context. In addition, many behaviours were iterative and such cases were marked accordingly (*).

With respect to *planning* behaviour, the underlying actions may be expressible by one of more of the other four coded behaviours. This is the case with planning 'what to Use', expressed by a *seek* behaviour (denoting access to the Google-collection) and (*eval(s))* (evaluating for selection from the listed search results). Accompanying utterances determine if it is a *plan* action. Some examples of actions coded as instances of one of the five behaviour types are shown in Table 5.7:

seek:	***eval(s):***	***eval(u):***	***compile:***	***plan:***
move to Google-collection to launch and access a search results	inspect & evaluate a result in supplied Google-collection and immediately pursue (click to launch selected source)	evaluate an actual information source for use (*utility*)	a single extraction from source to task deliverable	deciding what's required with reference to the Task-sheet (*resource T/S*)
move to browse a 'references' list or offered within an info source, i.e. a 'proxy collection', to pursue an alternative info source	browse Google-collection electronically for a result to launch, e.g., *FindOnPage* facility	revisit an open source after having moved away for a period of time	iterative switch from source to intermediate w/space + iterative switch between w/space and slides in same time-slot	deciding what to browse Google-collection results to plan 'what to *Use'*
transition into a select *(seek +eval(s))* immediately after a plan activity	inspect & evaluate a result in Google-collection & explicitly note worthiness for later source inspection, but not clicked at this stage	using F*indOnPage* for keyword content during source evaluation	an iterative (or not) activity from source to intermediate resource at this point-in-time	decide 'what to Do': creation of outline slides [schema]
move to launch and access a search engine, e.g., Google	evaluate a hyperlink within a source (drill-down)	evaluate and decide source is worth printing for later reference	an iterative (or not) activity from intermediate resource to task deliverable(slides), but isolated from original intermediate representation activity	review activity, e.g. representation, (which may include new slides) and poss one or more reference to the task-sheet

Table 5.7 Examples of each of the five behaviour-coded actions

Each participant's session consisted of multiples of instances of these behaviours.
To illustrate, an extract from participant p3's coded behaviour as it related to seeking, evaluating and extracting from two different web-based information sources, is shown in

Figure 5.5. These behaviours were further informed from the timelines during this period of time (Figure 5.4).

0.00.00 plan[what to Use from Google-collection]
O3.29.15 seek + eval(s)
03.29.10 eval(u)[IPS] +
05.23.14 compile [inc NOTES]
14.29.22 seek + eval(s)

Figure 5.5 Participant p3: extract coded behaviour with annotation (extract 0.00-28.30.20)

Abstraction from these chains of instances of behaviour enabled a better understanding of what these behaviours were 'saying', and where patterns and commonality might exist.

5.3.2 Analysis Step 2: Identifying *Episodes* of Behaviours

Sessions, as captured by timelines, can be conceptually divided into repeated chains of interaction behaviours. The term *episode* is used in this thesis to describe discrete chains of behaviour, i.e., one or more behaviours, algebraically expressed as abstractions from the behaviour coding scheme (5.3.1.2). Each *episode* had a focus or purpose, and was delimited by a recognisable change of focus along with simplicity of abstraction. There were two outputs from this analysis step:

i. algebraic expression of *episodes*
ii. observed behaviour *episodes* as sequences.

5.3.2.1 Output: *episodes* as algebraic expressions

Algebraically expressed instances of *episodes* can vary in the number of component behaviours and their complexity; examples include

*seek + *eval(s)*

represents an *episode* in which the participant initially seeks, then repeatedly evaluates for selection, that is, they identify several results worth pursuing;

eval(u)+ compile

is an *episode* purposefully evaluating a source for use and then compiling or extracting from it;

seek + eval(s) + eval(u) + compile

involves a move to (an instance of) the supplied Google-collection, inspects one result and select (highlight/click) the chosen result, process the subsequently presented information source, i.e., evaluate for use and compile, i.e., use content from the source in note-making, etc..

Iteration is an underlying complexity of *episodes* and is annotated accordingly, e.g., at individual behaviour, combination of component behaviours, or across the *episode* as a whole. The *episode*

*eval(u) + *(*(seek + *eval(s) + eval(u)) + compile)*

represents the following actions

- evaluate an existing (open) web-based information source (*eval(u))* and discard;
- two or more iterations over the combined three behaviour:

  seek, i.e., move to the Google-collection, inspect two or more results *(*eval(s))*, click or select a result and evaluate the chosen information source *(eval(u))* but discard source (perhaps just temporarily);
- followed by one or more iterations over all four component behaviours, i.e., over seek & select (after inspection of two or more results), evaluate source and compile (physically extract) from the information source.

This can be visually expressed as in Figure 5.6:

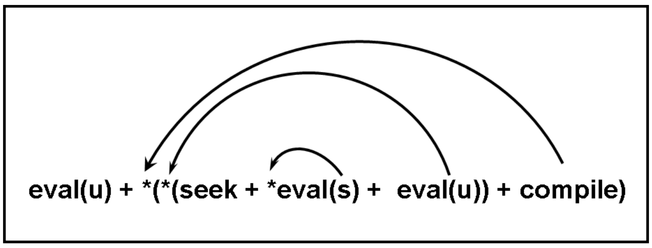

Figure 5.6 Example of iteration over an *episode* of behaviour

Occasionally an abstracted *episode* did not satisfy the criteria of simplicity. The following instance represents a grouping of focused behaviour *episode* but it could not be further abstracted, i.e., simplified

**(*(*eval(u) + compile) + *(eval(u) + seek + eval(s)))+ *eval(u) + compile + eval(u))*

5.3.2.2 Output: observed behaviour as sequences of *episodes*

Grouped as a sequence, the *episodes* form an expression of what the user did in any one session that was recorded. Each of the sequences of *episodes* provided a high-level view of that participant's behaviour; they showed both the integration and iterative nature of their underlying behaviours. An example sequence of *episodes* is shown in Figure 5.7 and all eight participant's individual sequences can be found in Appendix C.

1. *plan*
2. **(seek + eval(s) + eval(u) + compile)*
3. *plan*
4. *eval(u) + *(*(seek + *eval(s) + eval(u)) + compile)*
5. *plan*
6. **(*(seek + *eval(s) + eval(u))+ compile)*
7. *plan*
8. *seek + eval(s) + eval(u)*

Figure 5.7 Participant p3's user session expressed as a sequence of *episodes*

By dividing sessions systematically into *episodes* represented with a simple algebra, behaviour sequences were highlighted in a way that made it easier to identify patterns within and among sessions.

5.3.3 Analysis Step 3: Recognising 'Types of *Episodes* of Behaviour'

Five broad types of recurrent *episode* resulted from looking for commonalities and patterns. These were identifiable from

- each *episode's* underlying behaviour components
- its broad purpose
- any associated utterances.

These emerged from both examination of the *episode's* component behaviours and evidenced by related, explicit utterances. The five types of *episode* descriptors or labels intentionally indicate the nature of the associated behaviour contained in the *episode*. They are named and described as:

i. ***SeekToEvaluateForCompile***: describes any *episode* whose purpose was work with a source from seek through to usage. It contained a singleton or iteration of successive *seek, eval(s) to select, eval(u)* with an outcome of *compile* or not, i.e., the source could be discarded;

ii. ***SeekToEvaluateToCorroborate****:* was an *episode* representing the participant's intent to *seek* and select and evaluate one or more Google-collection results to corroborate other found or known information. The source content was never explicitly used, i.e., there was never a *compile* outcome from source evaluation *(eval(u)).* Whilst it can be argued that all *eval(u)* might include some form of corroboration, e.g., implicit comparison of located content, only *episodes* which had explicit statement of 'intent to corroborate' were labelled thus. That is, accompanying explicit utterances indicated the intent was corroboration or some form of comparison, and hence distinguished it from an *episode* representative of a 'seek to evaluate' but discard. All other examples were subsumed by *SeekToEvaluateForCompile* with an evaluation *(eval(u))* outcome of discard;

iii. ***EvaluateForCompil****e*: was any *episode* which intentionally evaluated located content for use *(eval(u))*, although c*ompile* was not necessarily an outcome, i.e. the intent may have been to evaluate for usage but instead the outcome could have been either discard, or note (the source) for later reference, or simply delay the use of the source. The *eval(u)* may have been the initial evaluation of an information source or a subsequent evaluation of a source that had not been previously used. Importantly, there was no significant *seek* behaviour, i.e., the source was already open ready for evaluation, although occasional drill-down *(seek+eval(s))* activity was present;

iv. ***Compile****:* was any *episode* where the dominant purpose was using the source, i.e., the *episode* contained *compile* behaviour dedicated to the use of source content with no significant seek, selection or evaluation activity;

v. ***Plan [indicative purpose]***: describes any *episode* which predominantly contained behaviour indicative of one or more of the four types of planning (5.3.1.2). Other behaviours such as an *eval(u)* as part of a review activity could be present, but planning intent remained the main focus of the *episode*.

The use of descriptive *episode-type* labelling readily informs more about the user's overall problem-solving approach. Analysis of these resultant sequences of *episode-types*, e.g., with respect to frequency, when they occurred in the session and the combinations, together with understanding the nature of the associated behaviours and how resources were used, provide insight into how participants made sense, i.e. how they collected and interpreted the located information for the task-in-hand.

To retain the richness of the behaviour *episode*, the sequences were colour-coded as *types* and a set of all participants' sessions, expressed as sequences of colour-coded *episode-types* is shown in Figure 5.8:

P1:

1. plan [*what to Do+ req T/S + what to Use*]
2. *(*(seek +*eval(s) + eval(u)) + compile)
3. seek + *eval(s) + *eval(u)
4. plan [*what to Use + review slides + req T/S]*
5. eval(u)
6. plan [*review slides*]
7. eval(u) + compile
8. plan [what To Use/*review+ review(slides)*]

P2:

1. *(*(seek +*eval(s) + *eval(u)) + compile)
2. *(seek+ eval(s) + *eval(u))
3. *eval(u) + seek + eval(s) + eval(u) + compile
4. plan *[review slides*]
5. eval(u) + compile + *eval(u) + *(*(seek + eval(s) +eval(u))+ compile)
6. *(*(seek + *eval(s) + eval(u)) + compile)
7. *(seek + eval(s) + eval(u))
8. plan [*review slides + ref source*]

P3:

1. *plan* [*what to Use*]
2. *(seek + eval(s) + eval(u) + compile)
3. plan *[review slides]*
4. eval(u) + *(*(seek + *eval(s) + eval(u)) + compile)
5. plan *[review slides+ req T/S*]
6. *(*(seek + *eval(s) + eval(u))+ compile)
7. plan [*review slides*]
8. seek + eval(s) + eval(u)

P4:

1. plan *[req T/S]*
2. seek + eval(s) + eval(u) + compile
3. plan *[what to Use + review slide s+ what to Do*]
4. *(*(seek + *eval(s) + eval(u)) + compile)
5. plan [*review slides*]
6. eval(u) + compile + *(seek + *eval(s) + eval(u))
7. plan [*review slides*]
8. eval(u) + seek + *eval(s) + eval(u) + compile + *(seek + *eval(s) + eval(u))
9. plan [*review slides*]

P5:

1. plan *[req T/S + what to Do + what To Use]*
2. *(seek +*eval(s) + eval(u) + compile)+ seek+ *eval(s)
3. plan [*outline + req T/S*]
4. eval(u) + *compile + *(seek + eval(s) + *eval(u) + *compile)
5. plan [*review p&p+ req T/S]*
6. compile
7. *(seek + eval(s) + eval(u) + compile)

P6:

1. plan [*what to Use*]
2. *(seek +eval(s) + eval(u))
3. *(seek + eval(s) + *(eval(u) + compile))
4. *(seek + eval(s) + *eval(u))
5. plan [*what to Do +ref source + review p&p]*
6. *compile

P7:

1. plan *[what to Use + req T/S]*
2. *(seek + eval(s) +eval(u))
3. plan [*what to Use + what to Do]*
4. eval(u) + compile + seek +*eval(u) + eval(s) + *(*eval(u) + compile)
5. plan *[review slides + what to Use]*
6. *(*(*eval(u) + compile) + *(eval(u) + seek + eval(s))) + *eval(u) + compile + eval(u)
7. plan *[review sources + review Collection +refs source + what to Use(Live Google)]*
8. *(*eval(u) + eval(s)) + *eval(u) + compile
9. plan [*review slides +Live Google seek +refs source+ review slides]*
10. *(*eval(u) + compile) + eval(u) + seek + eval(s) + *(*eval(u) + compile)
11. plan [*what to Use*]
12. *eval(u)
13. *(seek + *eval(s)) + eval(u) + seek + *eval(s) + seek + *eval(u)
14. plan [*review slides*]

P8:

1. plan [*req T/S + what to Do]*
2. plan *[what to Use]*
3. *(seek + eval(s) + eval(u) + compile)
4. plan [*what to Use]*
5. seek + *eval(s)+ eval(u) + compile
6. plan [*review slides + req T/S*]

Legend:
'*Episode* Type' descriptors:
SeekToEvaluateForCompile
SeekToEvaluateToCorroborate
EvaluateForCompile
Compile
Plan[*+ indicative purpose]*

Figure 5.8 Set of participants' sessions as sequences of colour-coded typed *episodes*

(A full size page is in Appendix C)

5.3.4 Analysis Step 4: Interpreting Participants' Sensemaking Strategies

For each session, a participant's individual sensemaking strategy can be broadly inferred from their sequence of behaviour *episodes-types*, together with reference to which resources are 'in-play' (visible and in use) and as corroborated by participant utterances. Together these can be interpreted to describe their sensemaking strategy, in terms of:

> when and how they *plan*,
> how frequently they use/refer to the task specification,
> what is the dominant approach e.g., top-down task oriented, or reactive, data driven;

their seek-select approach,

> when it happens and its relationship to other activities,
> what triggers their seeking,
> etc.;

how they evaluate,

> when it happens and its relationship to other activities,
> depth or breadth approach,
> in association with what sources,
> etc.;

their extraction patterns

> extract immediately or read a lot and extract at end, etc.;

how they use content to represent their understanding,

> what examples of structure prior to looking at sources etc.,
> what purpose are the emergent representations,
> etc.;

for any given source, how they use it,

> how many sources were used/discarded,
> patterns of decisions, early later,
> etc.;

how they use resources,

> how do they store and organise,
> are resources used in alternate roles,
> how many resources they typically keep 'in-play'.

These and other questions asked of the sequences of *episode-types* alongside the associated timelines serve to discover how participants made sense as they collected and used web-based information sources for their task purposes.

To understand the relationship between the sensemaking and seeking process, the range of participant's individual sensemaking strategies needs to be considered within the wider information seeking context.

5.3.5 Analysis Step 5: Exploring the Relationship Between the Information-seeking and Sensemaking Processes

Each of the participant's sensemaking strategies, as represented by a sequence of colour-coded *episode-types* (Figure 5.8*)*, was mapped against the emergent empirical framework (ref Chapter 4, Figure 4.4). Thus the framework models the strategy and provides a basis to explore and examine this relationship. It highlights any relationship between the information seeking process as represented by categories of information interaction, and the sensemaking strategies identified by the first four steps of Study-2 analysis. This enables the relationship to be explored. A full set of mappings are in Appendix C.

5.4 Study Evaluation

Study-2 was conducted from May 2007 until July 2007. The elapsed time was to accommodate laboratory access which was available for a maximum of two observations per week. Additional constraints were both the participant's and the researcher's availability matching the laboratory availability.

The Study design specification and the design criteria were met overall. Participants matched the requirement to be experienced information processors, and the group profile was a respectable sample from each of the faculty's staff profile. Furthermore, their feedback was generally positive and indicated that the session-task proved to be both engaging and popular.
A laboratory was equipped with the necessary recording facilities to capture both screen and participant images. All necessary information seeking type resources were readily in-place and all participants claimed, during debriefing, to have everything they would normally use for such a task. The laboratory environment was not identified as a problem apart from one case (p4) who indicated some difficulty with this type of task in 'laboratory-type conditions'.

The data sources were collected as planned:

- the resultant set of transcripts contained their transcribed think-aloud utterances, captured using dual-stream video recording. These held additional annotations from field notes, video recordings and screen captures;.
- any external representations, i.e., artefacts, emergent during the session were immediately gathered post-session;
- questionnaires captured demographic, some aspects of recalled typical behaviours, and session response data.

Together these provided a rich mixed source of data.

Analysis was broken into five distinct steps which made the analysis process more manageable and added to the uniqueness of the approach. Analysis remained manual throughout: to import into qualitative software, e.g., *Nvivo*, would have resulted in considerable loss of both formatting and annotations from the transcripts.

5.4.1 Data Collection Limitations

There are three aspects worth reflection, namely,

- lab based observations, with time constraint;
- the restricted access to any keyword search engine facility;
- technology hiccups.

5.4.1.1 Lab-based observations with time constraint

A time constraint is inevitable in any empirical observed studies; this constraint may have impacted on the participant's behaviour although all claimed that they acted as typical for the type of task undertaken. The constraint was minimised in as much as there was no requirement that every supplied information source had to be accessed or used, nor that the task deliverable had to be complete; thus it was hoped that what they did undertake in the session was typical behaviour for that type of task.

The think-aloud protocol has known limitations, i.e., it does not always elicit a volunteer's thought process (e.g. Ingwersen 2005). In this Study volunteers did not always convey their thoughts and some prompting was necessary, although steps were taken to minimise any intrusion as much as was possible, e.g., on such occasions, the timestamps were noted and the transcripts and recordings were scrutinised to detect any unusual or unexplained change in behaviour; no significant examples were found. On the other hand, occasional prompting did appear to encourage participants to talk and explain what they were doing and thus they occasionally lingered at that activity.

Video-stream screen capture does not guarantee unambiguous traces to the origins of used information, i.e., there is no exact traceability between the content used in the slides and its origins (instance of information source). This deficiency could be countered to some extent, for example, some association could be determined from the slide content and researcher's observation notes, although this is more difficult when participants build their own notes in intermediate resources such as paper (*pen&paper* resource) prior to their final representation in slides. Overall this perceived lack of traceability was not considered an issue for this Study.

5.4.1.2 Restricted access to keyword search engine features

This advised limitation appeared to slightly irritate only one participant and then not significantly, although several other participants did drill, i.e., followed hyperlinks to external sources from supplied sources. These actions occasionally resulted in access to web-based information sources not actually supplied via the Google-collection but in many cases the 'non-supplied source' was discarded without use, i.e., only four from 15 extra sources accessed were actually used. On another occasion, a participant was so concerned that they were not seeing what they believed should have been a search result entry in the Google- collection, that they undertook a new keyword search (using '*Live Google'*) - but this did not give them the expected results either, so they abandoned that approach. These actions would further indicate that the supplied Google-collection of search results was representative of the web-based information sources available at that time.

5.4.1.3 Technology 'hiccups'

The sessions experienced a few technology problems, although most were quickly resolved. The main interruptions happened during one particular session - when the audio recording feature of the video system temporarily failed on three separate occasions. Another interruption was due to the participant accidentally switching off the audio recording device; no data was lost as the participant identified the problem immediately they realised it occurred.

A few other technical interruptions were due to the difficulties participants had using the combined '*Ctrl&Enter'* function, specific to *MsWord*, to launch a live *WebPage-source*.

Most of these were resolved but occasionally the participants failed to launch a requested page due to both their adjustment and the slowness of the system to respond to their commands. These problems were outside of the researcher's control.

5.5 Summary

Empirical Study-2 was conducted in accordance with the design decisions as detailed in Chapter 3 and summarised in this Chapter (5.1). Two pilot studies checked the implementation procedure for nuances and issues, and from that a few modifications were undertaken prior to conducting the Study. Post-evaluation showed the empirical Study met the design criteria overall and the comprehension task proved to be interesting and engaging. A few limitations of the data collection were identified, e.g., the limitations of think-aloud protocols, the restricted access to keyword search engine facilities, and technology 'hiccups'; none had a significant impact on the Study.

Eight participants, all experienced information processors, were recruited to undertake a laboratory-based topic-comprehension task. Initial recruitment was via email circulation to selected distribution lists, followed by some purposive sampling. The task chosen was informed by both research and results from a straw poll, i.e.,

> *"Prepare, in outline, a 15-minute slide presentation for a mixed local community audience on the given topic: Determine and discuss the key issues with respect to the implementation and the implications of ID cards in the UK"*

A range of identified resources were supplied, including a pre-gathered closed-corpus collection of previously researched search engine results relevant to the topic. The laboratory based observation data was collected by several methods, namely,

- audio recording of think-aloud protocol;
- dual stream video capture of participant behaviours & screen interaction with all computer-based resources;
- researcher's own note-taking;
- post-session collection of (any) generated representations & post-session observation debriefing based on questionnaire.

Data analysis was qualitative, inductive and iterative. The initial raw (inter)action coding was based on two aspects:

- the evidence of interactions with the provided resources, namely, task-sheet *(resource-T/S)*, pre-gathered collection of *Google* search engine results (*resource-G*), various instances of information sources clickable from the supplied Google-collection *(resource-S*), various intermediate workspaces such as *pen&paper (resource-IW*), and task presentation resource, i.e., *MsPowerpoint* slides (*resource-D*).
- the empirically based framework of search, evaluation, and use actions (ref Chapter 4, Figure 4.4).

Analysis was broken into five distinct steps (Figure 5.3); outputs from each of the first four steps were typically subjected to a further step of analysis and some of the intermediate outputs not only contributed to the overall understanding of the results but also served as significant outputs in their own right. To illustrate, individual participant timelines which captured and highlighted participant interactions with the supplied resources were significant for further investigation into, and coding of, the raw (inter)action data (analysis step 1, Figure 5.3).

Each participant's session was associated with a sensemaking goal, i.e., to evaluate, understand, and make use of located web-based content. Thus each participant's sensemaking strategy could be broadly interpreted from the distinct sequence of behavioural *episode-types* that captured their session (output from analysis step 3 used in step 4, Figure 5.3). Associated individual timelines and utterances enhanced and reinforced this interpretation.

Furthermore, each of these algebraically represented sequences could be interpreted to determine the range of sensemaking strategies exhibited by the participants, during their sessions, as they undertook the given Study-task (analysis step 4, Figure 5.3). In addition, each sensemaking strategy, algebraically expressed as a sequence of *episode-types* (Figure 5.8) could be mapped to the emergent empirical framework (ref Study-1, Chapter 4, Figure 4.4), to model the participant's strategy within an information seeking context (ref Appendix C). This mapping offered the basis for exploring the relationship between the information seeking process and participant's sensemaking strategies.

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Chapter 6 - Empirical Study 2:
Sensemaking During a Web-Based Topic-Comprehension Task

6.1 Introduction

This Chapter reports results from a second empirical Study, whose detailed design and methodology are reported in Chapter 5. The Study was undertaken to investigate how experienced information processors interact with and make sense of web-based information sources whilst undertaking a topic-comprehension task.

The empirical framework based on Study-1 (Figure 4.4) provided insight into the range of interactions deployed by experienced information processors as they work with information sources across all phases of the information-seeking process during a research-related task. The framework suggested some relationship between sensemaking and the underlying seeking process, but the findings were broad rather than detailed, leading to this second Study, which is a more detailed investigation into sensemaking, and its relationship to information seeking during a problem-solving task.

Study-2 specifically addresses Research Question 2:

> *How do experienced end-users make sense, i.e., collect, extract and organise, relevant information from web-based information sources?*

The Study also addresses Research Questions 3, 4, and 5:

> *3) How do users externally represent both the collection and the meaning being derived from the information sources?*
>
> 4) *How does the user's sensemaking relate to the seeking process?*
>
> *5) What are the implications for interaction design for sensemaking support tools and systems?*

Study-2 was devised to contribute to the growing body of literature on web-based sensemaking, and to identify the requirements for interaction design for sensemaking technologies.

6.2 Roadmap

The five-step analysis approach used in this Study is described in Chapter 5. This five-step approach provides a useful organisation structure within which to examine the Study's results, as illustrated in Figure 6.1.

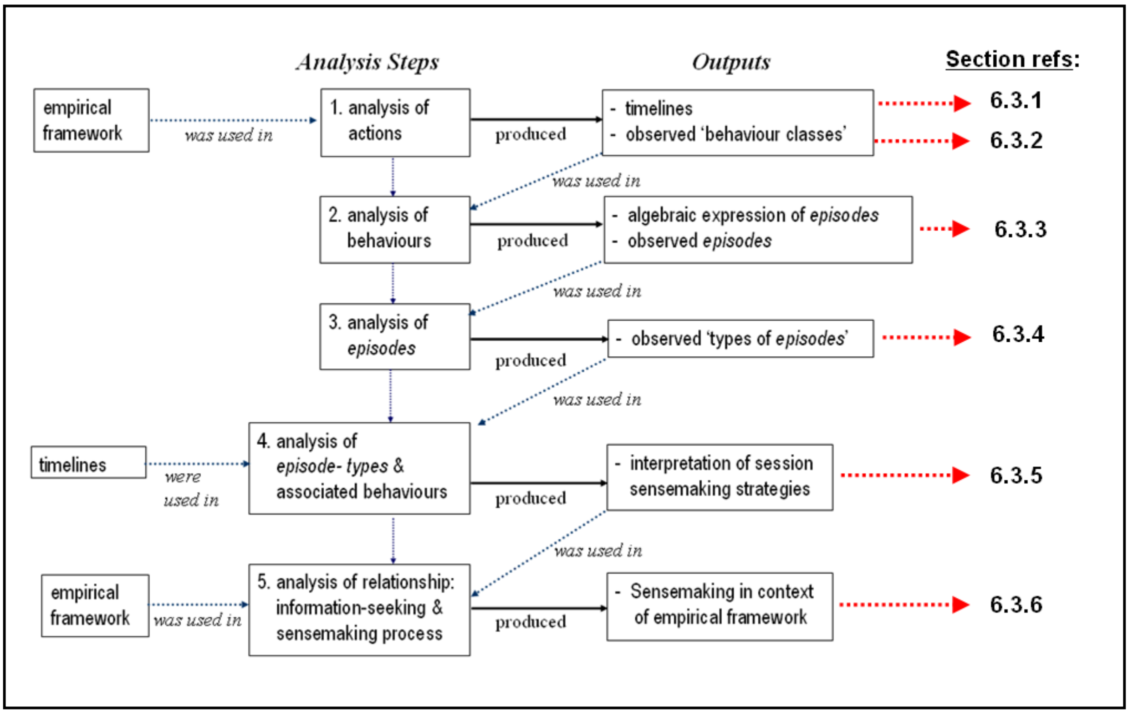

Figure 6.1 Analysis steps, outputs and Chapter references

Six strands of results are presented in this Chapter:

Section 6.3.1: Individual timeline graphs were developed for each participant (ref Appendix D). These capture the interactions between the participant and the resources supplied to complete the task. This was the first output from analysis step 1 (analysis of actions).

Section 6.3.2: A range of behaviour classes were deduced from participants' coded actions, based on the emergent timelines and with reference to the empirical framework (Figure 4.4). This was the second output from the analysis step 1.

Section 6.3.3: *Episodes* of behaviour, expressed algebraically as abstractions from the behaviour coding scheme, captured discrete chains of participants' coded behaviour. Sequences of *episodes* captured each participant's recorded actions in any one session. *Episodes* and sequences of *episodes* were the two outputs from analysis step 2 (analysis of behaviours).

Section 6.3.4: The user session was coded further as a range of *episode-types*, deduced from recurrent *episodes* and labelled to indicate the component behaviours contained in the *episode*. This representation of the user session was more readily associated with sensemaking goals. This was the output of analysis step 3 (analysis of *episodes*).

Section 6.3.5: Participants' sensemaking strategies were inferred broadly from their sequence of *episode-types* and associated behaviours, together with reference to which resources were 'in-play' (i.e., visible and in use) and as corroborated by participant utterances. The sensemaking strategies were the output of analysis step 4 (analysis of *episode-types* and associated behaviours).

Section 6.3.6: The relationship between *sensemaking* and information *seeking* was explored in the final step of the analysis. This is done with reference to participants' sensemaking strategies (as output from analysis step 4) and the empirical framework.

Each of these Sections is reported in some detail, followed by a brief Section summary in each case.

The Chapter discussion (6.4) discusses the results and findings from different perspectives:

- with respect to the relevant Research Questions (Sections 6.4.1 through 6.4.3);
- with respect to the findings from Study-1 (6.4.4);
- with reference to pertinent sensemaking literature (6.4.5).

The Chapter concludes with a Chapter summary (6.5).

6.3 Results

The Study was conducted as described in Chapter 5. Two key types of data were captured:

- *utterances and behaviours* throughout the task that provided evidence of the participants' sensemaking; and
- external representations.

Outputs and findings from each stage of the iterative, inductive analysis (as described in Chapter 5) contributed to an evolving understanding of the participants' sensemaking strategies. Participants' strategies and behaviours were complex and varied. The overall macro-level approach to their sensemaking exhibited many strands of micro-level strategies and sub-tasks. Thirteen significant findings were identified and numbered according to their order of occurrence (as summarised in Figure 6.2).

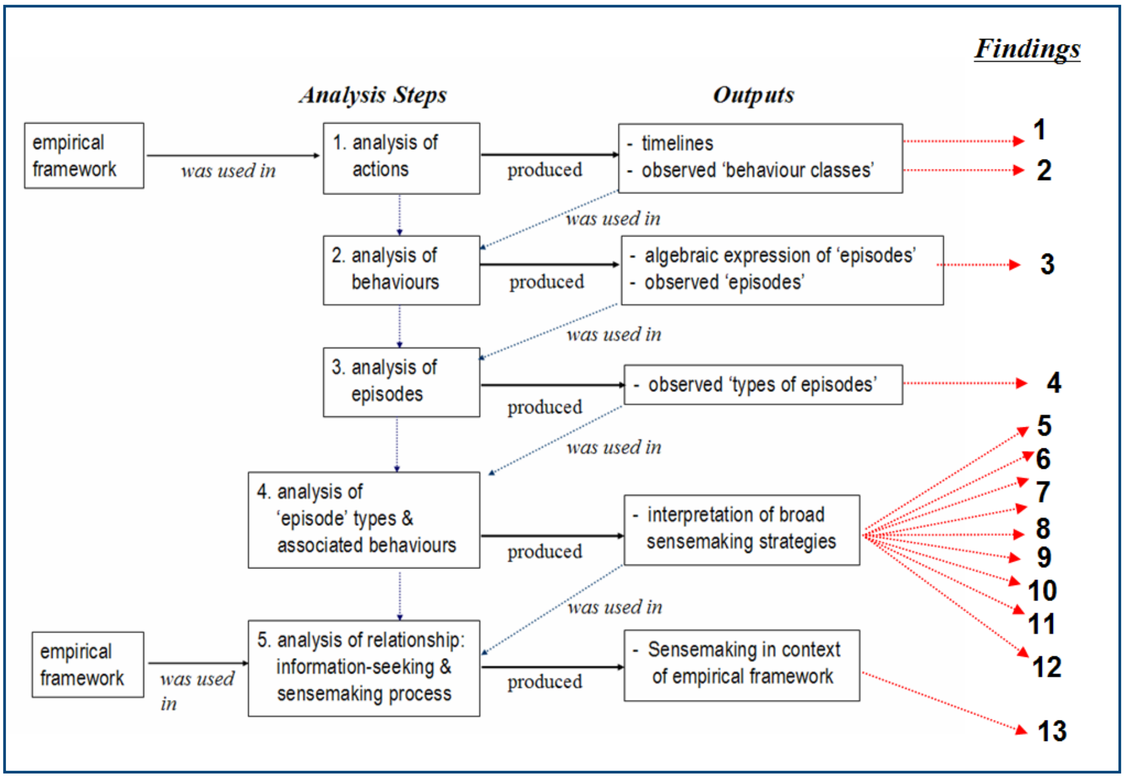

Figure 6.2 Key findings from outputs of analysis steps

These key findings are summarised here and are presented in more detail in the Sections that follow:

Finding 1 (Section 6.3.1): multiple resources were frequently 'in-play' at any one time, and there was evidence of erroneous switching between resources.

Finding 2 (Section 6.3.2): five categories of actions captured the complexities of observed interaction behaviours:

seek, eval(s), eval(u) compile, plan.

Planning was an important emergent category, and four different types of *planning* were evident.

Finding 3 (Section 6.3.3): sequences of *episodes* represented what each user did in any one session, and provided a means of expressing their problem-solving approach to the task-in-hand.

Finding 4 (Section 6.3.4): five types of *episode* sequences emerged, although the underlying algebraic expression could differ. These sequences highlighted a sensemaking goal associated with the session.

Finding 5 (Section 6.3.5): the sensemaking strategy used during non-trivial web-based problem-solving tasks was inferred from a sequence of *episode-types*, in association with which resources were 'in-play', and as corroborated by participant utterances.
Finding 6 (Section 6.3.5): there was no one overall pattern to the strategies deployed, but underlying commonalities, differences and patterns of behaviours between and amongst the *episodes* were identifiable.
Finding 7 (Section 6.3.5): planning *episodes* related the other activities to the task-in-hand; this relationship indicated the type of approach taken, for example, data-driven or top-down.
Finding 8 (Section 6.3.5): *seek* behaviours are integral to the overall sensemaking, and seek prompts or activators were identified.
Finding 9 (Section 6.3.5): one or more intermediate storage resources were accessed and used as workspaces, with a noticeable preference for pen-and-paper.
Finding 10 (Section 6.3.5): resources operated in roles other than those intended or expected.
Finding 11 (Section 6.3.5): extracted source content was used for both structure and detail of external representations. For example, source content was used to build overall structure, slide structure and titles, and the text content of slides.
Finding 12 (Section 6.3.5): external representations were the significant manifestation of participants' sensemaking and typically emerged during *compile* and *plan* activities. These activities occurred early in the sessions and iteratively throughout them. The representations were formed for different purposes, and representation was not always successful. The software did not always support the participant's requirements for extraction and use.
Finding 13: (Section 6.3.6): the empirical framework models instances of the sensemaking strategy within a web-based information-seeking context. The model highlights the relationships between information-seeking and sensemaking; it shows them as closely coupled throughout the broad seeking process, and depicts seeking activities as integral to sensemaking.

6.3.1 Timelines

Eight individual timeline graphs represented participants' interactions with the supplied resources. The detailed timelines are in Appendix D. The interactions reflected participants' individual preferences and styles. By way of illustration, an example annotated timeline is shown in Figure 6.3.

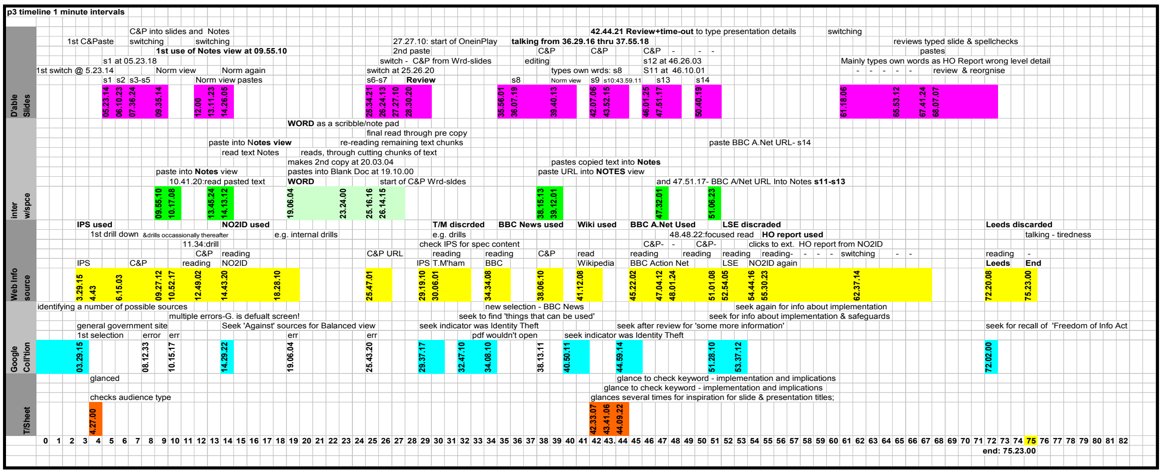

Figure 6.3 Example annotated timeline, participant p3

The participant's interactions with the supplied resources (as explained in Chapter 5, 5.3.1.1), are shown in the example timeline in Figure 6.3. Working upward from the bottom, the resources are:

- task-sheet (instance of *resource-T/S*),
- Google-collection *(*instance of *resource-G),*
- web-based information sources (instances of *resource-S*),
- optional electronic and non-electronic intermediate resources (instances of *resource-IW*), e.g., *pen-and-paper*
- slides, such as those used in *MicroSoft PowerPoint* (instance of *resource-D*).

The timelines provided insight into characteristics of a participant's interactions, for example:

- differences in which and how many resources different participants kept 'in-play' (i.e., visible and in use) within any given one-minute time interval;
- frequency of interactions with individual resources, indicative of the participant's preferences for different types of resources. For example, whether, for their storage/organisation needs, they access an intermediate resource such as *pen-and-paper* or electronic *notepad*, and/or slides (*resource-),* the default task-output representation;
- frequency of switching errors, when an unintended resource came into focus whilst switching between resources or whilst navigating to/between resources.

The timelines also offered insight into characteristics about resource usage patterns, for example:

- the significance of any resource during the participant's session and how often and how long any individual resource was 'in-play';
- the use of a resource in alternative roles. This is discussed later (6.3.5.4.2).

A worked example illustrates several of these results.

6.3.1.1 An example extract: participant p3 timeline

The timeline-graph shown in Figure 6.3 portrays participant p3's interactions throughout their observed session. An expanded extract of that timeline (Figure 6.4) better illustrates some examples of participant p3's interactions, including when and how many resources are 'in-play':

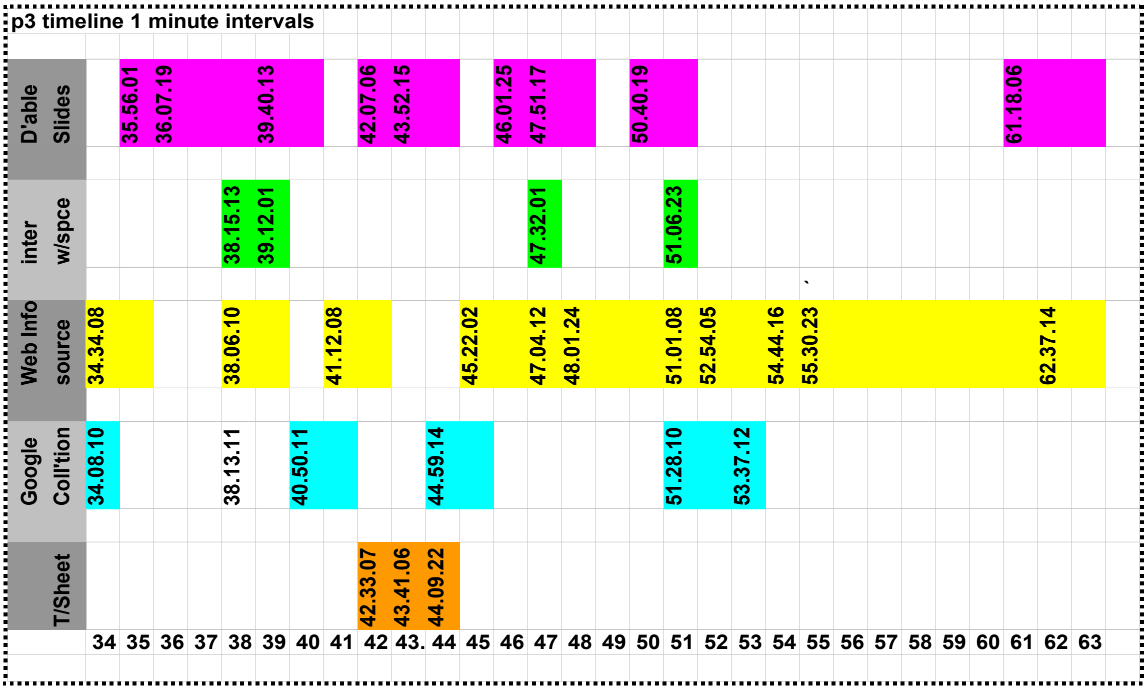

Figure 6.4 Extract from participant p3 timeline (timeslots 34-63)

This extract (Figure 6.4) illustrates:

- one resource 'in-play':, a web-information source, during the minute 49;
- two resources 'in-play': a web-information source and a *MicroSoft Powerpoint* slide during minute 46;
- three resources 'in-play': a web-information source, a *MicroSoft Powerpoint* slide, and an intermediate workspace (Notes) during minute 47;
- a series of discrete interactions with both a web-information source and the *MsPowerpoint* slide for approximately two minutes between 46.01.25 and 48.48.22;
- a short interaction, for less than one minute, with the Google-collection at 51.28.10-52.54.05;

- an almost-two-minute interaction with a single web-information source between 48.48.22 and 50.40.19;
- a long interaction, nearly 6 minutes, with some switching between two web-information sources between 55.30.23 and 61.18.06.

This timeline extract highlights the variation of resources 'in-play' during any one participant session.

6.3.1.2 Resources 'in-play'

All participants exhibited instances of one, two, and three resources 'in-play' during a one-minute time-slot, and several occasionally exhibited instances of four resources 'in-play' (Table 6.1).

Cell count of multiples 'in-play':									
P-ID: / multiples:	p1	p2	p3	p4	p5	p6	p7	p8	Total:
one 'in-play'	7	12	34	8	9	23	26	40	159
two 'in-play'	35	33	26	24	45	49	48	37	297
three 'in-play'	9	11	13	12	19	2	9	6	81
four 'in-play'	0	1	3	1	2	1	0	0	8
Total:	51	57	76	45	75	75	83	83	545
Actual session length:	50.15	56.08	75.23	44.22	74.44	75.33	82.24	82.38	

Table 6.1 Timeline cell-counts of resources 'in-play' per participant (one minute intervals)

Typically:

- multiple rather than single resources were 'in-play' for more than 50% of each participant's session.
- two 'in-play' was the most common multiple use, and, of these, the most common resource combination was a web-based information source combined with slides;
- examples of four 'in-play' were either transitional in nature or involved an error (6.3.1.3.).

Instances of both 'short' duration (less than two minutes) and 'long' duration (two minutes or longer) were evident across all categories of multiples. However, examples of one 'in-play' which lasted less than one minute were too brief to be distinguished; they are shown on the timelines as multiple resources ‘in-play’ during that one-minute timeslot. Such interactions, with two or more resources ‘in-play’, tended to be transitional in nature, often reflecting navigation between resources. An example is participant p3 in minute 47, navigating from a web-information source, to a Notes workspace, then onto slides (Figure 6.4). On the other hand, longer interactions with multiple resources ‘in-play’ often reflected more purposeful interaction behaviour, for example participant p3 interacting with a web-information source and a Notes workspace prior to switching to slides (Figure 6.3, timeslot 12.00-14.43).

Other results were:

- Multiple instances of the same type of resource were occasionally ‘in-play’, e.g., the participant interacted with two different instances of information sources (ref p3, example, 6.3.1.1).
- Instances of web-based information sources (*resource-S*) played a significant role in long interactions: over 50% of long, one ‘in-play’ examples and over 75% of long, two and three ‘in-play’ examples involved an instance of *resource-S*. There were no examples of long, four ‘in-play’ interactions with any combination of resources.

6.3.1.3 Switching between resources and navigating through information sources

Participants typically spent a high proportion of time and effort switching between resources. There were two distinct switching patterns:

i. switching between resources used for short periods of time;
ii. iterative switching between combinations of resources that were ‘in-play’ for longer periods of two minutes or more. A common example was repeated switching between information sources (*resource-S*) and slides *(resource-D*);

Switching was achieved through the use of the various open tabs and windows, or less frequently through the use of the ‘back button’ on the browser. On one occasion a participant (p6) returned to the Google-collection (*resource-G*) to access a previously-opened information source that was temporarily ‘lost’ amongst the task-bar-open-tabs.

Sometimes, the switching involved complex navigation, particularly when multiple resources were ‘in-play’ and/or large numbers of resources were open.

There was little or no return navigation to a host source for further evaluation after it had been used to provide a hyperlink to another source, but when it occurred, it sometimes proved to be difficult to navigate.

Occasionally, the switching between resources resulted in ‘switching errors’, when an unwanted resource became focal by mistake (e.g., Figure 6.3, p3 at timestamp 08.12.33). These errors occurred during two, three and four ‘in-play’ interactions, although four ‘in-play’ had the highest percentage proportional to the total number of instances per multiple (Table 6.2). The percentage calculation was based on the cell count as presented in Table 6.1.

P-ID/ multiples 'in-play’:	**p1**	**p2**	**p3**	**p4**	**p5**	**p6**	**p7**	**p8**	**total errors:**		**total as % of multiples**
one	0	0	0	0	0	0	0	0	0		0.00
two	0	2	0	0	0	2	9	1	14		4.71
three	0	6	3	2	1	0	5	0	17		20.99
four	0	1	2	0	1	1	0	0	5		62.50
Total:	0	9	5	2	2	3	14	1	36		6.61

Table 6.2 Number of switching errors per participant against number of resources ‘in-play’; and percentage of errors proportional to total number of interactions per number of resources ‘in-play’

All participants, apart from participant p1, made at least one error during switching/navigation activity, although there was no specific overall pattern to these errors. For example, participants p2, p3, p4, and p5, made the highest proportion of their errors during their three ‘in-play’ interactions, whilst most of participant p7 and p8’s errors occurred during two ‘in-play’ interactions. Participant p1 did not make any errors, and was the only user to deploy multiple open windows placed strategically on the screen; they also accessed/used the fewest information sources.

Whilst the resource used ‘in error’ varied, a large proportion seemed to involve an erroneous switch to the Google-collection (*resource-G*), which was often the default screen, or an instance of a web-based information source (*resource-S*).

6.3.1.4 Summary

The timelines provide a visual representation of the participant’s interactions with resources during the comprehension task; they evidence the visibility of each resource type throughout the observation and the varying numbers of resources ‘in-play’ during any one-minute interval. Analysis of the timelines led to:

> **Finding 1:** Multiple resources were frequently ‘in-play’ at any one time, and there was evidence of erroneous switching between resources.

Two ‘in-play’ was the most common multiple, most often with a web-information source and slides. The high volume of interactions with multiple resources ‘in-play’ demanded time and effort to switch and navigate between open resources. This in turn led to switching or navigation errors. These results have implications for interaction design.

6.3.2 Behaviour Categories

Five different types of behaviour were exhibited during the eight participant sessions. Four of these behaviours, *seek*, *eval(s), eval(u) and compile,* were recognisable as matching and thus corroborating the categories of interaction behaviours identified in Study-1 and captured in the empirical framework (Figure 4.4). The fifth behaviour, *plan*, emerged from the analysis as a significant behaviour that linked the other behaviours to the task-in-hand. These five types of observable actions are described as:

- having a focus;
- involving one or more resources ‘in-play’, with multiples of resources often ‘in-play’ at transitions between behaviours;
- having a recognisable outcome (e.g., discard a source, make a note, make an extraction);
- being delimited either by the defining characteristics of its behaviour class or by a significant change of information resource, where significant information resource switches were
    - a switch to the results (generated Google-collection);
    - a switch to a web-based information source;
    - a switch to use intermediate workspace as an information input (e.g. input to such as compile).

Information resource switches were considered insignificant if the switch to the second or subsequent resource did not result in the first or main resource being removed from the participant's attention. For example, glancing at the task-sheet (*resource-T/S*) during a primary activity such as evaluating a web-based information source (*eval(u))* is considered a non-significant resource switch in the context of that behaviour.

Each of the five categories was distinct, i.e., each had a set of identifiable characteristics by which participant behaviours were distinguishable. Table 6.3 lists the purpose of each of the five classes. Some were more complex than others; for example, *compile* behaviour had several facets including the extraction mechanisms and the external representations used. Nevertheless, they shared a few **characteristics**, e.g., each category was seen to:

- deploy at least a default or typical resource;
- exhibit a typical pattern of multiple resources 'in-play';
- exhibit a typical duration;
- have an outcome.

Plan behaviours may or may not be expressible as other coded behaviours, and the behaviour could occur in the midst of another activity, e.g., planning 'what to use' whilst searching the Google-collection (expressible as *seek* + eval(s)) or reviewing slides during the task (expressible only as *plan* behaviour).

seek:	(looking for sources), the transition into *evaluation-for-selection*
eval(s):	evaluate for selection (potentially useful sources are identified)
eval(u):	evaluate for use (a decision is made about the source, an action may be taken)
compile:	use (the gathered information is compiled, transcribed, paraphrased, or interpreted)
plan:	gather requirements, decide *what to do* or *use*, review, e.g. progress, set or revise goals, etc. Planning relates the other actions to the task; it is implicit in the framework, but explicit in participants' behaviours and utterances.

Table 6.3 Five behaviour classes

6.3.2.1 *Seek* behaviour

Seek was a transitional behaviour, on the boundary to *evaluating for selection* (ref Chapter 5.4.2). Typical **characteristics** of s*eek* were:

default/typical resource:	-	used an instance of the Google-collection as the main resource 'in-play', i.e., the behaviour was essentially a switch to an instance of the Collection in readiness to evaluate the listed search results;
typical number of resources 'in-play':	-	one resource 'in-play'
typical duration:	-	short, i.e., the time taken to 'move to supplied results'
outcome(s):	-	to evaluate for selection *(eval(s));* in practice, the behaviour was rarely separated from the accompanying *eval(s)* (Section 6.3.2.2).

There were a few exceptions to *seeking* information sources from the supplied Google-collection. *Seek* was occasionally integral to a 'drill-down' action involving an out-of-line hyperlink (see *eval(u),* Section 6.3.2.3). *Seek* behaviour was also integral within certain types of *plan* behaviours (6.3.2.5). Occasionally resources were used in roles other than their default roles (6.3.5.4.2).

6.3.2.2 *Evaluation for selection* behaviour *(eval(s))*

Evaluation for selection (*eval(s)*) was generally associated with a preceding *seek* behaviour. It involved inspecting the details of a search result entry for its potential usefulness (ref Chapter 5, 5.3.1.2). The purpose of a *seek-and-select* together was selection, either general or specific. Typical **characteristics** of *eval(s)* behaviours were:

default/typical resource:	-	use the Google-collection as the primary source 'in-play';
typical number of resources 'in-play':	-	one resource 'in-play';
typical duration:	-	short, with a very few exceptions, e.g., (p3, 32.47.10) for 4.5mins (although this includes

		time-out for a failed launch of a *pdf* document);
outcome(s):	-	select/pursue a single source immediately for eval(u); discard the resource; select for later eval(u) for batched source evaluation (This most often occurred in conjunction with certain types of planning action (6.4.2.1.5)); note verbally for later pursuit.

Most often there was no indication that more than one result entry was being inspected, and frequently a result entry appeared to be chosen without any apparent reference to others in the Google-collection. On the other hand, there was rare explicit evidence that multiple results were being considered during the selection process: utterances, accompanied by pointing to or highlighting a result entry in the Google-collection (p5, 15.42.23); or use of system *Find-on-a-page* feature (p5, 15.42.23).

As with *seek* behaviour, there were a few exceptions to typical *eval(s)* behaviour of selecting from the supplied Google-collection;

- *eval(s)* was occasionally integral to a drill-down action (*eval(u),* Section 6.3.2.3);
- *eval(s)* behaviour was occasionally exhibited within *plan* behaviour (6.3.2.5);
- some exceptions led to resources used in alternate rather than default roles (6.3.5.4.2).

6.3.2.3 *Evaluation for use* behaviour *(eval(u))*

'Evaluation for use' involved inspecting and evaluating actual, located, web-based information sources for their usefulness. Most often sources were scanned at the screen interface, although there were two instances when a print-out of a source was preferred for *eval(u)*. Participants typically scanned or read sources using a mix of breadth (page-by-page), and depth (drill-down on embedded links to another section of the web-site/source) approaches. These were considered non-significant drill-downs (ref Chapter 5.3.1.2).

Eval(u) occurred in three different contexts:

i. as a stand-alone activity;

ii. integral to most *compile* behaviour, i.e., during switches to a representation resource whilst using the located source content (6.3.2.4);
iii. integral to some *plan* activities (6.3.2.5).

The typical **characteristics** of the stand-alone occurrences of *eval(u)* were:

default/typical resource:	-	a web-information source;
typical number of resources 'in-play':	-	one resource 'in-play';
typical duration:	-	long; the majority lasted two minutes or more, with some instances lasting over five minutes, e.g., participant p3 evaluated a single source for approximately six minutes (55.30.22);
outcome(s):	-	to use the source or discard the source without any observable (physical) extraction; rarely, a source was noted for later printout, e.g., noted verbally (p2, 09.31.21), noted explicitly in{NoteView} (p3, 09.55.10); source noted as usable for the task but not for use during the observation (e.g., p4, 33.48); source content triggered a personal note (p7, 66.40.00)

External representations were not typical of *eval(u)*, but one example was when a participant marked an information source.

Complexity of *eval(u)* behaviour included occasional *significant* drill-down activity, i.e., a click/select on an embedded hyperlink within a source that enabled the participant to navigate away from the current website/webpage and offered access to other ***external*** information sources or to source content that was not necessarily accessible from the supplied Google-collection. This behaviour within the *eval(u)* manifested as either:
i. move to and select *(seek + eval(s))* an out-of-line hyperlink, or
ii. select (*eval(s)),* a hyperlink in-line with text.

Two participants (p6 and p7) exhibited more of these significant external drill-downs than others; sometimes a drill-down failed due to obsolete embedded links (p5).

Other observations about complexity of *eval(u)* were:

- on rare occasions, another resource type was used as a secondary but insignificant information source.
- the task-sheet was infrequently referred to during an *eval(u),* (e.g., p3, 04.27.00).
- two participants only deployed the find-on-a-page browser feature.

6.3.2.4 *Compile* behaviour

Compile involved an observable extraction from an information source, with some form of representation as output, typically directly onto slides, the task deliverable (*resource-D* - Chapter 5, Table 5.4.). During any one *compile* instance, the representation action involved various combinations of source and target resource. Participants:

- extracted and used selected web-based information source content towards the task deliverable (slideshow representation);
- extracted selected web-based information source content into an intermediate resource, and then extracted and used it towards the task deliverable (slideshow representation);
- extracted and used selected content held in an intermediate resource such as an earlier external representation, towards the task deliverable (slideshow representation). In these instances, the *compile* reflected the second phase of a two-phase *compile* executed by some participants (ref participant profiles, 6.3.5.4).

Simple *compiles* were less common; at its simplest a *compile* involved a single scan/read and extract from a source followed by representation, e.g., interpret (rephrase), order (list, reorder, tabulate, etc.), or tidy/edit. Typical **characteristics** of simple *compile* behaviours were:

default/typical resource:	-	single source input and single output representation resource;
typical number of resources 'in-play':	-	two resources 'in-play';
typical duration:	-	variable, although many simple *compiles* were short;

outcome(s):	-	representation, e.g., interpret (rephrase), order (list, reorder, tabulate, etc.), or tidy/edit

There were several examples of simple *compiles*, but the majority of the *compile* instances were more complex. Typical characteristics of the more common complex *compiles* were:

- *eval(u)* behaviour was integral to complex *compile*, i.e., the iterative switch to source for extraction and occasionally at end of extraction.
- resources ‘in-play’ varied between one and three.
- several, often rapid, iterations over the multiple resources ‘in-play’, e.g. switches between source content for extraction and the developing representation. There were numerous examples of high iteration (e.g., p3, 05.23.14).
- additional interactions with the emergent representation itself, e.g., further editing.
- long rather than short duration, for example one instance (p5) lasted 19 minutes.

Table 6.4 lists other examples of factors that made *compiles* complex. Occasionally several of the factors combined, e.g., multiple iterations using multiple extraction techniques, creating more than one representation and accessing more than one output resource. *Compile* resources were occasionally used in alternate roles (6.3.5.4.2). *Compile* behaviour was occasionally seen as integral to *plan* activity, e.g. when creating an outline representation structure (e.g., (p1, 0.00); (p5, 29.10.16); (p6, 54.00.00); (p7, 09.35.1)).

Compile complexity characteristic:	**p-Id: Example**
type of representation:	(p6, 18.11.23): hand-drawn ID card from source details
multiple representation resources	(p3, 19.06.04): uses *MicroSoft Word* as intermediate workspace for representation
multiple representations emergent	(p5, 31.09.11 - 49.50.04): represents to both pen-and-paper and slides from single source
multiples of extraction mechanisms deployed	(p3, 19.06.04): *copy-and-paste* to intermediate *MicroSoft Word*, edit heavily, then *copy-and-paste* from *MicroSoft Word* to slides with further edit; (p5, 31.09.11): *copy-and-paste* Table verbatim, plus own notes on *pen-and-paper*
**** compile*** - multiple of information sources used towards the representation	(p5, 55.24): information source and own pen-and-paper notes from several sources were used towards representation; (p7, 60.09.13): uses extract from an open source and previous pen-and-paper notes
multiples 'in-play' could vary within any single complex compile	(p3, 46.01.25): uses a mix of three resources 'in-play' during minute 47, with only the information source in focus ('in-play') for almost two minutes. Followed by two discrete periods involving two different combinations of resources 'in-play', namely slides and information source, followed by slides and an intermediary workspace (NotesView) until the end of that *compile* at 51.28.10
other resources were occasionally referenced during the compile	(p4, 39.56): referenced the task-sheet, increasing the multiple resources 'in-play' during that compile

Table 6.4 Complex *compile*: characteristics and examples

Example *compiles* from the participant p3 timeline, with differing multiples of resources 'in-play', are set out in Table 6.5.

Number of resources 'in-play':	Example description:	Example P3 timestamp:
One	(re)edit a representation in Intermediate *MicroSoft Word*	19.06.04
Two	extract content from source and transfer directly to slides	46.01.25
Three	extract text from source and paste into both slides and intermediate *NotesView* pages for further editing for own presentation	09.27.12

Table 6.5 Participant p3: example instances of *compile* with varying multiples 'in-play'

6.3.2.5 *Plan* behaviour

Planning was an important emergent behaviour that related the other behaviours to the task-in-hand. Any single instance of the behaviour could involve one or any combination of four discrete types of *planning*:

i. planning as deciding 'what to do' (e.g., creating an outline representation)

ii. planning 'what to use' (e.g., seek to consider the results collection)

iii. planning as 'gathering requirements' (e.g., reference to the Task Specification)

iv. planning as a 'review' activity (e.g., review of representation, outline slide structure, review of Google-collection, etc..)

These four types of *planning* are described fully in Chapter 5, Section 5.3.1.2.

Planning features are not readily describable as typical, because characteristics varied across the four types, and not all types of *planning* were exhibited by every participant. The duration of a *plan* activity reflected the mix of planning behaviour types therein. Generally, an occurrence lasted between 1 and 11 minutes, with most averaging around 3 minutes; an exception was participant p8 (0.00), who exhibited an instance of 26 minutes. With respect to frequency of occurrences:

- a review of a representation (typically held on slides) was the most common type of *planning*, exhibited by each participant at least once;
- deciding 'what to do' was the least frequently demonstrated type of *plan,* and one participant (p3) did not plan for 'what to do';

- *planning* behaviour was occasionally seen as secondary in other behaviours; for example, the supplied task-sheet was opportunistically referenced during *evaluation* and *compile* behaviours to check the requirements.

The number of resources 'in-play' varied, dependent on the type of *planning*:

- 'requirements gathering' typically focused on one 'in-play', the task-sheet;
- 'what to use' typically kept one 'in-play', the Google-collection;
- 'what to do' (outline schema) often involved two resources 'in-play' and resulted in some form of representation onto slides or an intermediate resource;
- 'review' activities often deployed a mix of multiple resources. For example one resource 'in-play' during a review of the created slides, but a combination might be involved when doing a cross-reference review between results held in Google-collection and an instance of information source (e.g., p7);
- the number of resources 'in-play' could vary during the behaviour instance, e.g., p3 (p3, 42.44.21) reviews slides then reviews slides with reference to the task-sheet;
- intermediate resources were opportunistically deployed specifically for *planning* purposes, e.g., reorganising the representation from slides to paper then back to slides (p2, 45.13.01).

Outcomes reflected the type of *planning* taking place:

- 'Requirements gathering' tended to influence the next activity, rather than produce a tangible outcome. An exception was an emergent representation, e.g., markings on the supplied task-sheet (p4, 00.24) and (p5, 0.53.40). This was an example of a resource in an alternative role (6.3.5.4.2).
- Browsing the Google-collection to decide 'what to use' normally resulted in a single source being selected at transition from the *plan* into the *seek* activity (e.g. p3, 0.00). Rarely, all chosen results were selected and launched for later evaluation (p7, 10.24.03). Exceptionally, participants annotated the Google-collection to highlight results judged to be of use. In this example the '*collection'* was used as an intermediate workspace to hold an emergent representation, and hence it was used in an alternate role (6.3.5.4.2).
- Deciding 'what to do' typically generated a plan-type representation, e.g., outline schema or structure (p8, 08.38).
- Review activity frequently generated an update or edit of an ongoing representation, typically on slides (p3, 42.44.21). Review of the supplied results Google-collection was undertaken, e.g., review for corroboration of dates (p7, 53.21.02), (p8, 62.16.12), or review to reflect on what had or had not been selected from results (p1, 47.00).

6.3.2.6 Summary

The second significant finding from the first step of analysis (Figure 6.2) was:

> **Finding 2:** Five categories of interaction behaviour (actions) captured the complexities of the observed behaviours: *seek, eval(s), eval(u) compile, plan*. *Planning* was an important behaviour that emerged from the analysis, and four types of *planning* were evident.

Compile was a complex behaviour, addressing different goals, with higher levels of iteration and switching between resources, and with a greater variety of extraction methods and representations in evidence. A summary of the characteristics of each category is given in Table 6.6.

Typical Characteristic	***Seek***	***Eval(s)***	***Eval(u)***	***Compile***	***Plan***
Duration:	short	short	long	mostly long	variable
Number of resources 'in-play':	one	one	one	two or more	variable
Main resource:	Google-collection	Google-collection	information source	source slides/ pen-and-paper	dependent on type of plan
Outcome:	eval(s)	eval(u), or discard, or note verbally for later pursuit	use, or note/print for later use, or discard	emergent representation	dependent on type of plan
Emergent representation?	no	no	rarely	yes	yes, depend on type
Intermediate resource accessed?	no	no	no	yes	yes
Resources used in alternate roles?	yes	yes	yes	yes	yes

Table 6.6 Summary: typical characteristics common to all behaviours

6.3.3 *Episode*s of Behaviour: Algebraic Expressions

As part of the analysis, in order to identify patterns in the activity data, participants' activities were expressed algebraically as 'behaviour *episodes'*, sequences of the coded behaviour categories. Each *episode* had a focus, and was delimited by a recognisable change of focus along with simplicity of abstraction.

Generally, *episode* expressions contained several component behaviours. The most common examples of *episode* behaviour involved:

a *seek* and then evaluation of a result entry from the Google-collection,
followed by select and evaluate of the source itself
followed by an extract (for use), from source content.

This *episode* is expressed as:

(seek + eval(s) + eval(u) + compile)

Episodes also involved more complex, often iterative behaviour. For example, the common *episode* cited above might be iterated. Iteration is indicated with an asterisk preceding the component or group that repeats:

**(seek + eval(s) + eval(u) + compile)*

Consider a more complex example: for a period of time, participant p3 was concerned with trying to find some source content to use for the task-in-hand, and their behaviour was:

a *seek* move to the Google-collection to evaluate multiple search result entries,
before *selecting* a source for further evaluation,
which resulted in the source being either discarded or used.

P3 repeated this process four times, with some sources discarded and others used. This *episode* of activity, (Table 6.7), is expressed as:

**(*(seek + *eval(s) + eval(u))+ compile)*

Iteration is shown at several levels:

- component behaviour level, when several results were considered i.e., *(*eval(s))*
- combination of component behaviours, when p3 iterated over more than one source and discarded each, i.e., **(seek + *eval(s) + eval(u))*
- and across the whole *episode*.

This *episode* illustrates a sequential source-processing mode, i.e., when a source is systematically processed from selection through to discarding or use. In other *episodes*, a participant adopted a batch approach, selecting a number of sources, for subsequent evaluation source-by-source. In each case the outcome was to discard or go on to use at that point. This is expressed as:

**(*(eval(u)) + compile)*

6.3.3.1 Sequences of e*pisodes* of behaviour

An entire session could be expressed as sequences of *episodes* of behaviour. These sequences reflected both the iterative and integrative nature of the participant's approach. As an example, participant p3's session, (also shown in p3's timeline, Figure 6.3) is represented in Table 6.7 as a sequence of *episodes.* Each *episode* is described in the first column, and its algebraic abstraction is given alongside in the second column. (A full set of sequences representing each of the eight participants' sessions is shown in Appendix C).

General description of *episode:*	**Abstraction of *episode (*numbered*):***
Initial period of time spent planning 'what to use'	*1. plan*
Period of seeking from sites with general background information for evaluation and compilation: iteratively seeking, evaluating and extracting from two separate web-based sources	*2. *(seek + eval(s) + eval(u) + compile)*
Period of time planning as a review activity	*3. plan*
Period of specific evaluation and compilation: Several *seek* iterations each for different specific keywords, four actual sources evaluated but not all used. First source accessed via an open-tab (existing sources), others selected from results collection	*4. eval(u) + *(*(seek + *eval(s) + eval(u))+compile)*
Planning as a review activity (slides)	*5. plan*
Period of specific evaluation and compilation over 23mins. Iteration across four sources for specific 'implementation/costs content', but some not used, i.e. discarded.	*6. *(*(seek + *eval(s) + eval(u))+ compile)*
Planning as period of review /reorganise slides. Significant review & reorganise slides + some edits	*7. plan*
Period of specific evaluation; a response to a 'trigger' in the previous review, final attempt to locate some specific detail previously seen in a source but they were unsure where it was	*8. seek + eval(s) + eval(u)*

Table 6.7 Participant p3: session as algebraically-expressed *episodes*

There were very few exact matches between algebraically-expressed *episodes*; one was the expression:

**(seek +eval(s) + *eval(u))*

This pattern was presented by participant p1 at *episode* 2, participant p5 at *episode* 7, and participant p8 at *episode* 3. Yet some underlying commonality was apparent, e.g., ‘seek to evaluate for compile’ activity, expressed as:

(seek + eval(s) + eval(u) + compile)

This was evident as an *episode* in all but one (p7) participants’ sessions, although the amount of iteration typically varied. That said, there was at least one example of an exact match in iterative formats between p1, p2, p3 and p4: this was when they iteratively sought and selected (more than one source was considered at selection), then evaluated and discarded more than one source, before evaluating and deciding a source was useful. This is expressed as *(*(*(seek +*eval(s) + eval(u)) + compile).*

Only 13% of *episodes* did not match, in component expression, to another *episode* in the same or a different session. Three of these *episodes* were present in participant p7’s session which was the only participant to exhibit batch mode processing.

6.3.3.2 Summary

Participant’s activities were chunked into *episodes*, which were then expressed algebraically. Each session was captured as a sequence of these *episodes.* These sequences reflected both the iterative and integrative nature of the participant’s activity. The key finding from the second step of analysis (Figure 6.2) was:

> **Finding 3:** Sequences of *episodes* represented what each user did in any one session, and provided a means of expressing their problem-solving approach to the task-in-hand.

Whilst some commonality was evident across and between *episodes,* more emerged from continued analysis of the *episode* sequences.

6.3.4 *Episode Types*

Patterns and commonalities among *episodes* were identified, and from these five *episode-types* were induced. Each *episode* was identifiable as an instance of one of five *episode-types* (step 3, Figure 6.2). The descriptive labels reflect the *episode-type’s* dominant underlying purpose (inferred from actions, outcomes, and utterances):

SeekToEvaluateForCompile

SeekToEvaluateToCorroborate

EvaluateForCompile

Compile

PlanEpisode [+ indicative purpose]

More detailed definitions of each *episode-type* are offered in Chapter 5 (Section 5.3.3) and the full set of participant sessions, expressed as sequences of *episode-types* are in Chapter 5 (Figure 5.8). Other characteristics of the types were induced from the range of instances exhibited. These characteristics are listed in Table 6.8.

***Episode-type*:**	**Typical observations from instances:**
SeekToEvaluateForCompile	Highly iterative across all levels of the *episode*, i.e., more than one source sequentially evaluated and used (or discarded) during any one *episode*
SeekToEvaluateToCorroborate	Commonly iterative, i.e., more than one source evaluated for corroboration (e.g., p2 and p6)
EvaluateForCompile	Often associated with batch-mode working, e.g., iteratively evaluate batches of open sources for use or discard (e.g., p7); non-iterative otherwise (e.g., p1)
Compile	Only a single source was used in *compile episodes* (e.g., p5), but multiple sources used for external representation in iterative *compile episode* (p6)
PlanEpisode *[+ indicative purpose]*	***indicative purpose* = requirements gathering**: Involved reference to the supplied task-sheet and sometimes resulted in some form of external representation such as markings on the supplied sheet (e.g., p4, p5). ***indicative purpose* = deciding 'what do'**: Typically resulted in an emergent outline schema or structure (e.g., p1, p8). ***indicative purpose* = deciding 'what to use'**: Reference made to Google-collection to identify potential sources of information. Exceptionally it resulted in an emergent external representation (e.g., p8). ***indicative purpose* = review activity:** This involved a review of own representation (commonly), or Google-collection (rarely, e.g., p1). An external representation was typically produced or revised. The task-sheet was occasionally referenced (e.g., p1, p3, p5, p8).

Table 6.8 *Episode-types:* typical characteristics deduced from observed instances

Typed sequences convey something of the overall approach adopted during each participant's session. A worked example now illustrates this.

6.3.4.1 Participant p3: example sequence of *episode-types*

Figure 6.5 shows participant p3's sequence of *episode*-types as an extraction from the set of colour-coded sequences (Chapter 5, Figure 5.8). A full set of participant sequences, colour-coded as *types,* is shown in Chapter 5 (Figure 5.8).

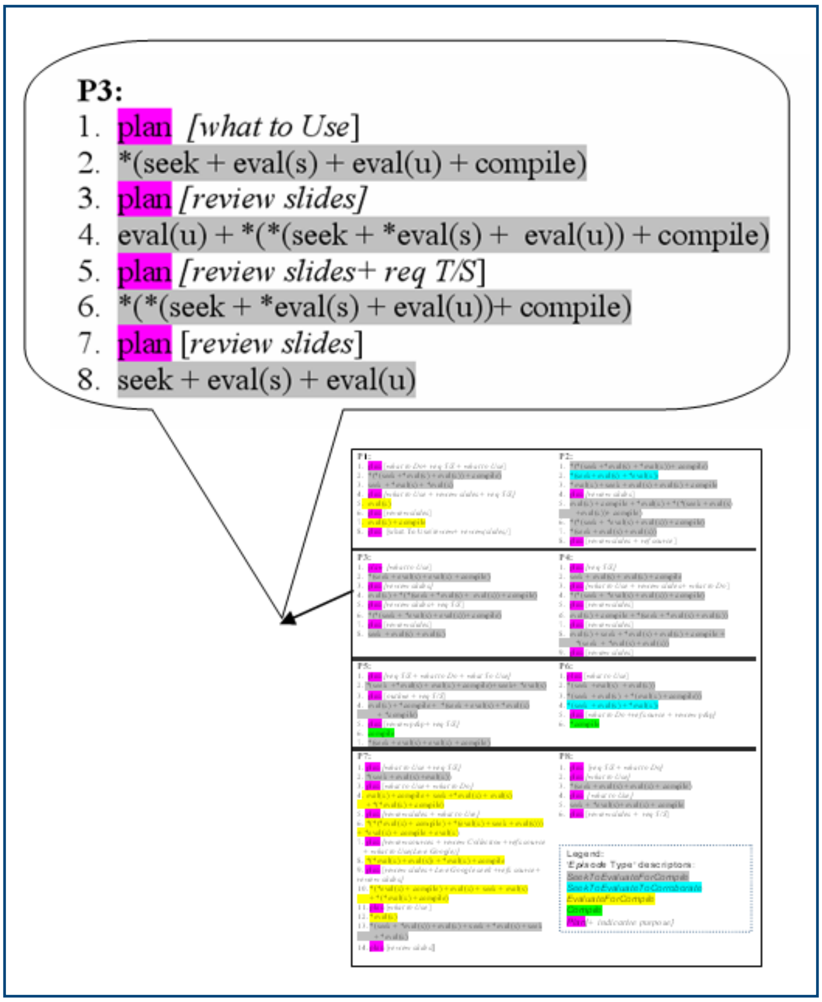

Figure 6.5 Participant p3 expressed as a sequence of colour-coded *episode-types*

Legend: the colour-code as used to identify *episode-types* as Chapter 5, Figure 5.8:
Grey colour-coded is SeekToEvaluateForCompile; magenta is Plan[+ indicative purpose]

Participant p3 completed the task-in-hand through a combination of two types of *episodes*. (S)he undertook regular planning activity (*PlanEpisodes*) interspersed with periods of sequential seeking to locate sources for evaluation and use (*SeekToEvaluateForCompile)*, The way (s)he undertook or executed a *SeekToEvaluateForCompile* varied as seen from the associated expressions *(episode 2, 4, 6, 8)*. In the main, these varied with respect to the iterative nature of the *episodes,* but occasionally the behaviour varied by components (which is not so obvious in this example but is more apparent in the instance of *episode* 10, participant p7 (Chapter 5, Figure 5.8)).

Expressed as typed *episodes*, the whole session is more readily associated with an overall sensemaking goal: participant p3 was iteratively collecting, evaluating and integrating new information for their own specific problem/task needs. In addition, (s)he planned strategically during their session. This participant's approach is examined in more detail in the next Section (6.3.5.1.1).

6.3.4.2 Summary

Further analysis identified five emergent types of behaviour *episode*, and sequences of these *episode-types* expressed the user sessions. This representation served to highlight the participant's overall sensemaking approach.

The key finding from the third step of analysis (Figure 6.2) was:

> **Finding 4:** Five types of behavioural *episode* emerged, although the underlying algebraic expression could differ. These sequences highlighted an associated session sensemaking goal.

6.3.5 Sensemaking as a Strategy

Various representations have been produced to capture the participants' sessions:

- timelines captured the nature of the participant's interactions with resources and highlighted the resources 'in-play' throughout the session (6.3.1);
- sequences of *episodes* captured the user behaviour that was recorded in a session (6.3.3);
- those sequences abstracted as *episodes-types* revealed more about the session approach, and served to highlight the link between the session and an associated sensemaking goal (6.3.4).

The sensemaking strategy employed by a participant during a session was inferred from these analyses, with reference to both their utterances and their own external (re)representations, which provided explicit evidence of this sensemaking. These sequences of *episode-types* offer insight into how individual participants made sense as they completed the web-based topic-comprehension task.

The strategies can be explained with respect to how participants:

gathered (*seek* + *eval(s)*),

evaluated (*eval(u)*),
used the found information (*compile*), and
planned throughout the session (*plan*).

This Section begins by offering three individual contrasting sensemaking approaches. Next, various patterns and commonalities across all participants are reported. To aid clarity, the sequences of *episode-types* are diagrammatically re-presented as labelled *episode-types.*

6.3.5.1 Individual sensemaking strategies: three example session profiles

Each participant exhibited a unique session strategy, albeit with commonalities and similarities evident across and between their approaches. The selected examples are those considered the most varied in their approach: participants p3, p6 and p7. For each example, two figures represent the strategies:

i. the sensemaking strategy seen as a sequence of *episodes* labelled as *types*. This representation best highlights the session approach and the complexity of the associated *episode* behaviour.(a full set is shown in Appendix C)

ii. the sensemaking strategy seen as the sequence of *episodes* mapped against their timeline. This mapping better illustrates the range of resources 'in-play' across each *episode* and across the whole session. (a full set is shown in Appendix C)

6.3.5.1.1 Participant p3

Participant p3 began their session by taking a few minutes to examine and *plan* what sources to use (*episode* 1). Thereafter, they interspersed periods of sequentially seeking and processing sources (*episodes* 2,4,6,8) with periods of review-planning, to check if the developing slideshow was flowing and making sense (*episodes* 3, 5, 7). The time devoted to planning (*PlanEpisodes)* were relatively short, compared to the time devoted to the seek-driven activities (*SeekToEvaluateForCompile,* Figure 6.6).

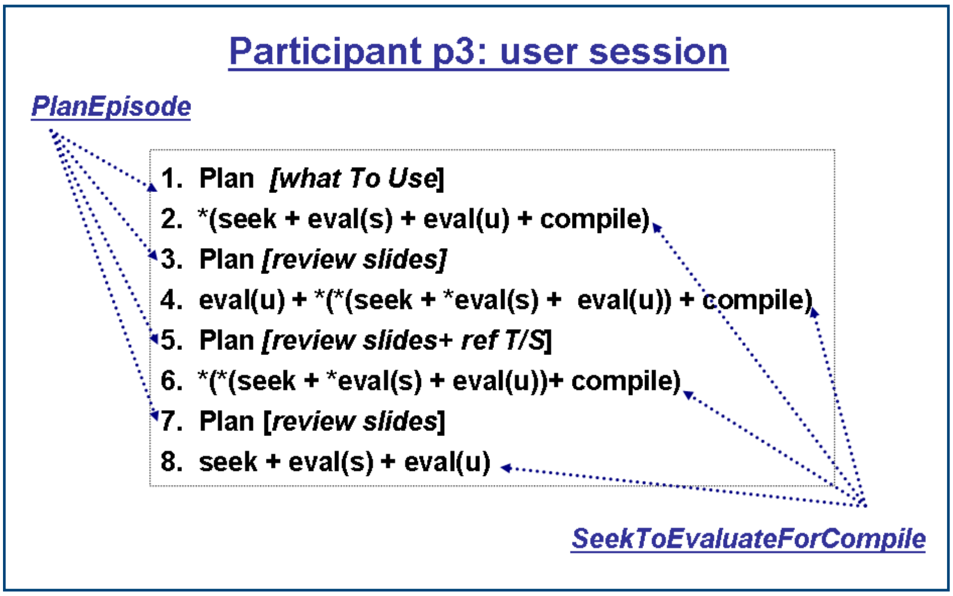

Figure 6.6 Participant p3 session: sensemaking strategy as a sequence of *episodes* labelled as types

With further reference to Figures 6.6 & 6.7:

<u>How did participant p3 *gather*?</u>

Participant p3 sequentially sought and processed information sources from the supplied Google-collection. Typically, these seek-driven actions were iterative, with between two and four sources processed during any one seek *episode*. As the session progressed, participant p3 moved from more general seeks to more focused, specific seeks in-line with their developing understanding of the topic. Several factors prompted new or further seek-driven activities. The most common were:

- their thoughts from the previous review(plan) of the developing slides (external representation), e.g., seeking a balanced viewpoint;
- relevant keywords or concepts identified within a located source, result entry, or the task-sheet;
- recall of an earlier noted Google-collection result to follow-up.

<u>How did p3 *evaluate*?</u>

Evaluation was immediate after selection, with only one resource (information source) 'in-play' for the duration of evaluation. Participants applied considerable effort to understand and interpret the content, and their source interactions were a mix of breadth (page-by-page scanning/reading) and depth (following embedded hyperlinks to contained sections of content). Accompanying utterances indicated how they were making sense and mentally cross-referencing between sources, for example:

[reading the Home Office Report ...]

" ... which is what that NO2ID site was on about ..." *(p3, episode 6, 63.17.02)*

Other utterances also suggested interpretation:

- the type of detail that would best suit the hypothetical audience [e.g., at 04.27.00];
- the scanning/reading was often summarised [e.g., at 45.22.02];
- questions/debates where p3 agrees with what is being read/scanned [e.g., at 47.38.05]

Participant p3 selected and evaluated nine sources from the 16 results supplied in the Google-collection, and discarded three of the nine (33%) without explicit usage. However they offered other outcomes; for example several sources were noted as being worthy of printout to take along to the hypothetical task presentation:

"Normally what I do when I present a talk I need a lot of information in front of me, I print out a few pages of notes ... and then I would refer to that as I click it up in Power Point. ... I would probably print that out [NO2ID] separately and have it as additional pages [in the presentation], because it won't all fit on the notes section for the slides that I have got." *(p3, episode 3, 28.30.20)*

<u>How did p3 represent or integrate the located information?</u>

No outline schema was created prior to the first interaction with the information resources, which reflected p3's explicit pre-session statement of having no knowledge about the topic. Instead, the emergent representation (slides) appeared as p3 was informed by what they found, understood and used. Typically, their sensemaking artefacts (slides) emerged regularly as outputs from *compile* behaviours throughout the session. One slide, however, emerged mid-session from a *plan[review]* activity. (Representative samples from p3's slides are in Appendix C.)

Source content was used to build slides, and to provide structure and detailed text on the slides. Each of the six sources seen to be used during the session, contributed to at least one or sometimes two slides, although no slide reflected content from more than one single source. The 'extraction and usage' was usually an iterative activity, with several switches between extraction of the source content and (re)representation onto the target slides. There were a few instances of this being a two-step activity, for example when content was pasted into intermediate resources, and then reworked prior to being pasted to slides. Source content was used:

- verbatim (frequently),

- verbatim with editing (frequently),
- or re-written in own words (less often).

Utterances concerning the usefulness of source content frequently accompanied their emergent representations.

A few external representations were created for purposes other than the slideshow. For example, notes about the source URL were created and pasted in the *Notes* facility, making them available for later use (*episode* 6, 47.32.01).

How did p3 store, structure and organise the task deliverable?

Generally participant p3 deployed slides, the task deliverable, as the main sensemaking artefact. They frequently (re)structured, amended and reorganised these slides during the session. However, they also made use of two intermediate resources, *MicroSoft Word* and *NotesView* of the slides, for structuring, editing and re-organising, prior to pasting the re-worked representation to the slides (representative examples are given in Appendix C). . This illustrates an example of a resource used in an alternate role.

How did p3 manage the resources?

The number of resources 'in-play' across the session varied between one and three 'in-play' (Figure 6.7). Instances that involved either time spent evaluating a located information source, or several minutes spent editing and rewriting their emergent representation from copied-and-pasted text into their own words, tended to have one resource 'in-play'. Sometimes four resources were 'in-play' during transition between activities (Table 6.1). Several navigation errors occurred whilst three or four resources were 'in-play', and almost all of these were switching errors to the default Google-collection window/screen (e.g., Figure 6.7 [10.15.17]).

A significant switch of resource types was typical at the end of an *episode* and often suggested progress in p3's sensemaking. As an example, after working with sources (locating, evaluating and extracting source content), they switched to review and edit their slides, before switching back to locate more information sources to help them fill remaining gaps in their knowledge. This can be seen in Figure 6.5, between *episodes* 2 to 3 to 4, again between *episodes* 4 to 5 to 6, and again between *episodes* 6 to 7 to 8.

<u>How did p3 *plan* the session?</u>

Overall, participant p3 adopted a mixed sensemaking strategy; they exhibited a mix of top-down techniques, e.g., task requirements gathering (*episode* 5) and planning 'what to use' (*episode* 1), alongside frequent review during which representations were typically edited and reorganised (data driven, bottom-up techniques (*episodes* 3, 5 and 7).

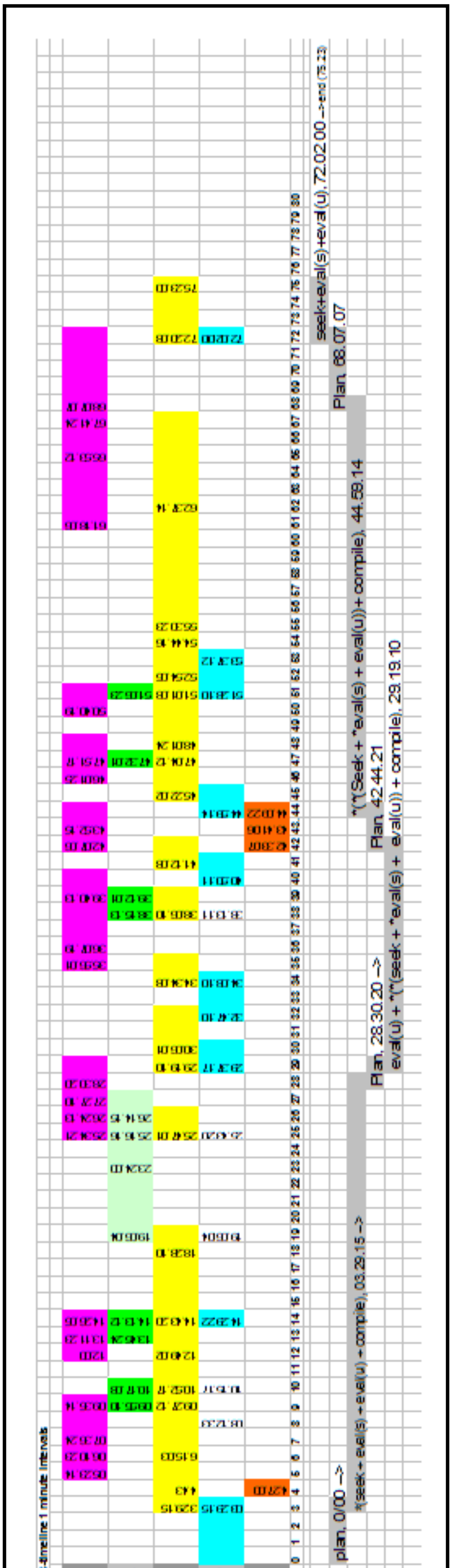

Figure 6.7 Participant p3 session as a sequence of *episodes* mapped against timeline

6.3.5.1.2 Participant p6

Participant p6 took a few minutes at the start of the session to assess what sources might be useful for the task-in-hand. Thereafter, several sources were selected sequentially, one-by-one, and evaluated. If judged useful, the content was used immediately. Attention then turned to pursue a few sources that might corroborate what they had read so far. There followed a period of reflection and planning before a considerable amount of time was spent interpreting their gathered material and representing it onto slides.

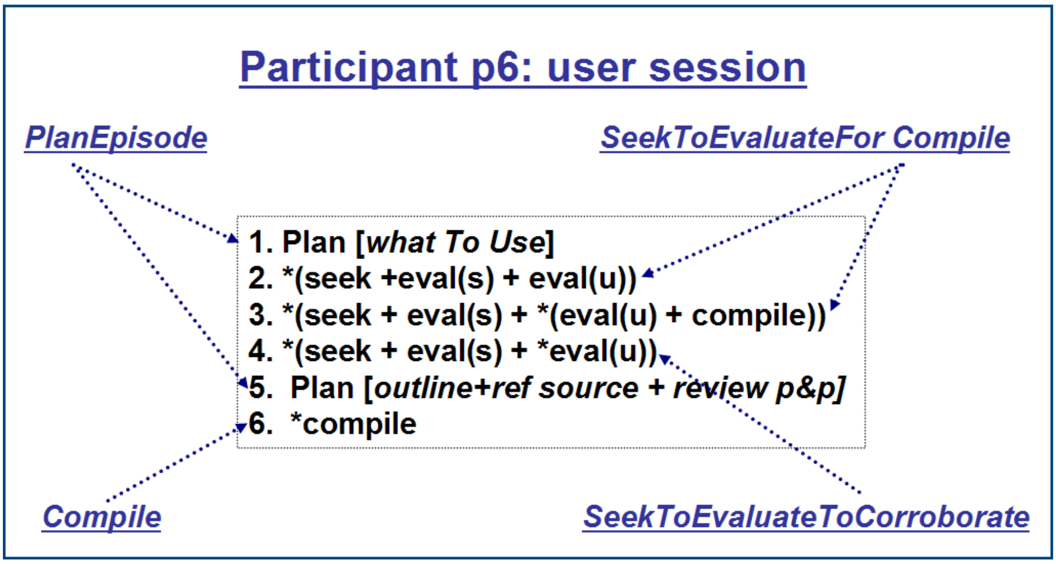

Figure 6.8 Participant p6 session: sensemaking strategy as a sequence of *episodes* labelled as types

Both Figures 6.8 and 6.9 highlight the opportunistic approach taken by participant p6. P6 devoted an initial period to planning 'what to use', followed by two iterative periods of sequential processing of several sources for use or discard (*episodes* 2 and 3). Next, they iteratively sought sources to corroborate some previous found information (*episode* 4). All content was temporarily captured as notes using *pen-and-paper* (intermediate storage). Participant p6 then planned (*episode* 5) how to organise, structure and use the intermediate representation towards the final slideshow, before actually using the notes to build that task deliverable (*episode* 6). They did not reference the task-sheet again after the session started.

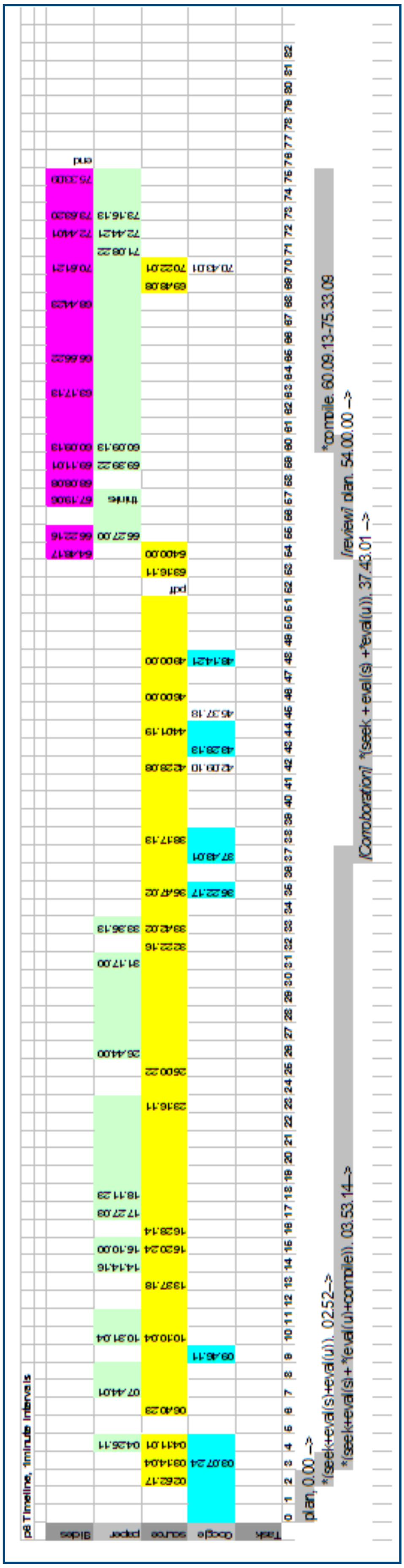

Figure 6.9 Participant p6 session as a sequence of *episodes* mapped against timeline

6.3.5.1.3 Participant p7

Participant p7 began by considering the task requirements and browsing the supplied Google-collection to assess which results might be useful for the task-in-hand. Initially, they selected and evaluated sources sequentially, one-by-one. If the content was judged useful, then it was used immediately. The pattern then changed to batch-mode source selection, followed by batch evaluation, with the content used immediately if the source was judged useful. Participant p7 switched back to sequential processing for the last few sources they processed.

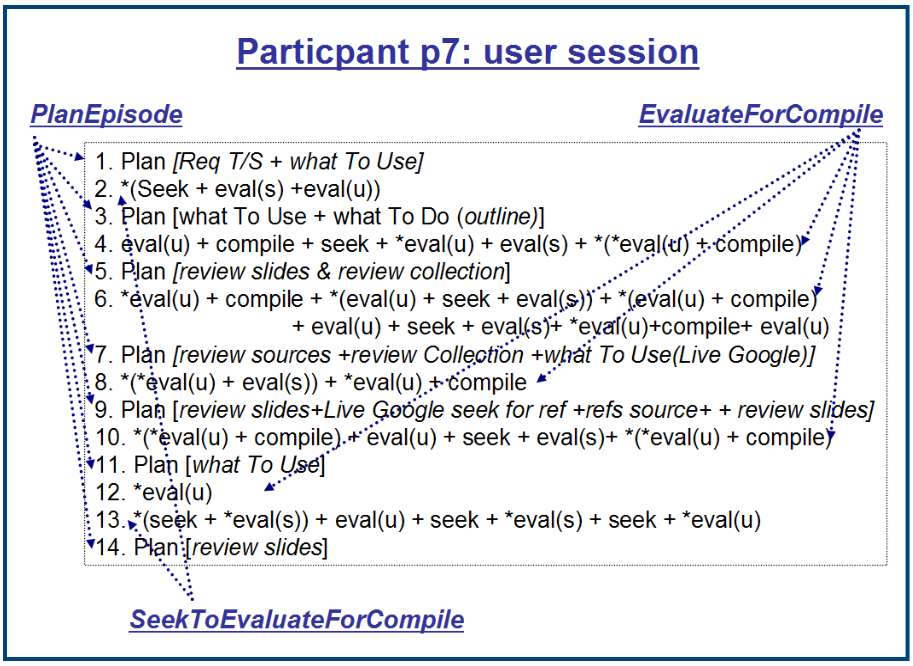

Figure 6.10 Participant p7 session: sensemaking strategy as a sequence of *episodes* labelled as types

As shown in Figures 6.10 and 6.11, participant p7 adopted by far the most complex strategy and was the only one overall to exhibit batch-mode processing. A further complexity of this particular sensemaking strategy was that the participant was unconvinced that the supplied results (Goggle-collection) offered enough scope, so p7 occasionally made use of the 'Live Google' search engine (outside the general guidelines for the session). In the event, no further sources were located via 'Live Google'. Overall, 13/16 sources were evaluated, plus a further seven sources located from drill-downs to external sites; of these 20, seven sources were apparently used.

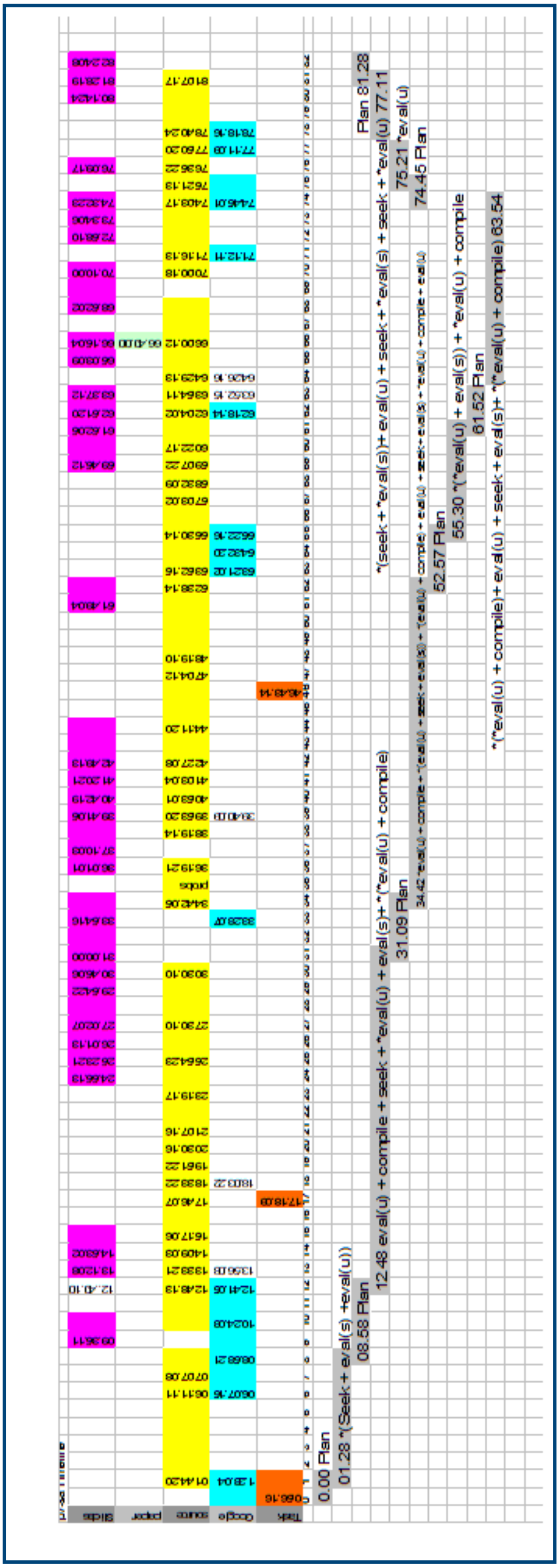

Figure 6.11 Participant p7 session as a sequence of *episodes* mapped against timeline

6.3.5.2 Session patterns and commonalities

Expressing the sessions as sequences of *episode-types* offered insight into patterns and commonalities across the participants' broad approaches to the task-in-hand. Frequency counts aided this exercise, and the counts per *episode-type* per participant are shown in Table 6.9.

***Episode*-type:**	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**
SeekToEvaluateForCompile	2	5	4	4	3	2	2	2
SeekToEvaluateToCorroborate		1				1		
EvaluateForCompile	2						5	
Compile					1	1		
PlanEpisode	4	2	4	5	3	2	7	4
Total episodes per participant:	8	8	8	9	7	6	14	6
% of PlanEpisodes:	50%	25%	50%	55%	43%	33%	50%	67%

Table 6.9 Frequency of *episode-types* per participant session
(from all sessions listed Chapter 5, Figure 5.8)

- two types of *episode*, namely seek-driven activities to evaluate for compile (*SeekToEvaluateForCompile,* and *planning* activities *(PlanEpisodes)* were common to all participants. The other three *episode* types were less common. Evaluating sources for compile was particularly apparent for participant p7, which reflected their unique batch-mode approach to source selection (6.3.5.1.3);
- all approaches were characterised by at least 25% of *planning* activity *(PlanEpisodes)*, and by 50% or more in five of the eight cases. *Planning* was an important activity, but any patterns need further investigation, as the *planning* behaviour itself varied to include one or combinations of four different types of *planning* (6.3.5.3);
- all participants exhibited iterative periods of sequential-mode source-processing (*SeekToEvaluateForCompile*), with participant p2 displaying a relatively higher iteration than others. In many sessions, this activity was at least as dominant as p*lan*-type activities. Two participants evidenced a dedicated *compile episode* in which they

built their final slideshow from their previously gathered and represented content (e.g. from notes).

Many of the approaches were characterised by the interspersed activities of seeking sources to evaluate for usage (*SeekToEvaluateForCompile*) and *planning* activities (*PlanEpisode*). Indeed, a regular mix of these types of *episodes* characterised the strategy for three cases: participants p3, p4 and p8.

Other commonality was seen in both participant p5 and p6's two-phase approach to their usage (*compile*), i.e., they dedicated an additional period of time solely to (re)represent information content they had already gathered and temporarily represented as artefacts of their sensemaking, e.g., in this cases hand-written notes. However, their approaches are not otherwise similar.

The remaining participants, p1, p2 and p7, although characterised by combinations of the common two *episode-types* did not reflect any particular patterns in their session approach. Nonetheless, participants p1 and p7 were the only two to directly evaluate already-opened information sources for possible use (*EvaluateForCompil*e). However, that is where the similarity between these two cases ended.

6.3.5.3 The role of planning

The dominance and importance of planning activities was evident from the sequences of *episode-types* (Table 6.8 and Figure 5.8). *Planning* activities were seen to relate the other *episodes* to the task-in-hand. The frequency of particular types of planning and when they occurred during a session provided insight into the overall session strategy, as discussed below.

6.3.5.3.1 Requirements gathering

Prior to the start of session, participants were provided an opportunity to read and question the task requirements as per the supplied task-sheet (ref Chapter 5.2.3), however all but participant p6 referenced the available task-sheet again during the session. One participant (p4) chose to focus on the requirements for a period of time prior to accessing any sources. Others (p3 and p7) occasionally checked requirements alongside other planning actions. P3 occasionally checked for requirements such as audience type outside *planning*, for example whilst *compiling* from sources. Similarly, p2 only referred to the requirements outside planning activities, for example whilst undertaking evaluation of sources. P8 devoted a proportionally large chunk of time gathering task requirements, both at the beginning and end of the session. Only two participants (p4 and p5) marked the task-sheet, i.e., used it as a representation resource for organisation/planning.

6.3.5.3.2 'What to do'

Three participants demonstrated top-down approaches by creating an 'outline schema' or structure as an external representation. This was done at the beginning of their session prior to accessing any results from any source content or indeed prior to accessing the supplied Google-collection for the first time. Each did their outline differently:

- p1 created a few outline slides (task deliverable).
- p5 drafted an outline in pen-and-paper (an intermediate workspace).
- p8 created an outline representation in *MicroSoft Word* (an intermediate workspace).

Other outline schemas were created either during a *planning episode* later in the session (p4, p5, p6, p7), or as part of a *compile* activity whilst processing a source (p2).

6.3.5.3.3 'What to use'

Making decisions about 'what to select for possible use' from the supplied Google-collection was the first planning action performed by many participants. For three participants (p3, p5, p6), it was the only time this planning action was undertaken. P4 planned 'what to use' only once, and not until after they had processed at least one web-based information source, whereas p1 considered the Google-collection for 'what to use' several times during their session.

All participants who adopted a sequential mode of processing identified suitable result entries but did not launch them; instead, the sources were left to be opened one-by-one as and when the participant was ready to process that source.

One participant (p7) worked sequentially at the beginning of their session, but switched to batch-mode processing thereafter (Figure 6.11, *episode* 3, 5, 9, 11). In this batch-mode, they typically selected and launched several sources together during the planning activity, in preparation for later batch evaluation (during a period of *EvaluateForCompile*, ref Figure 6.11, *episode* 4, 6, 8). At another point, they performed two separate '*live Google'* searches during the session and inspected the results for ‘what to use’ (p7, *episodes* 7 and 9).

Finally, participant p8 used the Google-collection as an intermediate workspace; they browsed the Google-collection and annotated any results judged to be of interest or of use. The annotations were reviewed and edited during a subsequent planning *episode* which was an example of a resource used in an alternative role (6.3.5.4.2).

6.3.5.3.4 ‘Review’ planning

‘Review’ planning was the most common type of *planning* undertaken, and it occurred regularly. The majority of these *episodes* involved a review of the developing slideshow in whatever medium (e.g., slides, pen-and-paper, *MicroSoft Word*). ‘Review’ planning typically followed seek-to-evaluate-for-compile *episodes* (e.g.,p3 and p4).

Typically representations were edited or (re)organised during these reviews. For example, as described earlier, p2 conducted a two-phase review, when key aspects of the slide representation were noted onto pen-and-paper, which was then reorganised and annotated prior to changing the slides accordingly. On the other hand, the review sometimes involved other material or content as well as the external representation, for example, the Google-collection was reviewed for dates for corroboration (p7 and p8), and the Google-collection was reviewed as a reflection of what had or had not been selected for further consideration (p1).

6.3.5.3.5 Planning as indicating sensemaking approaches

As well as binding the other activities to the task-in-hand, the planning activities offered insight into the sensemaking approach adopted. Each of the four *planning[types]* indicated a particular approach, as summarised in Table 6.10. An analysis of the frequency and occurrence of planning types indicated the sensemaking approach for each participant:

- a dominance of task-oriented and plan-oriented activities indicated a top-down approach;
- a dominance of reactive, data-driven activities or none, indicated a bottom-up approach;
- no clear dominant planning activity indicated a mixed approach.

Planning[type]	***indicates***	***sensemaking approach***
Requirements gathering (ref t/sheet)	*indicates*	Task-oriented
Decide 'what to do'	*indicates*	Task-oriented
Decide 'what to use'	*indicates*	Plan-oriented
Review activity (review, reorder, etc.)	*indicates*	Reactive and iterative
No strong planning	*indicates*	Data-driven

Table 6.10 Sensemaking approach indicated by planning activity

Analysis of the planning types exhibited, in the context of the richer descriptions of behaviour, was used to infer both the dominant approach for each participant, and an overall approach for each, as summarised in Table 6.11.

p-ID/approach	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**
Dominant approach(s)	task & plan	reactive & mixed	plan & reactive	task & mixed	task & plan	plan & task	plan & task	task & plan
Overall approach:	**Top-down**	**Bottom-up**	**Mixed**	**Mixed**	**Top-down**	**Top-down**	**Top-down**	**Top-down**

Table 6.11 Each participant's overall sensemaking approach derived from *planning* activities

6.3.5.4 Profiling outcomes: other patterns

The detailed profiling of each session also highlighted other patterns and commonalities in participants' sensemaking strategies. These are reported in this Section:

- seeking patterns and seeking prompts;
- general resource usage and patterns concerning storage and organisation of resources;
- how sources and source content were used;
- sensemaking artefacts.

6.3.5.4.1 Seeking patterns and seeking prompts

Seeking was integral to the overall strategies. Between 50% and 87% of the *episodes* in each session reflected '*seek +select*' activity. Generally, participants adopted a sequential approach to seeking, selecting and evaluating sources for use, with only one (p7) adopting a batch-mode approach. The focus of selection typically changed and iterated across from 'general to more specific needs' although two participants (p1 and p8) only sought content for general needs, they never sought the deeper level of detail.

A number of prompts triggered participants' seek-related actions. As indicated by their utterances, they wanted to locate sources:

- relevant to specific task-keywords;
- offering a balance to viewpoints already located and used;
- that gave additional information about a newly-found keyword or concept in an already-evaluated source;
- for corroboration purposes;
- that offered a different style or level of language, for better or broader understanding.

6.3.5.4.2 Resource usage

Timelines have already contributed to the insights into each participant's broad sensemaking strategy; for example each *episode* sequence, mapped to the respective timeline, highlighted the relationship of resources 'in-play' to *episodes*. In addition, the pattern of resource interactions helped to reinforce the characteristics of the underlying *episode* expressions. Regrouping the eight participant timelines into five different resource timelines (Figure 6.12, with larger renditions in Appendix D) allows further examination for patterns of resource usage during their sensemaking.

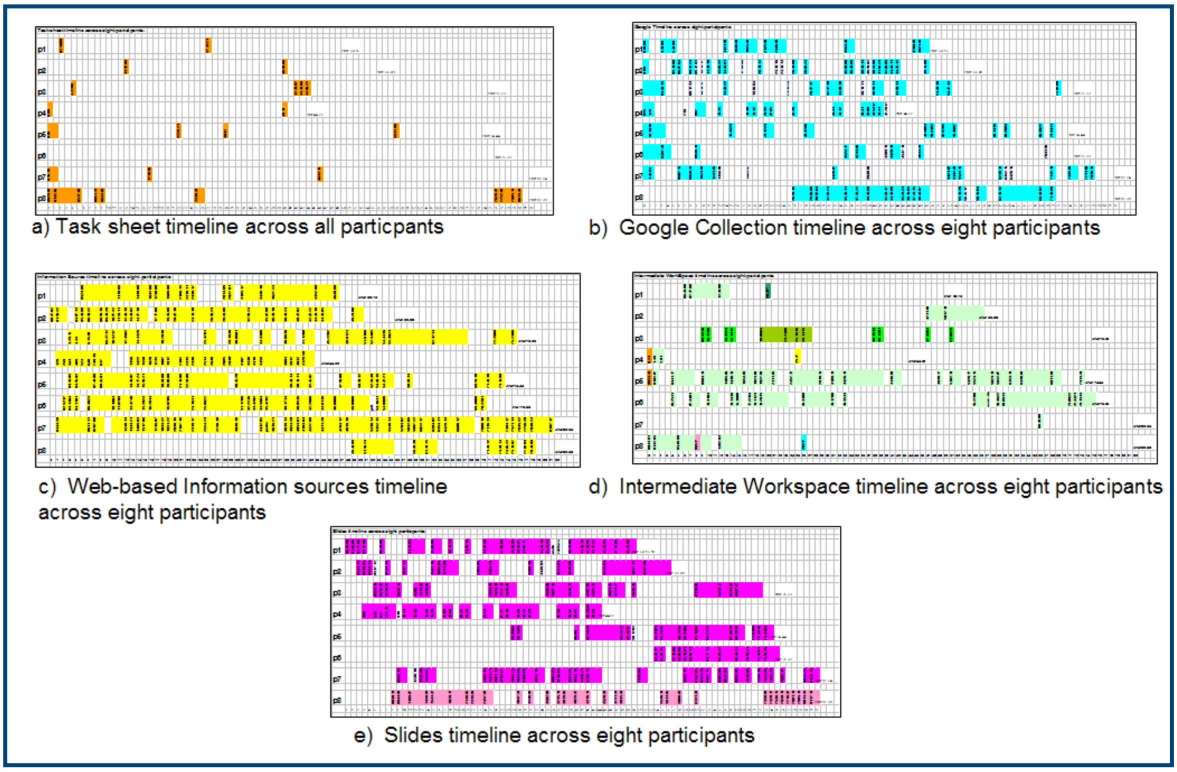

Figure 6.12 Five resource timelines:
a) Task-sheet, b) Google-collection, c) Web-based information sources, d) Intermediate workspace resource, e) Slides

Legend note: the participants read from top-to-bottom p1-p8 in each timeline

Resource usage differed for each participant. However, there are some patterns. For example, the task-sheet was infrequently accessed for typically short duration, reflecting the apparent lack of requirements gathering during the session (6.3.5.3.1). The Google-collection was 'in-play' much more frequently; the interactions were mainly two minutes or less, apart from one participant who took a task- and plan-driven approach (6.3.5.3.5).

Typically, throughout each of the eight sessions, at least one web-based information source was 'in-play', often as the primary resource, emphasising the amount of time participants dedicated to evaluating sources. There were three distinct patterns to participants' interactions with web-based information sources (*resource-S*):

- interaction throughout the session (Figure 6.12 (c) participants p1-p4, p7), illustrating the regular, iterative nature of their evaluation and extraction activities;
- periods of no interaction during the latter half of the session (Figure 6.12 (c) participants p5 and p6), illustrating a two-phase approach to using found content;

- no interaction until as late as half-way through the session (Figure 6.12 (c) participant p8), illustrating a strategy involving considerable planning, both requirements gathering and planning ‘what to use’.

The task requirement was to produce a presentation slideshow, with *MicroSoft Powerpoint* supplied as a resource. For the seven participants who used this resource, it was ‘in-play’ for much of their session:

- interactions throughout the session (Figure 6.12 (e), participants p1 to p4);
- the first interaction was significantly delayed, but thereafter the resource was used consistently until the end of session (Figure 6.12 (e), participants p5 and p6); illustrating the emphasis on (re)presentation as a second phase of content usage;
- a slightly-delayed first interaction with slides, whilst the participant discarded a few evaluated sources whilst planning ‘what to do’ (Figure 6.12 (e), participants p5 and p7).

Storage and organisation preferences

The combined use of slides with intermediate workspaces (Figure 6.12 (d) and (e)) highlighted a few patterns that reflected participants’ sensemaking approaches, e.g., organisation and restructuring frequently occurred during planning activities.

- Five participants (p1 to p4, p7) regularly collected and assimilated found content on slides. Occasionally they accessed an additional intermediate workspace either for storage or for organisation and structuring. Additional workspace interaction was typically early in the sessions, apart from p2, who only used an intermediate workspace for (re)organisation purposes at the end of their session.
- Two participants (p5 and p6) preferred to use pen-and-paper for representation, and they kept it ‘in-play’ throughout the session. Initially they stored the found content. As a second stage, this intermediate ‘self-generated content’ was further organised and (re)represented onto slides
- One participant (p8) worked with two types of intermediate workspaces for storage /organisation throughout. P8 chose to work with *pen-and-paper* for initial storage and outline schema representation, then with *MicroSoft Word* for both outline/organisation and more detailed representations. P8 did not access slides.

Intermediate workspace resources

All participants deployed at least one type of intermediate workspace resource. The colour-coded cells highlight both the type of resource and when it was used (ref Figure 6.12 (d)). All used pen-and-paper, although not always for the same purpose. In addition to the two (p5 and p6) who used it as their primary storage/organisation resource, others used it as:

- a secondary resource for note-taking during use;
- a planning aid, either for an initial outline schema, or for reorganising a representation late in the task.

MicroSoft Word and *NotesView* were similarly used for note making, and *MicroSoft Word* was used to develop outline slides. The Google-collection and Task-sheet were also used as a temporary intermediate workspace.

Resources used in alternate roles

Occasionally resources were used in roles other than their default or expected role. Every resource type was used, at least once, in an alternate role:

- reference resources (task-sheet and Google-collection) were used for representation/organisation purposes during planning activities, e.g., keywords contained on the task-sheet were marked/underlined during requirements gathering;
- results listed in the Google-collection were prioritised with numbered annotation during deciding 'what to use';
- pen-and-paper used as an output resource during a final review/reorganisation activity was then used as input to a second iteration of the activity, which produced a reordered/(re)represented slideshow;
- content noted on pen-and-paper was used as input during a subsequent *compile* activity;
- content temporarily represented in *MicroSoft Word* was reorganised and edited prior to being used as input to the next step in the same compile instance;
- instances of information sources were used in two different roles, e.g.:
    - occasionally used as 'proxy' collections points holding clickable hyperlinks to other web-based sources;
    - used as an intermediate workspace representation device when content was marked/annotated as useful in the future.

6.3.5.4.3 Information sources: evaluated and used

Table 6.12 summarises the numbers of information sources and slides used by each participant. Sixteen search results (surrogate sources) were offered (via the Google-collection results), and a selection of these was evaluated as useful. Several participants accessed additional external sources via hyperlinks embedded in supplied sources. Only a few of these extra resources were explicitly used to produce the task deliverable.

	p1	**p2**	**p3**	**p4**	**p5**	**p6**	**p7**	**p8**
No. of sources evaluated	6	16	8	10	7	7	13	3
No. of sources used	4	7	5	6	6	4	7	3
No. of sources via hyperlinks evaluated	0	1	1	0	0	3	5	0
No. of external sources used	0	1	1	0	0	3	1	0
Total no. of slides generated (excl. Title slide)	13	10	14	12	3	9	66	7*

Table 6.12 Numbers of sources and slides per participant

Some participants relied on only a few located sources from which to develop their slideshow (collective representations). Usually, the slide content could be traced to the originating source, except where participants (p5 and p6) gathered content from various together on *pen-and-paper*, prior to building slides from the gathered content

Sources that were judged to be useful were normally used immediately, and at least five participants (p1, p2, p5, p6, p7) showed preference for content from one or two particular sources above others. In all cases, sources remained open for the remainder of the session, and a few participants did re-access open sources for further reference or extraction purposes, e.g., p1 initially evaluated and bookmarked a source, revisited it to evaluate it further, then revisited it again and built four slides from its content.

6.3.5.4.4 Specific use made of source content

Source content was typically used toward one or more slides, e.g., participant p1 used a source to generate and populate seven slides. A single slide representation was often populated from more than one source. The source content contributed to both the structure and the content of the representation.

Source content used towards structure:

- slide titles, e.g. participant p3 used site name and keywords from WebPage content as heading (slide 9, 26.24.13);
- bullet point structure, e.g., participant p4, slide 4, 15.20);
- keywords were extracted from pasted bullets/lists as slide title (p3, 42.47.12).

Source content used towards detailed slide text:

- *verbatim* copy-and-paste, (p3, slide 2, 42.07.06);
- copy and type own words, (p3, slide 10, 61.18.06);

6.3.5.4.5 Extracting and representing

Extracting and representing appeared predominantly during *compile* activity but occasionally during *planning* behaviours (6.3.2.5). The mechanism varied, with many participants exhibiting a variety of techniques, sometimes during a single instance of *compile* behaviour (e.g., p3, 35.06.01). The most common technique was select/highlight, copy content and paste it *verbatim* (copy-and-paste) as a representation. Most participants used a variant of this copy-and-paste:

- copy text *verbatim* to slides or to intermediate storage (including pen-and-paper);
- copy-and-paste text (as above) but further edit text or organise into different structure (e.g., p3, 19.06.04);
- type or write main keywords rather than copying all the existing source text (e.g., p5, 16.54 wrote keywords to pen-and-paper);
- copy-and-paste icons and cartoons (e.g., p7, 42.49.13).

Other techniques included:

- paraphrase (e.g., p3, 61.18.06);
- interpret text/content as a drawing (e.g., ID card from text description, p6, 18.11.23).

Table 6.13 lists the main extraction and representation techniques used by each participant.

p-ID:	p-1	p-2	p-3	p-4	p-5	p-6	p-7	p-8
Dominant extraction mech-anism:	mixed, copy-and-paste	mixed, copy-and-paste	mixed, copy-and-paste	type + mixed, copy-and-paste (verbatim)	note-taking + type own words	note-taking + type own words	mixed, copy-and-paste	note-taking

Table 6.13 Participants' dominant extraction mechanism

Interaction with the information sources was typically iterative during the *compile* instance, e.g. several switches to *copy* then *paste* several separate chunks of content, possibly followed by further edits.

6.3.5.4.6 Emergent representations

External representations made during the session were explicit evidence of participants' sensemaking, of their use of content towards the task-in-hand. The representations emerged throughout the session and were an output from the majority of *episodes* (Table 6.14), evidence that participants' sensemaking was a continual process.

***Episodes*:**	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**
Total *episodes*	8	8	8	9	7	6	14	6
No. of *episodes* with representation as outcome	6	6	6	8	7	3	8	6
Percentage of *episodes* with representation as outcome	75%	75%	75%	89%	100%	50%	57%	100%

Table 6.14 Percentage of participants' *episodes* with representation as an outcome

Participants generated representations early and frequently. Representations were typically generated when the participants extracted structure and/or content and represented it for their own needs. Representations were also generated during their *planning* activities and during one evaluation activity (6.3.2.3).

The majority of the representations were generated as a series of slides, consistent with the task, although two participants (p5 and p6) favoured pen-and-paper prior to re-representation onto slides, and one participant (p8) used pen-and-paper for an initial outline schema, prior to switching to *MicroSoft Word* for the remainder of the session

The range of representations was unsurprising:

- keywords/notes or bullet points/lists, used verbatim or with editing;
- a hand-drawn graphic interpreted from source content (p6);
- URLs copied from address bar into representation;
- markings on the supplied task-sheet;
- the use of a system bookmark (e.g. favourites);
- copied images/icons;
- quotations.

Representations particularly associated with planning activities included:

- (re)edited / (re)organised representation (widely evidenced);
- markings on Task-sheet (p5, 0.00);
- annotations on electronic version of Google-collection (p8, 29.09.00).

Edited or organised/reorganised representations were also an outcome in many instances of a *compile* activity.

Occasionally the participant used representation as a planning/organising aid or as a retrieval mechanism. Examples are shown in Table 6.15.

Purpose:	Example representation:	Example occurrence:
sensemaking artefact	notes, keywords, lists/bullets, drawings, etc.	use & planning activities
planning/organising aid	markings on supplied information sources, annotations on Google-collection, titles on empty slides	evaluation (e.g., p4, e'sode 4); planning (e.g., p8, e'sode 2); use (e.g., p2, e'sode 1); planning (e.g., p4, e'sode 3)
retrieval mechanism	a bookmark, note to self, source marked for future use.	use (e.g., p1, e'sode 2); use (e.g., p7, e'sode 10); evaluation (e.g., p4, e'sode 4)

Table 6.15 External representation: purpose with examples

6.3.5.5 Summary

This Section (6.3.5) presented results from the fourth step of analysis, which inferred sensemaking strategies from participants' behaviour, representations and utterances. There were a number of key findings.

> **Finding 5:** The sensemaking strategy used during non-trivial web-based problem-solving tasks was inferred from a sequence of *episode-types*, in association with which resources were 'in-play', and as corroborated by participant utterances.

Participants' sensemaking was a mix of underlying, sometimes complex, behaviours with multiple resources 'in-play'. Important differences were seen in the iteration patterns within and across the *episode* sequences. Two key types of activity (*SeekToEvaluateForCompile* and *PlanEpisodes*) were common to all strategies. Some participants used a mix of only these two types of activity to complete the task-in-hand, whilst others exhibited more varied approaches. Hence:

> **Finding 6**: There was no one overall pattern to the strategies deployed, but underlying commonalities, differences and patterns of behaviours between and amongst the *episodes* were identifiable.

This Section offered detailed sensemaking profiles for selected individuals (participants p3, p6 and p7). Profiling answered deeper questions about their sensemaking and showed the importance of particular activities:

> **Finding 7:** Planning *episodes* related the other activities to the task-in-hand; this relationship indicated the type of approach taken, for example, data-driven or top-down.

> **Finding 8:** Seek behaviours are integral to the overall sensemaking, and seek prompts or activators were identified.

Some commonalities and patterns in resource use were identified across the profiles:

> **Finding 9:** One or more intermediate storage resources were accessed and used as workspaces, with a noticeable preference for pen-and-paper.

> **Finding 10**: Resources sometimes operated in alternative roles than those intended or expected

> **Finding 11:** Extracted source content was used for both structure and detail of external representations. For example, source content was used to build overall structure, slide structure and titles, and the text content of slides.

External representations emerged early, frequently and opportunistically as explicit evidence of participants' sensemaking:

> **Finding 12:** External representations were the significant manifestation of participants' sensemaking and typically emerged during *compile* and *plan* activities. These activities occurred early in the sessions and iteratively throughout them. The representations were formed for different purposes, and representation was not always successful. The software did not always support the participant's requirements for extraction and use.

6.3.6 The Relationship Between Information Seeking and Sensemaking

The relationship between seeking and sensemaking can be explored by mapping individual sensemaking strategies, expressed as sequences of colour-coded *episode-types,* onto the empirical framework. Mapping highlights the relationship between the sensemaking strategy and the information-seeking process (expressed as information interactions). An example mapping, modelling participant P3's sensemaking strategy, is given in Figure 6.13 (ref Appendix C for full set of eight mappings). It emphasises:

- the sequential and iterative nature of sensemaking across the whole seeking process;
- that sensemaking spans the seeking process on almost all iterations of *episodes*;
- each *episode's* pathway throughout the process;
- patterns across the processes.

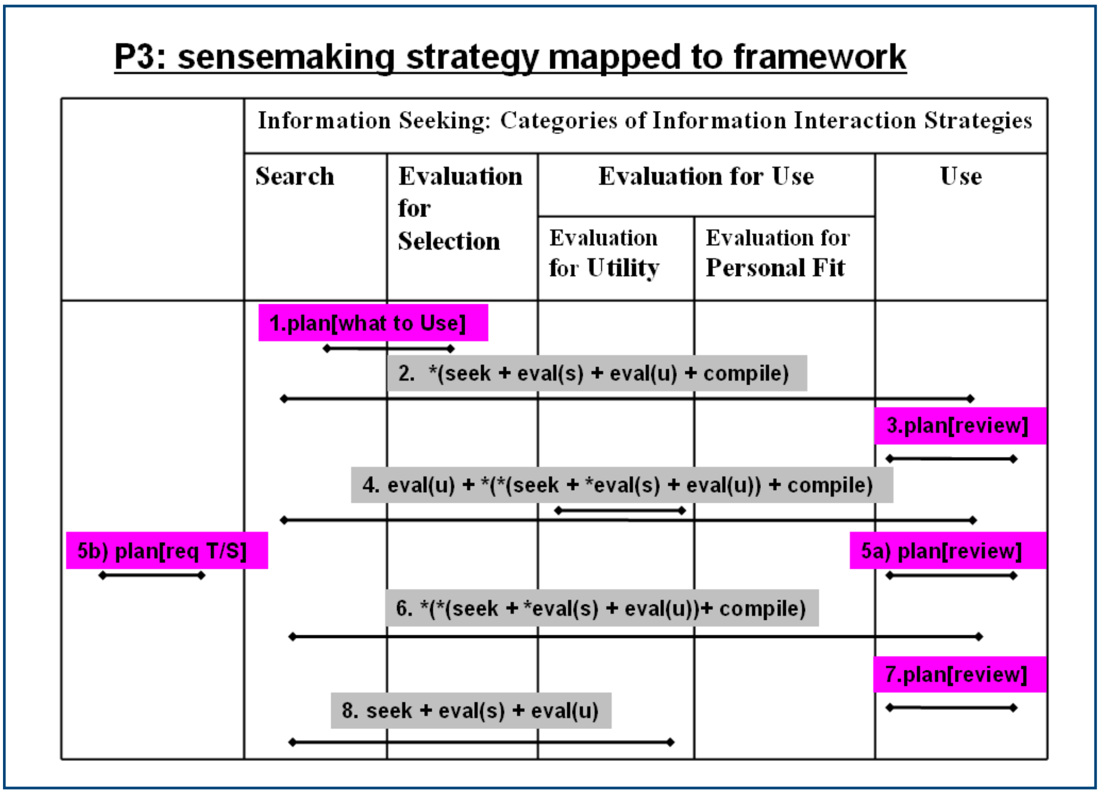

Figure 6.13 Mapping to model p3's sensemaking strategy

Legend: The colour-code used to identify *episode-types* is as used in Chapter 5, Figure 5.8; grey denotes *SeekToEvaluateForCompile,* while purple denotes *Plan[+ indicative purpose].*

Information-seeking is acknowledged elsewhere as integral to sensemaking (Dervin 1983, pg 3), but this mapping offers further insight into other aspects of the relationship. At a macro-level, the relationship is seen from the close mapping between the individual behaviour components. *Planning*, a sensemaking activity that emerged from the analysis, spans and relates to different aspects of the broad web-based information-seeking process. Planning activities about 'what to use' from the supplied Google-collection, map onto the *search* and '*evaluate for selection'* categories of the underlying information-interaction strategies. *Requirements gathering* and planning 'what to do' map onto the pre-search phase of the seeking process. *Review* maps onto the *use* category.

Mapping instances of the sensemaking strategies against the empirical framework from Study-1 shows how closely coupled the processes are:

> **Finding 13:** The empirical framework models instances of the sensemaking strategy within a web-based information-seeking context. The model highlights the relationships between information-seeking and sensemaking; it shows them as closely coupled throughout the broad seeking process, and depicts seeking activities as integral to sensemaking.

6.4 Chapter Discussion

The findings of Study-2 are discussed in this Section in terms of the Research Questions they address (questions 2 to 5). Then, the findings are discussed with reference to the findings from Study-1 (Chapter 4), and as compared to selected relevant literature. Limitations of the Study are considered prior to an overall Chapter summary.

6.4.1 Addressing Research Question 2

Research Question 2 asked:

> *How do experienced end-users make sense, i.e., collect, extract and organise relevant information, from web-based information sources?*

Participants exhibited complex and characteristically iterative sensemaking strategies, which were expressed in this analysis as a sequence of activities, chunked into *episodes*, and categorised into *episode-types*. There was no single common sensemaking approach: some participants exhibited a top-down, other a bottom-up (data-driven) and others a mixed approach. Two key *episode-types* were common to all strategies: *SeekToEvaluateForCompile* (referred to in this discussion as seek-driven *episodes*) and *PlanEpisodes*.

Planning was often the driver of the strategies or at least played a key role in the participant's approach, and it related other activities to the task-in-hand. Four different types of planning were identified, distinguished by purpose:

- 'requirements gathering'
- 'what to do'
- 'what to use'
- 'review'.

Participants typically located and processed several sources sequentially prior to changing to another activity such as a review of their emergent representations. They readily discarded sources after evaluation and immediately used any sources they judged to be useful. Generally, they left sources open throughout the session, and a few re-accessed open sources for further reference or extraction purposes.

Participants typically held various combinations of multiples of resources 'in-play' throughout the session, and this necessitated that they switch frequently between resources. The resources they used for storage and organisation (representations) reflected their personal preferences, and most often they used an intermediate workspace, such as pen-and-paper or *MicroSoft Word* in addition to the primary representation, slides.

External (re)representations were the significant manifestation of participants' sensemaking: typically, they emerged during usage (*compile)* and *planning activities* that occurred early and iteratively throughout the session. Exceptionally, representations emerged as an outcome from *evaluation* activities. Occasionally participants created representations for other purposes such as retrieval (e.g., bookmarks, pasted URL), or as an organisation aid to restructure located source content into their own representation.

Some participants were fairly selective in their use of sources, preferring to rely on a few corroborated sources to generate a batch of slides, whilst others undertook to investigate as many if not all sources in the Google-collection for possible nuggets of information that might be useful. Participants typically used source content towards one or more representations (slides), and they often populated a slide with content extracted from more than one source content. The content itself contributed to both the representation's structure and its detail/content.

6.4.2 Addressing Research Question 3

Research Question 3 asked:

> *How do users externally represent both the collection and the meaning being derived from the information sources?*

The range of representations (6.3.5.4.6) was not unique to this Study. For the most part, participants generated notes or structured slides with listed bullet points and text detail. There were some variations, including a hand-drawn graphic interpreted from source content. Generally participants used slides for their external representations throughout, but often one or more intermediate resources were deployed prior to generating slides. As participants made more sense, they might interact with the external representation, to amend the content of the artefact or to develop the structure.

6.4.3 Addressing Research Question 4

Research Question 4 asked:

> *How does users' sensemaking relate to the seeking process?*

The relationship between seeking and sensemaking was explored through mapping individual sensemaking strategies, expressed as sequences of colour-coded *episode-types* (Chapter 5, Figure 5.8) onto the empirical framework (Chapter 4, Figure 4.4). This mapping (Figure 6.13) highlights the relationship between sensemaking, seen as a sequence of instances of *episode-types* and the information seeking process, seen as categories of information interactions. The information seeking and sensemaking processes were shown to be closely coupled, with planning evident as a sensemaking behaviour that links to the task-in-hand, and *seeking* and *use* behaviours shown to be integral to the sensemaking process.

6.4.4 Comparing Findings to Study 1

Overall, the results from Study-2 helped to validate the categories of information interactions depicted in the empirical framework from Study-1 (Figure 4.4). The behaviours from Study-2 broadly mapped onto those previously identified.

Evaluation *(eval(u))* appeared to map more to *evaluate for utility* than to *evaluate for personal fit*, although there was evidence to support the distinction of *evaluation for personal fit*. For example, participants occasionally revisited a source and evaluated specific material to extract, having previously identified that the source had useful content. In another example, during complex *compile* behaviour with iterative switching between source and target representation, participants undertook further evaluation, deciding what content to use at that particular point-in-time for the task-in-hand. These results concerning *evaluation for personal fit* are not as robust as relevant findings from Study-1. However, given the time-constraint and the nature of the task, this boundary between *evaluation for utility* and *personal fit* is worthy of further investigation. This is outside the scope if this project.

Study-1 offered results indicative of explicit sensemaking occurring during *evaluation for personal fit* and use/compile, and implicit sensemaking occurring elsewhere during the seeking process (Chapter 4, Section 4.8.2). Findings from Study-2 corroborated these initial results and offered further insight. Study-2 showed that participants adapted their seek and evaluation goals as their understanding of the topic developed, and external representations emerged as they made sense. There was further corroboration found between the two studies:

- a similar range of extraction and representation mechanisms was used;
- a similar range of emergent representations, although those from Study-2 were in fact a sub-set of those from Study-1, which also had several complex representations more suited to longitudinal tasks;
- a similar preference for the use of pen-and-paper as an intermediate workspace.

Planning emerged as a sensemaking activity only in Study-2, extending the model developed from Study-1.

6.4.5 Study 2 Findings Compared to Other Related Research

The view of sensemaking presented in this Study is compared to the work of Dervin (1983), Russell et al. (1993) and Qu and Furnas (2005), key researchers in the field..

Comparison to Dervin's sensemaking framework

Study-2 findings map well onto Dervin's outline model that identifies the three concepts: Situations – Gaps – Uses (Outcomes). In this Study, the comprehension task is considered the 'Situation' context, and the 'Gaps' are participants' lack of knowledge about the topic, which gives rise to their information needs. They develop an approach or strategy to bridge the 'Gaps', enabling them to move to 'Uses', which in this case results in their task slideshow. This is expressed diagrammatically in Figure 6.14.

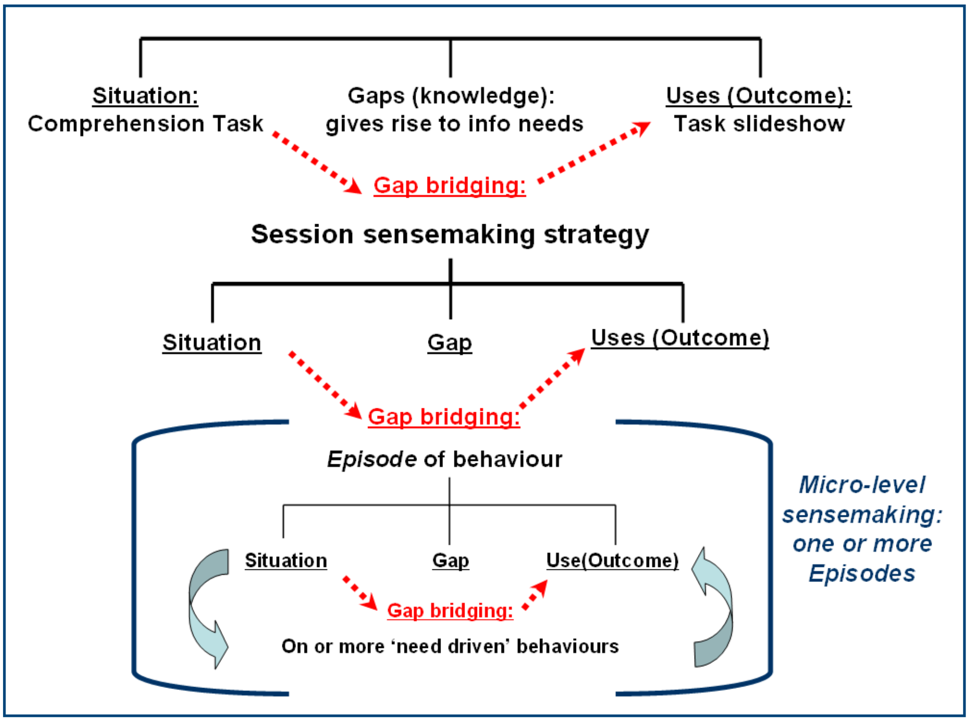

Figure 6.14 Pattern of sensemaking mapped against Dervin's framework

The diagram (Figure 6.14) reflects the related macro-level and micro-level findings presented in this Chapter, showing that Dervin's model can be interpreted as relevant to each level. The presented findings have shown that sensemaking is a highly iterative strategy expressed as sequences of *episodes* of behaviour, each of which conforms to Dervin's framework.

Comparison to Russell et al.'s 'Learning Loop Complex' model

The findings from Study-2 can also be described in terms of Russell et al. (1993) 'Learning Loop Complex' model (Chapter 2, Figure 2.10). Participants developed outline slides as representations or schemas (the *generation* loop) and repeatedly searched to locate and add or encode the slides with detailed content (the *data coverage* loop). When they found other relevant content that did not fit with their existing representations (*residue*), they created new slides, and/or amended slides and/or occasionally deleted slides (the *representational shift* loop). The observed sensemaking strategy was highly iterative, as is Russell et al.'s model.

Three aspects are worth comment:

i. Outline slide(s) were generated from existing knowledge or experience in only a few cases. More often, outline slides were prompted by what was read from the located information sources (during *data coverage* loop) or from discovering *residue* (the *representational shift* loop).

ii. The search for representation and content were more integrated than Russell's findings. Instead they were more in line Qu & Furnas findings (2005).

iii. Generally participants in this Study reflected the integrated nature of searching and representing as in Russell et al.'s original model (1993) rather then the distinct foraging loop and inner loop as suggested by Pirolli et al. (2005) and the later revised 'Learning Loop Complex' model (Russell et al. 2008). Only two cases exhibited the distinct foraging and sensemaking loops as per Pirolli et al..

Comparison to Qu & Furnas 2005

A further comparison can be made to a Qu and Furnas's empirical study investigating "sources of structure in external representations" (2005). There was an important difference between Qu et al.'s study and this Study-2: the environments. Their study used a sensemaking-supporting information-gathering system (CoSen) to support participants' searching and representation tasks such as creation of bookmarks and outline talk representations. Despite this difference in environments, some findings from both studies were similar. Study-2 found that:

- seeking activity was integral to the sensemaking, and utterances suggested that participants were attempting to make sense of what they found (Finding 8). This echoes Qu and Furnas' finding.
- located content was extracted and used for both structure and detail of emergent external representations (Finding 11). This was an integrated activity, consistent with Qu and Furnas' findings, rather than the separate actions as found by Russell et al. (1993).
- without the constraints of a specialised system, Study-2 offered insight into participants' representation use, such as numbers of resources 'in-play' and the types of representation resource preferred for the task. Additionally, although bookmarks and outline schemas were evident, this Study-2 did not restrict participants to just these representations.

6.4.6 Limitations of Study 2

Efforts were made to provide a naturalistic environment, giving participants access to all resources they would normally use for such a task. Indeed, feedback suggested that participants were comfortable with their environment and the laboratory configuration. Each claimed their approaches under observation were typical. However, the results presented in this Chapter were obtained through observation of a topic-comprehension task that was necessarily time-constrained. Time-constrained studies inevitably carry consequences and several aspects may have been influenced:

i. Many exhibited a mixed mode 'extract and represent' approach, but it is difficult to determine whether the extraction techniques deployed were influenced by the time-constraint.
ii. The variety of (task deliverable) slideshows suggested that the time constraint might have been a factor in what they managed to produce. For example, some slide presentations were fairly complete, while others contained slides that were 'titled' but empty, and others had only a single bullet point to indicate the purpose of the slide.

Each of the design choices might have been a source of bias. For example, task and other factors including data, experience and knowledge can influence the choice of external representations (Faisal et al. 2009). System functionality such as concept mapping tools can also be an influence. The task requirement, to deliver a slide presentation, probably encouraged participants to work in slide-type structures or similar transferable structures. Nevertheless, the findings raise some valid external representation requirements for design.

6.5 Chapter Summary

Study-2 investigated sensemaking from a strategy perspective. Each individual participant's sensemaking strategy was inferred from their sequence of behaviour *episode-types*, together with reference to which resources were 'in-play', and as corroborated by their utterances. Four steps of analysis (Figure 6.1) informed the strategy inference, and the detailed nature of the instances of strategies became apparent as analysis progressed.

Despite individual variation, there were some underlying patterns to the set of strategies. Thirteen key findings (enumerated in 6.3) offered insight into the sensemaking. These thirteen findings are merged and summarised here:

- *seek* actions were integral to sensemaking. Several seek prompts were identified, with relevance for the exploratory search research community.
- *planning* emerged from the analysis is another integral component of both information-seeking and sensemaking. It bound the other activities to the task-in-hand and was the driver for many strategies. When and how participants *planned* offered insight into their sensemaking approach;
- multiple resources were typically 'in-play', and resource interaction patterns across the strategies showed some reliance on intermediate workspaces for organising/planning, retrieval and sensemaking. Resources were used in more than one role;
- emergent representations were the significant manifestation of participant's sensemaking, often amplified by utterances. Utterances occasionally independently implied sensemaking. Extracted source content was used towards both structure and detail of emergent external representations.

Each sequence of *episode-types* mapped onto the empirical framework from Study-1, highlighted the relationships between sensemaking and information seeking. The model highlighted the iterative sensemaking pathways through the overall seeking process. Sensemaking and seeking are intertwined, with *seek* actions integral to the sensemaking. Emergent external representations explicitly showed *use* and *planning* activities to be significant sensemaking activities.

The *Use* component of information seeking has received little attention to date; investigating the use of found content during sensemaking has provided valuable insight into the complexity of the underlying *Use* behaviour (6.3.2): how participants used the located content for their own task needs and produced emergent representations (6.3.5.4.5 and 6.3.5.4.6). Additionally findings offer insight into the way the resources are accessed during sensemaking. No other such study to date is known to provide this combined detail.

Chapter 7 - Web-Based Sensemaking: Implications for Interaction Design

This Chapter attempts to address the fifth Research Question:

> *What are the implications for interaction design of sensemaking support tools and systems?* *(ref Chapter 1.3.5)*

The objective of this fifth Research Question was to understand and interpret the findings from the first four Research Questions, as addressed by the two main studies (re Chapter 4-6), and identify the implications for the design of software to support sensemaking tasks (hereafter referred to as sensemaking technologies). This is analogous to the first key step in interaction design which is to identify needs and establish requirements for the user experience (Sharp et al., 2007).

Information seeking itself is known to be an interactive task (e.g., Marchionini 1995, pg 17; Belkin et al., 1995, pg 4) and results from this project show that all of the five component behaviours underlying sensemaking are characteristically interactive. These are

> *seek, eval(s), eval(u), compile* and *plan*

Each consists of a series of interactions between user and the resources provided by the computer-based system or any supplementary resource such as *pen&paper* . Participants spent their time between two main types of activities

- interacting with the search-engine interface, selecting and evaluating selected web-based information sources from returned *Google* results (known as the Google-collection);
- interacting with located information sources to create, edit/organise their own external representations using various 'extraction and representation' mechanisms;

In the case of Study-2, visual inspection of the timelines (ref Appendix D) and as supported by other aspects of the analysis, indicates that the bias of time was spent on the latter sub-task, what Russell et al. in their updated model calls the sensemaking loop of the process (ref Russell et al., 2008) . This research is interested in the design implications that arise from these interactions between end-user and the located information sources as they make sense, i.e., use located information for their own purposes. Unfortunately findings showed that some of the existing computer-based functionality was not always robust enough for this activity.

Seven of the thirteen Study-2 findings (ref Chapter 6.3) relate to the sensemaking loop and are considered to offer insight into the interaction design needs for sensemaking support technologies. An interpretation of these findings, with respect to their implications is the focus of this Chapter. Another finding evidences how integral seek/search actions are to the sensemaking process (ref Finding 8, Chapter 6.3.5). However, this research is not concerned with implications concerning the search engine per se and this finding was not explored further.

It is the more detailed findings from Study-2 that best inform this fifth Research Question. Findings from Study-1 provided an overview of where sensemaking occurred explicitly in the seeking process, e.g., mainly during usage of information, and samples of emergent (re)representations, gathered post-sessions, illustrated the range of representations generated during such tasks. This range contained sophisticated examples, e.g., concept maps generated by specialist tools, through to simple lists, and on-source examples such as underlines, highlighting and margin notes. These sensemaking artefacts were generated outside the data collection session (ref Chapter 4.5), and at different times, likely over weeks and months. As such the Study was not devised to gather data about the interaction experience during external representation. Instead Study-1 findings feed into this fifth Research Question through providing the framework for the second more detailed Study and as a base range of representations for comparison with Study-2 results.

Section 7.1 considers the seven empirical findings from Study-2 (1, 2, 7, 9-12, Chapter 6.3), with respect to the insight they offer into interaction design requirements for sensemaking technologies. The design implications are discussed (7.2) and a conclusion is then offered (7.3).

7.1 Empirical Findings: Areas of Activity and Indicative Implications

The seven key findings judged to indicate implications for design are

Findings 1, 2, 7, 9, 10, 11, 12 (ref Chapter 6.3)

These organise into three areas of activity where technology support could enhance the user experience during sensemaking tasks. The activity, its associated indicative implication, and contributing findings (numbered as from Study-2), are listed in Table 7.1.

Area of activity:	Indicative design implication:	Underpinning Finding(s):
1. switching between resources (including navigation)		
	functionality to support end-users' switches between multiple resources 'in-play' at any one time;	1
2. external representation and re-representation		
	more robust mechanisms to support users' often complex extraction and representation activities. Furthermore, intermediate workspace resources and resources not normally seen in external representation (output) roles might be used for this purpose.	9, 10, 11, 12
3. planning including management		
	management support with respect to resources and the process, particularly planning activity.	1, 2, 7, 9, 10

Table 7.1 Three areas of activity, associated indicative design implications and underpinning findings

The next Section presents the characteristics of the findings underpinning the three implications. This is followed by a discussion regarding the design implications.

7.1.1 Switching Between Resources (Including Navigation)

Finding 1 and its related results (ref Chapter 6.3.1) showed that multiple resources were frequently 'in-play' at any one time throughout the task. As a consequence of high occurrences of multiples 'in-play', the majority of sensemaking behaviours carry an overhead: switching between or navigating within and across resources. Each resource type typically has a different associated application, e.g., *Word* document and *PowerPoint* slides. Inevitably this has a reasonable risk of error and results showed that switching typically executed via open tabs, resulted in over 6% errors across the total number of interactions when multiples of resources and applications were 'in-play' (ref Chapter 6 Table 6.2).

An extract taken from participant p3 timeline (Figure 7.1) illustrates the frequency of multiples 'in-play', showing an example instance of each of the four possible multiples of resources 'in-play'. It also highlights an example switching error when the participant switched from an information source to the Google-collection rather than the intended switch to their slides representation (Figure 7.1, timeslot 38).

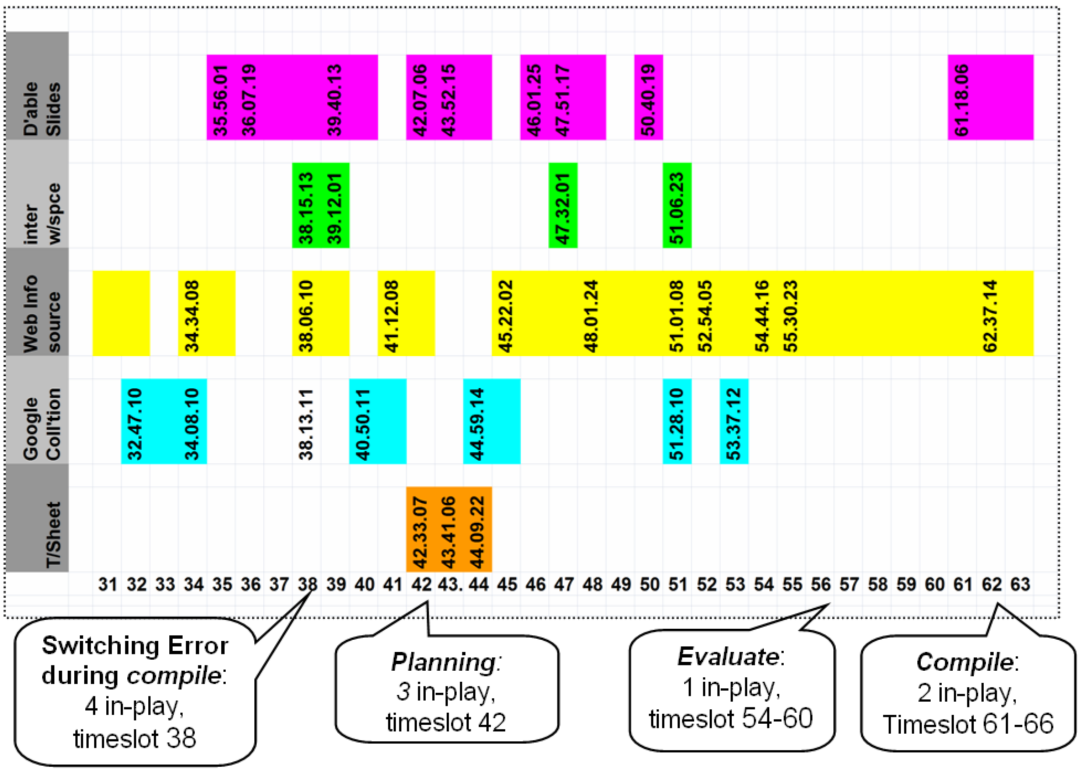

Figure 7.1 Extract of participant p3 timeline

There is no pattern in how users use and mix multiples of resources ‘in-play’ and there are a number of factors that contribute to the complexity of this implication:

- within each instance of a resource ‘in-play’ there could be multiple instances of that resource type ‘in-play’, e.g., several different instances of information sources (web-sites) might be ‘in-play’;
- instances of varying multiples can be ‘in-play’ for varying lengths of time and the switching can often be rapid for short bursts or less intense for longer periods;
- the types or combinations of multiples of open resources are dependent on user’s preference, particularly in the case of their preferred intermediate workspace;
- the volume of instances of multiples ‘in-play’ across the session reflects the complexity of the underlying behaviour and their characteristics with respect to resource usage.

Navigation around information sources was less of an issue although there were navigation errors, usually as a direct consequence of breadth-and-depth searches within and across websites, i.e., when users drilled down on selected in-line or out-of-line hyperlinks. Often such searches created complex navigation paths which were not easily retraced with so many resources open, and only resolved by use of the ‘Browser back button’ or switching back to the Google-collection and re-launching a required information source.

Despite the availability of the in-built multiple-windows functionality, e.g., side by side, cascade etc., it was rarely implemented. Instead, with some obvious frustration and resultant errors, participants battled to switch between multiple instances of resources using open tabs. Working with multiple resources ‘in-play’ also evidences the need for management of resources (7.1.3).

7.1.2 External Representation and Re-Representation

Extract and representation activities as seen in a sensemaking context, are typically iterative and complex. Emergent external representations are the significant manifestation of participant’s sensemaking typically emergent during usage (*compile*) and *planning* activities which occurred early and iteratively throughout the session (ref Finding 12, Chapter 6.3.5). These representations were formed for different purposes such as planning and organisational aids or retrieval aids, but most commonly they were generated as sensemaking artefacts that were often re-represented. They ranged from simple such as lists, to more complex such as a hand-drawn graphic interpreted from located source content.

Extracted source content was used for both structure and detail in emergent representations: source content was used to build such as overall slide structures and titles as well as slide's text (ref Finding 11, Chapter 6.4). Typically a range of mechanisms were deployed to extract and represent source content, the less common mechanisms being

- copied-&-pasted URLs for further searches;
- creation of system bookmarks for later reuse/reference;
- annotations and markings as organisation/planning aids, e.g., markings on the paper task- sheet (which was an example of resources in alternate roles);
- free-hand drawings (with *pen&paper*).

The style of the user's 'extract and represent' actions typically reflected either an 'author-type' or 'compiler-type' approach (Priemer et al., 2004). An 'author-type' style describes users who prefer to generate and create their own representations from assimilated content without direct copying. On the other-hand, a 'compiler-type' approach to content usage describes users who extract content from given sources and use it, sometimes almost unedited.

Everyday generic software packages, e.g., *MsWord*, *MsPowerpoint*, support most of the user's representation needs, regardless of their style. There were however two noticeable and significant limitations:

i. the representation was not always successful, i.e., the software did not always support the extract-represent requirements, when copy and pasting chunks of structured text, tables, icons/drawings, and quotes. This was more of a problem to the users who extracted and used verbatim, i.e., adopted 'compiler-type' tendencies (ref Table 2.2.c);
ii. the software sometimes lacks the flexibility to support fluidity, when users randomly mark or make change/enhancements with underscore, arrow symbols, grouping symbols (circles etc.). Indeed this was a key reason for a commonly expressed

preference to use a *pen&paper* intermediate workspace/resource. This was more a problem when users adopted an 'author-type' style.

These activities, by their nature, typically deploy multiple resources, often 'in-play' together and often for long periods of time, for example, highly iterative extraction of information from an information source to iteratively use/build towards an external (re)representation(s) on the target resource. The resultant switching including navigation requirements adds to the user's switching overhead and general effort (7.1.1).

A few additional complexities of (re)representation were apparent in both usage behaviour and *planning*:

- utilisation of one or more intermediate workspace resources, particularly *pen&paper*;
- some resources were deployed in non-default roles, i.e., in alternative roles.

These aspects are now presented.

7.1.2.1 External representation using intermediate workspace resources

One or more intermediate storage resources were accessed and used as workspaces for representation with a noticeable preference for *pen&paper* (ref Finding 9, Chapter 6.3.5). The individual resource timelines evidence how frequently this occurred and the timeline capturing usage of an intermediate workspace resource across all participants is shown here (Figure 7.2)

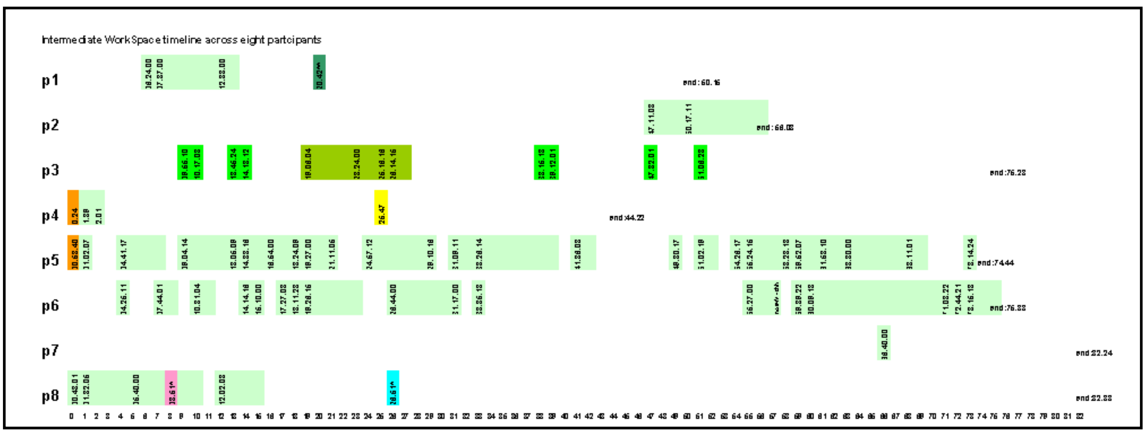

Figure 7.2 Intermediate resource timeline across eight participants

(A full size version of this timeline is in Appendix D).

The pale green colour-filled cells indicate where there is a preference for *pen&paper* over any other choice of intermediate workspace, e.g., *MsWord, Notepad*. As seen (ref Figure 7.2) there is a noticeable preference for *pen&paper*.

Workspaces were utilised for various purposes. They were used to hold an outline schema representation during organisation/planning activities, or for emergent sensemaking artefacts, i.e., ongoing representations. Typically any *pen&paper* representations were similar to those already identified in electronic format, e.g., lists, bullet points, but others more specific to *pen&paper* were

- notes which varied from one word through to sentences;
- markings, freeform arrows/grouping symbols etc.;
- free-hand drawings.

The most cited valued property of *pen&paper* was its 'random access' that enables enhancing of notes and lists, linking one note with another using a freeform arrow. Another suggestion was that *pen&paper* was preferred because it better reinforced understanding over working electronically to do the same task. That is, *pen&paper* facilitated their own style of working rather being harnessed by technology limitations.

Instances of intermediate workspaces are generally used in association with other resources and as such contribute to the overhead of switching issues (7.1.1), and the management of multiple resources (7.1.3).

7.1.2.2 External representation using resources in alternate roles

Resources may operate in non-default roles, i.e., alternative roles than those intended or expected, and these alternate roles are often acting as representational resources (ref Finding 10, Chapter 6.3.5). For example, the supplied Task-sheet and Google-collection were occasionally marked or annotated as an aid or reinforcement exercise. In other words these resources acted as representation (output) resources rather than in their default (intended) role as information sources (input resources). In the main, such examples involved a paper instance of the resource but examples were observed using electronic versions. A resource in alternate roles implies another complexity of representation needs and also contributes to management issues (7.1.3).

7.1.3 Planning Including Management

The *planning* related findings indicate some unique considerations as well as serve to reinforce some of the previously discussed implications for switching (7.1.1) and representation (7.1.2). Five findings indicate planning and management issues.

7.1.3.1 Planning activities

Planning is a complex activity and highly visible throughout the process. It played an important role in managing and organising the task to completion (ref Finding 7, Chapter 6.3.5). Four different types of planning contribute to this purpose (ref Finding 2, Chapter 6.3.2). Characteristically these four planning types encompass much other behaviour, and can involve aspects of either creating and editing external representations as in planning 'what to Do' or planning 'Review' , or such as searching for sources (planning 'what to Use'). Furthermore planning typically involves physically switching between and handling multiple resources. The four types can occur in any combination and at any time and each instance of each type is unique. Thus each instance can be considered to have its own unique management/organisational requirements:

- each *plan* type can occur as a singleton or in combinations at any point in the overall process;
- typically each *plan* type deploys a particular resource type, e.g., an input information resource or an output representation resource and this varies according to type/purpose and to a lesser extent user preference;
- multiples of these resources are invariably 'in-play' for all types, for mixed durations;
- typically external representations emerge or are re-represented, e.g., edited, during three of the four types of *planning* but could exceptionally emerge from all four;
- an intermediate workspace resource is frequently deployed for organisation/planning purposes;

- each type might deploy instances of resources in alternate roles, for example Google-collection (input) annotated (treated as an output) when deciding ‘what to Use’;

This suggests design implications from *planning* activity arise across several facets, namely,

- across time
- across variance within the activity
- variance in resource usage
- variance in representation needs.

Planning is essentially a management task which in itself raises design implications as described, but aspects contribute to the other two areas of implications (see 7.1.1 and 7.1.2). Resource management, on the other hand, raises different issues.

7.1.3.2 Managing the resources

The issues identified in the previous areas of activity (7.1.1 & 7.1.2) need to be considered from a management perspective:

i. multiple instances of resources ‘in-play’ has been a common thread throughout and can lead to switching errors. These multiples of resources need managing;

ii. The use of intermediate workspaces is a relatively common occurrence and also needs managing.

7.1.3.3 Managing resources in alternate roles

The frequent deployment of resources in alternate roles suggests this is more than a one-off, individual requirement. The examples (ref Chapter 6.3.5.4.2) can be grouped as

- supplied task-related sources, e.g., task sheet and Google-collection, deployed for organisation/planning purposes;
- instances of information sources deployed as ‘Proxy Collections’ for further sources of content (contained, click-able hyperlinks). A slide-content hyperlink can similarly be used for this purpose;
- output (representation) resources used as source(s) of content at a later stage, e.g., notes on *pen&paper* might be used as input later to a usage/sensemaking activity.

This adds a further complexity to the already complex behaviours underlying sensemaking. As an implication it contributes to all three key areas of design interest mentioned.

7.2 Discussion and Design Implications

Users deployed the available resources in accordance with their own preferences as they sought to gather and represent found content to serve their own sensemaking needs. However the task occasionally proved frustrating as they tried to use and manage the multiple resources they kept 'in-play'. The current everyday system and resources proved adequate most of the time, there were occasions when either the functionality was not robust or not flexible enough for the user's requirements. This occasionally resulted in errors.

Seven specific findings (from Study-2) offered some insights into indicative design requirements, i.e., three areas of activity were identified where technology might be applied to better support the everyday sensemaking task. Investigation into each area highlighted requirements that either do not exist in current everyday systems, i.e., planning and management activities, or exist but are either cumbersome or insufficiently robust for the user's needs. The three areas of activity are discussed and compared with other published literature.

Switching and navigation between multiple open resources

Users exhibit a high incidence of multiple resources 'in-play' (visible and in use) at any one time that necessitate a similarly high incidence in resource switching (which often involves application switching), including navigation. There is no pattern in how users use and mix multiples of resources 'in-play'. Furthermore, the actions occasionally result in errors.

This implies that sensemaking technologies should support users with suitable switching including navigation features to help minimise their effort and improve accuracy as they move between volumes of open resources and/or retrace from breadth and depth web-site searches. These could be specific switching/navigation features, e.g., robust tracking features to offer a safe pathway when users switch between multiples of open resources and retraceable pathways from their in-depth exploration of multiple open information sources. Current features such as browser back button failed to support some user needs. The support technologies should provide for a more effective, efficient and safe user experience.

This type of support was also suggested by Russell et al. (2008) who found that users encountered errors when using more than one instance of *Google Notebook* for an everyday sensemaking task. It is suggested that this empirical work extends Russell's finding to a more general implication: given the high incidence of multiples of resources 'in-play', fluidity of movement between open windows is essential throughout the task, regardless of whether they are general software objects such as instances of *Google Notebook* or *MsOffice* slides/word documents, or even open browser tabs to located information sources. Furthermore, these findings contribute to the ongoing issue of windows management which has been a key design issue for sometime (Sharp et al., 2007, pg 229).

External representation and re-representation

Usage behaviours in a non-trivial sensemaking context involve often complex, extract and representation activities. The representations may have different purposes but commonly they are used as external aids to off-load the user's mental structures.

The current technology, e.g., a mix of *Microsoft Office* applications offer the basic copy and paste functionality but these were not always fit for purpose as representations occasionally failed. Therefore everyday systems should offer more robust representation functionality that better support the range of everyday representation extractions.

Findings also highlight the frequent use made of an intermediate workspace for representation output. This was not necessarily restricted to a resource normally used as an output or representation resource, but instead resources supplied as input information sources were similarly used for representation purpose, e.g., underlining, annotating. It is this understanding of how the users deploy more than one representation resource that provides additional insights into the everyday 'micro-level' sensemaking.

Many others report that sensemaking technologies should support external representation: Pirolli et al. (2005) studied intelligence analysts and identify the need for external facilities possibly using information visualisation suitable to this type of user needs. Zhang et al. (2009) studied groups of students undertaking a given sensemaking task in a two-screen workstation sensemaking environment with custom installations of both note-taking and concept mapping software. They conclude that sensemaking needs a representation aid that is simple and flexible to accommodate the various ways users represent. Attfield et al. (2011) show how teams of legal investigators are reliant on representation facilities to support document annotation, and suggest a tool that readily supports extract representations with embedded links to data sources would be useful across different groups of sensemaking practitioners. Kuhthau et al. (2001) studied how lawyers, as a particular group of information workers, used information in their work-tasks, and concluded that lawyers need systems that offered construction facilities. Faisal et al. (2009), in a position paper, explore the idea that categorising representations may help inform design methodology for tools that support interactive sensemaking.

In this empirical work, the considerable incidence of *pen&paper* used as an intermediate workspace for representations illustrates the value users place on the random access, fluidity and flexible characteristics of such a resource. Additionally, such functionality might have been sought from resources not normally associated with representation (resources in alternate roles). Together these issues imply that everyday sensemaking should be supported by resources and intermediate workspaces that not only be robust and suitable for use, but should offer flexible features that mimic the characteristics offered by *pen&paper.*

This preference for *pen&paper* (as a workspace) resonates with the considerable volume of literature reporting paper technologies and versus digital technologies. For example,

- O'Hara and Sellen (1997) found that the ability to annotate while reading was important in enforcing an understanding of the source document, and helped in planning for writing. They noted that this was a seamless task when working with paper but more troublesome and evident as two separate tasks when doing so online. In conclusion they called for technologies to enable annotation and marking as an integral part of reading and the need to build support for these processes;

- Sellen (1997) reported that *pen&paper* better supported the use of multiple documents and movements between documents;
- Fu et al. (2005), from their analysis of Web Annotation tools, suggests that the types available, when combined, offer almost everything that is achievable on paper. They conclude that the tools do not yet offer sufficient to replace *pen&paper* and are not generally satisfactory for the end user experience. Furthermore, Fu et al. suggest that the user's needs for annotations in the Web environment do not differ significantly from their needs in the paper environment.

Planning including management

There is an overarching requirement for management support with respect to resources and the process, particularly planning activity. The planning activity often reflects aspects of other behaviours but it also exhibits unique management/organisational requirements.

This activity has the potential to place the most demands on any future system support due to the core complexity of the activity, arising from such as the combination of *planning* types in action, as well as the related complexity of their underlying actions, e.g., each type's own default resource and multiples of resources 'in-play', and its associated extract and representation mechanisms. The common thread through these findings is

- the users' reliance on multiples 'in-play';
- deployment of intermediate workspaces for representation;
- the resources occasionally used in non-default roles.

This suggests a need for, and management of, an integrated environment to allow users easy and efficient access to multiples of resources in any one instance and throughout the process. Access should include intermediate storage resources to be used as temporary workspaces and the facility to deploy resources in non-default roles. Together such an integrated environment would serve to ease the user's frustrations, improve their efficiency and generally enhance their sensemaking experience.

Qu et al. (2008) similarly called for task management support to underpin the complex nature of the exploratory search typically characteristic of sensemaking tasks. Such support is expressed in terms of keeping track of searches but they also suggest that the multiplicity of sensemaking tasks needs management support. A comparison with this project's findings are judged valid given this project's Study-2 has shown that seek/search behaviours are integral to the sensemaking process (ref Finding 8, Chapter 6.3.5), and sensemaking iterates throughout the information seeking process (ref Finding 13, Chapter 6.3.6).

Others have similarly concluded the need for an integrated environment: Russell et al. (2008) argue that everyday sensemaking tools should be integrated as well as fast and simple to use and must fit with a user's work practices. Zhang et al. (2009) talk of a need for an integrated workspace in sensemaking to provide a) space to store, organise and manipulate information and b) to build structure. The integration, they suggest, should assist the user's switches between both activities.

Planning including management is not known to be supported or evident in current everyday systems used in sensemaking tasks, and inclusion should ease the burden of the sensemaking task.

7.3 Conclusion

This Chapter reports on the interpreted implications for interaction design of sensemaking technologies as determined from the empirical findings (Research question 5). The findings suggest three areas of activity where technologies could support sensemaking. They lead to suggest an integrated tool or system that would improve the user experience through

- support for users as they switch between and manage various multiples of resources 'in-play';
- support for users as they switch between – and transfer information between – different applications (e.g., web browser and workspace);
- facilitate user's flexible representation needs including the use of intermediate workspaces and resources used for representation rather than their intended roles;
- management support with respect to both resources and the process, particularly planning activity

The requirements for sensemaking technologies might be too broad and varied to implement within one system, and an alternative solution might be to apply system options such as preference settings to configure according to user needs. This type of debate, between implementing a single large complex IR system versus a series of several small well-tuned systems, was raised by Belkin in his presentation to the exploratory search community (Belkin, HCIL, 2005).

Although there is no exact comparable empirical work for this project, the design implications offered in this Chapter resonate with selected current literature. The quest into sensemaking technologies is relatively young. Card (2005) talked of a new class of emergent interfaces that were “attention reactive” and able “to handle sensemaking tasks”. Russell et al. (2008) reminds us that whilst there are many high-end support tools aiding professional sensemakers there is little support as yet for the everyday end-user in everyday sensemaking.

Chapter 8 - Conclusion

8.1 Research Approach

The literature review (Chapter 2) has shown that, to date, research into information behaviour has paid little attention to how end-users make use of located information. Information usage typically requires users to make sense of found information and integrate it into their own existing knowledge for their own task needs. Similarly the review has shown that studies into everyday sensemaking are currently under-represented. The research reported in this dissertation attempted to contribute to the existing body of knowledge. It investigated how end-users made sense as they located and used web-based information content for their tasks. In this context sensemaking is taken to mean

> *"the strategies and behaviours evident when users collect, evaluate, understand, interpret, and integrate new information for their own specific problem/task needs"*

The overall aim was to discover more about sensemaking and its relationship with information seeking in web-based environments, and to help inform interaction design of sensemaking technologies. This aim was expressed in five specific Research Questions:

1. What is the broad range of typical behaviours and strategies deployed by experienced users as they interact with information sources whilst undertaking information-related tasks in web-based environments, and where is sensemaking evident?
2. How do experienced end-users make sense, i.e., collect, extract and organise relevant information from web-based located information sources?
3. How do users externally represent both the collection and the meaning being derived from the information sources?
4. How does users' sensemaking relate to the seeking process?
5. What are the implications for interaction design of sensemaking support tools and systems?

Following a Feasibility Study, undertaken to assess the suitability of design and data capture decisions, two main empirical studies were designed to either specifically address or inform these five Research Questions (Figure 8.1);

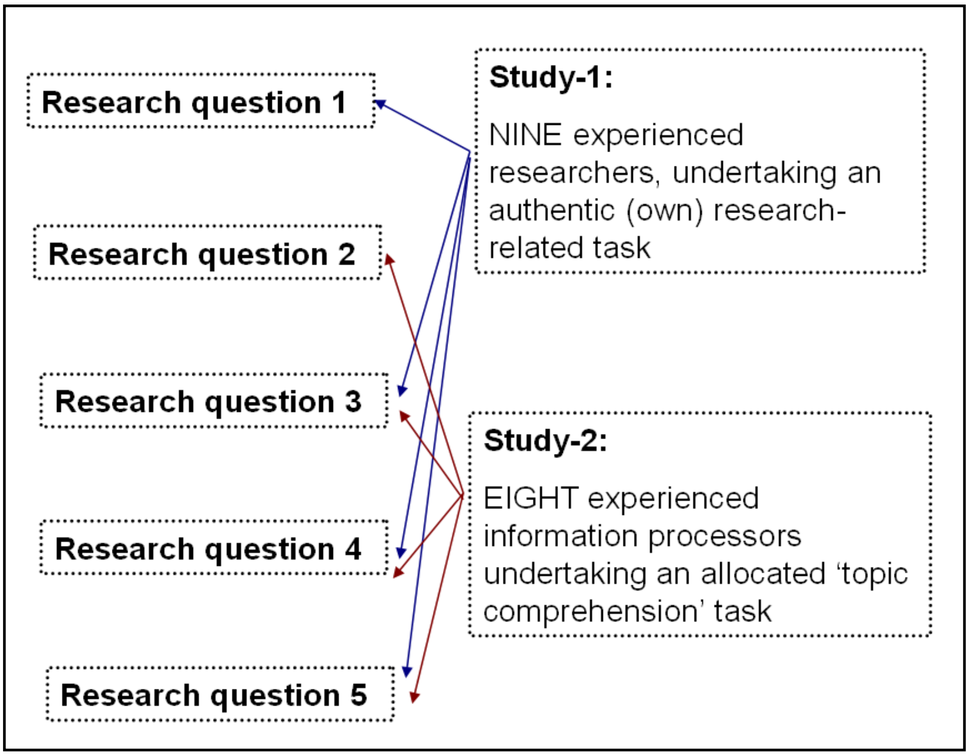

Figure 8.1 Relationship between Empirical Studies and Research Questions

The initial step towards understanding sensemaking in web-based environments was to undertake a first broad exploratory investigation into information seeking to investigate the nature of the end-user's interactions with information sources, i.e., when and how they used the information sources during the information seeking process and where their sensemaking was evident. Study-1 specifically addressed Research Question 1; it investigated the interactions of nine experienced researchers whilst they undertook an own-choice research related seeking task in web-based environments. The significant output from this Study was an emergent empirical framework that offers an information interaction perspective on the seeking process.

Study-1 also informed Research Question 3, and provided a basis from which to explore the sensemaking and seeking relationship (Research Question 4). The Study findings also provided the foundation for a second more detailed Study into users' sensemaking during web-based seeking.

The second empirical Study was designed to undertake a more focused investigation into sensemaking; there was a need to understand how experienced users make sense of content found from web-based information sources (Research Question 2), and how they externally represent the meaning being derived from the information sources (Research Question 3). It was also important to discover how sensemaking related to information seeking in web-based environments, i.e., further explore the indicative findings of Study-1 (Research Question 4).

Study-2 investigated how eight experienced information processors individually completed a lab-based non-trivial topic comprehension task. A five step analysis produced a range of visual representations that expressed the lab-based user session. Together, these visual representations combined with user's utterances to offer a comprehensive insight into the complexities of sensemaking during web-based seeking tasks.

Both of these Studies were devised to help inform the requirement implications for interaction design of sensemaking technologies (Research Question 5, Figure 8.1).

8.2 Contributions of the Research

Study-1 took a different perspective from other reported empirical information behaviour related studies; most previous studies have focused on search behaviours and evaluation particularly relevance judgments (Chapter 2). From a sensemaking perspective, the Study bridged across previous information seeking studies that paid little attention to the 'use of located information', i.e., the usage component (Chapter 2). It corroborates some of those previous observations and extends them, by distinguishing different phases within participant's evaluation of information sources and identifying relationships between them.

Findings from Study-2 offer a unique perspective on sensemaking: this dissertation proposes that sensemaking can be viewed as a strategy inferred from a sequence of typed behaviour *episodes* that represent a user's session. Each session is associated with a sensemaking goal, e.g., to evaluate, understand and interpret located web-based content and extract and integrate/ use it for their task needs. The research found that end-users have distinct and individual sensemaking strategies when characterised this way.

By adopting the reported approach, the research makes three important contributions, and furthermore, the fully documented methodology is applicable to a range of different tasks and different contexts.

8.2.1 Contribution 1: An Emergent Empirical Framework

The first contribution comes from the research undertaken through Study-1:

> **An emergent empirical framework captured user's behaviour during information seeking, as five discrete categories of information interactions, each identifiable by its own purpose and characteristics.**

The framework does not imply linear progression and readily supports the cyclic, iterative nature of their seeking. The framework as presented in Chapter 4 is included here for easy reference.

<table>
<tr><th rowspan="3"></th><th colspan="5">Categories of Information Interaction Strategies</th></tr>
<tr><th rowspan="2">Search</th><th rowspan="2">Evaluation for Selection</th><th colspan="2">Evaluation for Use</th><th rowspan="2">Use</th></tr>
<tr><th>Evaluation for Utility</th><th>Evaluation for Personal Fit</th></tr>
<tr><td>Purpose:</td><td>Finding/ locating information</td><td>Selecting sources to look-at</td><td>Deciding what source/ document to read (examine in depth) & store or print</td><td>Digesting the content and determining which content to extract, synthesise, use</td><td>Organising and incorporating into a body of knowledge</td></tr>
<tr><td>Characteristics:</td><td>interaction with the query interface, search engine, tools, etc.</td><td>interaction with the results lists at screen</td><td>interaction with the information source at screen</td><td>interaction with the information source predominantly using paper-based source</td><td>interaction with the information source(s) and with its (their) representations</td></tr>
</table>

Figure 8.2 Empirical Framework: Categories of Information Interaction Strategies in Web-based Information Seeking **(Duplicate of Figure 4.4)**

This emergent empirical framework (Figure 8.2) is judged to contribute in four ways:

i. it offers further insight into the complexity of evaluation, i.e., evaluation for use often manifests as a two-phase process from which representations emerged in the latter phase ('evaluation for personal fit'). Findings from Study-2 suggest the demarcation with 'information usage' is fuzzy during time constrained tasks (ref Chapter 6.4.4), and this in itself is an interesting insight for further investigation;

ii. use behaviour and strategies are explicit and the framework supports focused enquiry into source usage;

iii. an information interaction perspective on seeking contributes to the wider information behaviour discourse; the research proposal was presented to a doctoral workshop at Information Interaction in Context (IIiX, 2006);

iv. the framework readily supports extension. For example, it was extended to highlight where prompts or indicators for further seek-driven activity were apparent and where they linked to examples of explicitly evidenced sensemaking, e.g., representation interactions (Chapter 4, Figure 4.5). These indicators, as extensions, were of interest to the Exploratory Search community (Abraham et al., 2007).

This framework provided the basis for a second more focused investigation into understanding how users made sense of the located information and the relationship between sensemaking and information seeking.

8.2.2 Contribution 2: Three Emergent Visual Representations

The second empirical Study (Chapter 5 and 6) was a more focused investigation into sensemaking; there was a need to understand experienced users sensemaking and how they externally represent as they derive meaning from located information sources (Research Questions 2 and 3). It was also important to discover how sensemaking related to web-based information seeking (Research Question 4) and build on the findings from Study-1.

Three of the visual representations (visuals) output from Study-2 are presented as the second contribution of this research. Each visual provides an alternative perspective of a sensemaking session that expresses the user's sensemaking strategy and links to the framework; together they are offered as an important contribution to sensemaking research. Furthermore as outputs from a qualitative and inductive five-step analysis (Chapter 5, Figure 5.3), these three visuals are readily replicable. They are:

i. Timelines

ii. The user's session as a sequence of *episode-types*

iii. The empirical framework representative of information seeking, modelling a user's sensemaking strategy

8.2.2.1 Timelines

Individual timelines provide a visual representation of a user's interactions with resources during a sensemaking session and support questions about the significance of different patterns of interaction. They provide insight into the role resources play in micro-level sensemaking. They make evident which and how many resources user's keep 'in-play' (visible and in use) and their preferred representation resource(s) for creating/storing, organising and structuring their own emergent external representations (e.g., paper-based, slides). Timelines provide a basis for further analysis into the user's sensemaking and usage of information sources, and combined with an understanding of associated behaviours the timelines afford a rich picture of resource usage.

As a set of instances, timelines can be interrogated for differences in which and how many resources different users keep 'in-play', as well as resource interaction and usage patterns across user groups. Furthermore they combine to highlight possible leverage points of interest to interaction design for sensemaking technologies, including points of multiples of resources are 'in-play' which can lead to interaction errors. Eight instances were generated from Study-2 (ref Appendix D).

8.2.2.2 The user's sensemaking session as a sequence of *episode-types*

The second significant emergent visual representation depicts a user session expressed as sequences of abstracted, typed behaviour *episodes.* These sequences captured what each user did in any one session that was recorded, and as sequences of typed *episodes* they highlight a session's associated sensemaking goal. In this example (Figure 8.3), a combination of planning and 'seeking to evaluate for use' activities are applied in order to make sense of and use available information to complete their task. Eight instances resulted from Study-2 (ref Appendix C).

This visual representation of a session (Figure 8.3) evidences the user's overall approach with respect to how they collect and make sense of located information for the task-in-hand. It expresses the user's sensemaking strategy by highlighting:

- how the user approaches the task overall, e.g., plan or task-driven, or reactive and data driven;
- the iterative and complex nature of their strategy;
- when and how they specifically plan for their actions;
- when and how they undertake to seek and evaluate information sources;
- when and how they extract and use (*compile*) from located information sources;

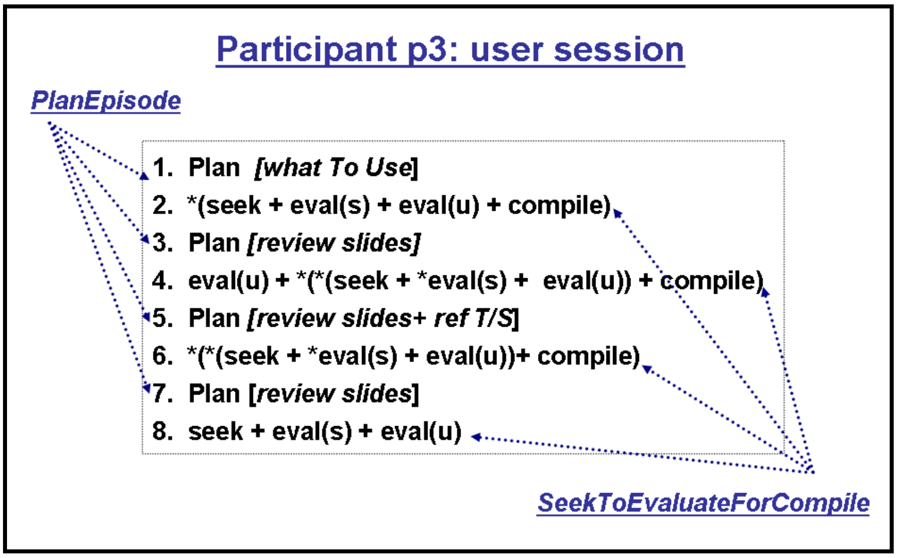

Figure 8.3 Participant p3 session: sensemaking strategy as a sequence of instances of *episode-types* **(Duplicate of Figure 6.6)**

The sequence expresses the overall, macro-level sensemaking and supports further investigation into the more detailed aspects of the user's behaviour through the contained individual *episodes* of behaviour that express the micro-level sensemaking activity. Together these algebraic *episodes*, with reference to the associated timeline and as corroborated by participant utterances, provide additional insight into how resources are used for representation and organisation, as well as more detail about how the located information sources are used.

A set of instances of 'sequences of session sensemaking strategies' can be compared for patterns both within and across user groups.

8.2.2.3 The Empirical Framework modelling a user's sensemaking strategy

Research Question 4 asks

> *How does users' sensemaking relate to the seeking process?*

Sensemaking and information seeking have been coupled for many years (Chapter 2) but this research has addressed this question as a two step process. Firstly it offers unique perspectives on both information seeking and sensemaking:

- information seeking is offered as a framework representing the seeking process from an interaction behaviours perspective (Contribution 1, 8.2.1);
- sensemaking is considered from a strategy perspective inferred from a sequence of *typed* behaviour *episodes* that represent a user's session (Contribution 2.ii, 8.2.2.2)

The relationship is highlighted in a third visual representation that emerges from mapping or overlapping a representation of the sensemaking strategy against the empirical framework.

For this purpose, the representation of the session strategy is an instance of a sequence of colour-coded *episode-types* (Chapter 5, Figure 5.8). The resultant emergent visual, models the sensemaking strategy within an information seeking context. An example of mapping for case participant p3 is replicated here for ease of reference (Figure 8.4).

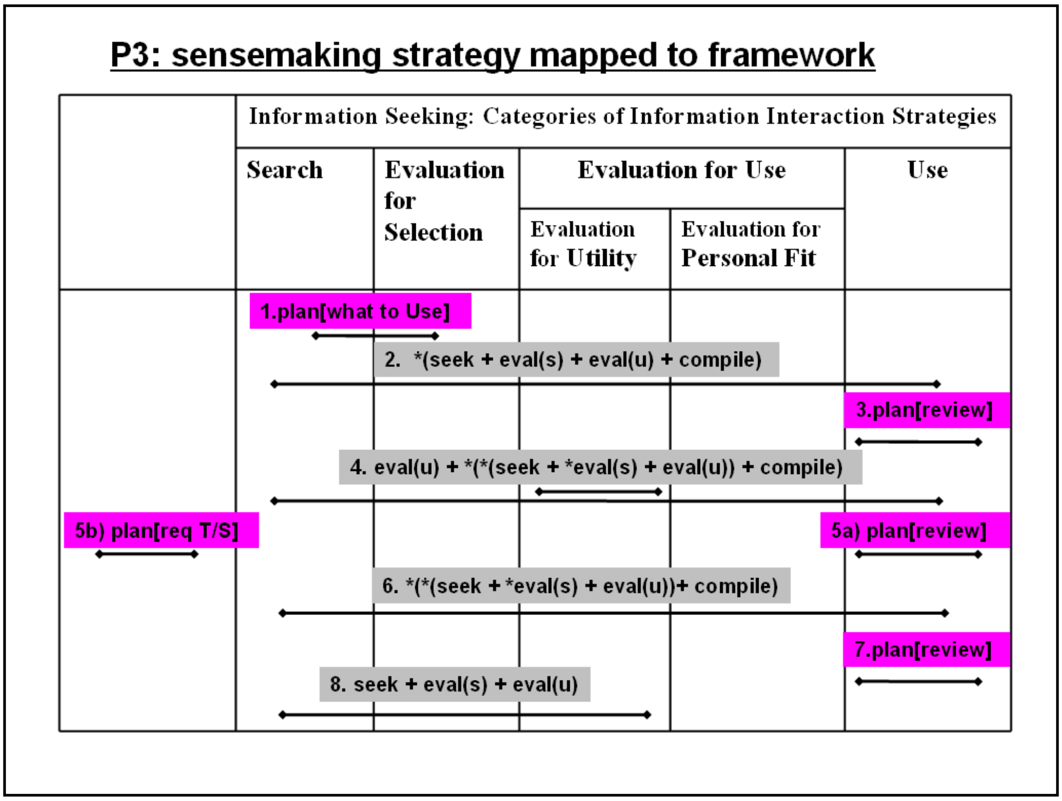

Figure 8.4 Empirical Framework modelling p3's sensemaking strategy (Duplicate of Figure 6.13)

Legend: *episode-type*: grey denotes ***SeekToEvaluateForCompile***

magenta denotes ***Plan [+ indicative purpose]***

This model (Figure 8.4) highlights the user's sensemaking pathways through the seeking process and the iterative nature of these pathways. In addition, these explicit pathways emphasise the complex and interwoven relationship between both processes, and highlight the likely occurrences when sensemaking is evidenced explicitly. For example, explicit evidence of sensemaking, i.e., emergent external representations (sensemaking artefacts), occur iteratively both at points of usage (*compile*) and often at an *evaluation for personal* *fit* activity. Furthermore and importantly, these external representations frequently emerge at points of *planning* activity which typically occurs frequently, and regularly throughout the process (e.g., Figure 8.3, participant p3). For example, planning 'what to do' usually occurs early or the first action of the session and mapps onto the pre-search phase of the seeking process, whereas planning for 'review' is most often associated with the source usage activities and typically occurs at the end of a session. At other points in the session, associated utterances often indicate implicit sensemaking and the model enables further investigation.

The visual provides a structure which readily highlights these points in the relationship, and a set of instances of these models support further investigations into patterns and differences within and between groups of users.

8.2.3 Contribution 3: Implications for Interaction Design

Research Question 5 could only be informed from interpretation of the results rather than from participants' data. It asked

> *What are the implications for interaction design of sensemaking support tools and systems?* *(Research Question 5, Chapter 1.3.5)*

The suggested interaction design requirements are the third contribution of this thesis.

The findings suggest areas of activity where sensemaking technologies could support and improve the user experience. These are:

- In any one instance, providing support for the high incidence of necessary switching between and navigating across multiples of different resource types 'in-play'. Switching might be *within* the same application (e.g., between information sources accessed in a web browser); or switching might be *across* different applications (e.g., from a web browser tab to a word processing page) (Chapter 7.1.1), creating quite a complex information management challenge, both for users and for tool developers. The level of integration needed for switching between applications would be at the level of the operating system, rather than within a given application.
- Providing improved support with more flexible features for external representation and re-representation (Chapter 7.1.2).

- Providing management support with respect to both the resources used in variant roles and the process itself, particularly planning activity. This support is not known to exist in current everyday computer-based systems planning and management (Chapter 7.1.3).

These findings extend other known studies by their insight into implications for users using everyday software such as *MsOffice* for everyday sensemaking tasks. They offer insights into the micro-level sensemaking with respect to how users deploy variant representation resources in this context. It is for these reasons that this research is claimed to contribute to the growing body of literature concerning sensemaking technologies.

8.3 Limitations

In line with the research design (Chapter 3), this research conducted a series of qualitative empirical Studies to investigate sensemaking and its relationship with information seeking. Whilst such approaches offer a rich dataset, they have some known limitations, namely,

i. the results are not always regarded as generalisable, because they are shaped by the particular task and environment;

ii. alternative contexts often need to be explored and/or the results need to be compared with large scale datasets to provide some validation and robustness;

iii. questions can also arise about the influence of the setting/environment on the results when studies are time constrained and lab-based (as is this Study-2).

This research has been mindful of these limitations and measures were taken to minimise any bias. For example, the task in Study-2 was selected carefully to represent an authentic sensemaking task. However, it was necessarily constrained to be a particular task in a limited time-span (see Chapter 5). Further research might investigate different types of sensemaking tasks. Additionally, the environment was created to maintain the feasibility of the Study while focusing on the participants' sensemaking (rather than their query generation). Although a corpus was presented, participants could follow the live links and search for additional material. A future study might allow a full query-driven search.

It can be argued that comparison between the Studies reported and with existing literature helps address the generalisability of these results; however further work could improve their generalisability. To address some of the known limitations of this type of research, further studies can be undertaken using:

- alternative task contexts,
- alternative user-groups, and
- large data sets.

These would offer a broader basis for comparison.

8.3.1 Comparative Studies: Alternative Task Contexts

Study-2 could be repeated for another non-trivial, problem-solving type task. Timelines could be created for all participants in this third study and the coding strategy could be broadly in line with the approach taken in Study-2. Outcomes from analysis could be visually represented as formats already utilised (Chapter 5) to enable direct comparisons to be made.

By adopting the same coding and analysis method for this alternative dataset, the findings can be directly compared with those from Study-2. Such comparison would help validate Study-2 findings and any differences could be investigated to understand how different task contexts influence participant's behaviours and strategies. Findings from this third dataset would also further validate the emergent empirical framework (Study-1, Chapter 4). On the other hand, it could be argued that several small scale qualitative studies are still not sufficient for any findings to be generalisable. Further comparison with large data sets would help address this aspect.

8.3.2 Comparative Studies: Large-Scale Data Sets

The range of external representations, i.e., the sensemaking artefacts generated, and the representation methods deployed in both Studies did not appear to be particularly unusual. These results embody a relatively small sample of 17 participants and further large scale studies would provide the means to corroborate these current findings and offer some scope for generalisability. Two large scale studies could be undertaken:

The first study would be to investigate how representative were the representation methods found in this research (Study-1 and Study-2). This could be conducted as a web-based questionnaire requesting respondents to recall and report on a recently completed task. As such it would gather data about the example types of external representation generated and the representation methods used by a wide range of users conducting everyday web-based sensemaking tasks. The data could be categorised and counted and results could be compared with the existing results to corroborate or highlight differences for further investigation;

A second large-scale study could determine how representative the sensemaking strategies from Study-2 are. This study could be similarly conducted as a web-based questionnaire or could use a reporting mechanism such as a critical incident-log. Respondents could be asked to describe the process they followed in a recently recalled problem solving task and identify the software they use for the task. Guidelines and a sample could be offered to illustrate what was expected. The reported sensemaking strategies could be analysed for iterations of seek, evaluate, use and planning behaviours; these could be overlaid onto instances of the empirical framework which would be used to corroborate current results or highlight differences to be investigated. Permission could be sought to conduct a sample of follow-up interviews as required.

Studies asking volunteers to recall using questionnaires or report logs are fairly common in information behaviour studies, and the literature suggests that such methods can be reliable (Schamber, 2000; Ingwersen et al., 2005). These two large scale studies would provide some corroboration and a basis for possible generalisation of this research's existing findings.

8.4 Other Future Directions

As well as studies to further validate and help generalise the findings from this research, there are other research areas and new technologies that offer extensions and new dimensions for this research.

8.4.1 Exploratory Search

Exploratory search (ES) is a relatively new community who are interested to design search systems, e.g., Information-Seeking Support Systems (ISSS) that support everyday users, characterised as users who often have only a vague idea of their search needs but submit multiple queries that typically return large volumes of information from the Web. The connection between exploratory search and sensemaking was shown by Qu et al. (2008), and this current research has contributed to the exploratory search literature with respect to where and what type of situations activate or trigger further search actions (Abraham et al., 2007). Nonetheless, there is scope for this project to extend and further contribute to the field of exploratory search. The work could be extended in a number of ways, for example,

i. an investigation into how the iterative sensemaking activity manifests into further exploratory search actions. This current research identified several reasons for further searches but any detailed line of enquiry into this aspect was outside the scope;

ii. any future large scale studies (as described in 8.3.2) could also help inform the exploratory search community. A specific question could be to focus on the relationship between the queries submitted to everyday standard browsers and the representation construction using everyday software. The query formulation (behaviour) was not a focus of this current project.

8.4.2 Interaction Design: Sensemaking Technologies for Everyday Users

The contribution of design implications (8.2.3) offers insight into these issues and future investigations would provide for a focused investigation into more detailed requirements for each of the three areas of implications.

One way forward could be a series of studies, undertaken to vary the everyday software and resources to discover any patterns in users' interaction behaviours, and similarly vary the types of task and volumes of resources. An evolving prototyping cycle could then test and further inform the requirements.

A second strand of investigation could be to undertake a literature review to establish what features are being tested or are being successfully incorporated into specialised support systems and how these could enhance the everyday experience for everyday sensemaking tasks. Should access be available, selected available tools could be evaluated against identified requirements.

8.4.3 New Challenges from Ubiquitous Computing

This project was conducted using the standard interaction platform of keyboard/mouse input and GUI screen output. Whilst this will no doubt remain the everyday standard for some time, newer interfaces and types of interactions associated with pervasive and ubiquitous computing are becoming more of a reality (e.g., Sharp et al., 2007; Being Human report, 2008). These advances pose exciting opportunities for further exploration into the role of sensemaking and give rise to some immediate broad questions:

- how does sensemaking manifest when interacting with interfaces that respond to body interactions such as gesture?
- do the body interactions enhance or distract from the sensemaking?
- where or in what context might these technologies be applied to specifically support the sensemaking?
- how does this fit with the current interpretation of sensemaking?

Pirolli et al. (2011) have already noted that ubiquitous computing could often involve situational awareness and likely involve social exchanges, thus broadening the act of collecting and organising information for deep understanding and integration. Indeed there are many reported examples already exploring sensemaking in ubiquitous environments. One is an investigation into how firefighters make sense in emergency situations (Dyrks et al., 2008). This was part of a WearIT@work European research project (http://www.wearitatwork.com/) which investigates wearable computing technologies in four different workplace contexts, including emergency rescue and healthcare. Nevertheless, this is a young emergent research field and should offer many opportunities for investigation into numerous contexts.

Thesis Glossary

<u>**Term:**</u>	<u>**Meaning:**</u>
Action	Unit of raw user activity Process of doing (Collins gem Dictionary)
Behaviour	Action that is identified as an instance of a behaviour class
Behaviour class (Study 2)	A category of action (based on the empirical framework and informed from the timelines) seek: looking for sources, i.e., accessing the supplied Google-collection, the transition into evaluation-for- selection eval(s): evaluate for selection (potentially useful sources are identified) eval(u): evaluate for use (a decision is made about the source, an action may be taken) compile: use (e.g., the gathered information is compiled, transcribed, paraphrased, ordered/tidied, or interpreted) plan: planning relates the other actions to the task; it is implicit in the framework, but explicit in participant's behaviours and utterances. Planning has four distinct purposes: gather requirements decide 'what to Do' decide 'what to Use' review, such as progress, set or revise goals, etc.

Term:	**Meaning:**
Categories of information interactions (Study 1)	***search*** information interaction strategies involved choosing a search engine and formulating query(ies) to locate relevant information sources; ***evaluation*** information interaction strategies were to do with determining the value of an information object from inspection of one or more of its features or content; ***use*** information interaction strategies were concerned with interpreting, extracting, organising and integrating the found information into an existing body of knowledge. A discrimination is made between different *evaluation* strategies: ***evaluation for selection*** strategies involved interactions with surrogates for information objects in results lists. *evaluation for utility* was concerned with asking '*Is this information source of use?',* **evaluation for personal fit** was concerned with asking 'Is the information what I want to use?'. ***Use*** strategies were concerned with deciding 'how to best use' the located information for the participants' own purposes.
Episode	*Episodes* of behaviour algebraically expressed participant's activities as chains of one or more behaviour components (study-2). Each *episode* had a focus, and was delimited by a recognisable change of focus along with simplicity of abstraction.

Term:	**Meaning:**
Episode (sequence of)	Sequences, of *episodes* captured the recorded actions of what each participant did in any one session (study-2)
Episode-type (type of *episode)*	Recurrent *episodes* associated with a purpose (the result of looking for commonalities or patterns) (study-2): These are defined as: ***SeekToEvaluateForCompile****:* describes any *episode* whose purpose was work with a source from seek through to usage. It contained a singleton or iteration of successive *seek, eval(s) to select, eval(u)* with an outcome of *compile* or not, i.e., the source could be discarded; ***SeekToEvaluateToCorroborate****:* was an *episode* representing the participant's intent to *seek* and select and evaluate one or more Google-collection results to corroborate other found or known information. The source content was never explicitly used, i.e., there was never a *compile* outcome from source evaluation *(eval(u)).* Whilst it can be argued that all *eval(u)* might include some form of corroboration, e.g., implicit comparison of located content, only *episodes* which had explicit statement of 'intent to corroborate' were labelled thus. That is, accompanying explicit utterances indicated the intent was corroboration or some form of comparison, and hence distinguished it from an *episode* representative of a 'seek to evaluate' but discard. All other examples were subsumed by *SeekToEvaluateForCompile* with an evaluation *(eval(u))* outcome of discard;

Term:	**Meaning:**
Episode-type (type of *episode)* ***Cont*.**	***EvaluateForCompil**e*: was any *episode* which intentionally evaluated located content for use *(eval(u))*, although c*ompile* was not necessarily an outcome, i.e. the intent may have been to evaluate for usage but instead the outcome could have been either discard, or note (the source) for later reference, or simply delay the use of the source. The *eval(u)* may have been the initial evaluation of an information source or a subsequent evaluation of a source that had not been previously used. Importantly, there was no significant *seek* behaviour, i.e., the source was already open ready for evaluation, although occasional drill-down *(seek+eval(s))* activity was present; ***Compile**:* was any *episode* where the dominant purpose was using the source, i.e., the *episode* contained *compile* behaviour dedicated to the use of source content with no significant seek, selection or evaluation activity; ***Plan [indicative purpose]***: describes any *episode* which predominantly contained behaviour indicative of one or more of the four types of planning (5.3.1.2). Other behaviours such as an *eval(u)* as part of a review
Episode-type (sequence of)	Sequences, of *episodes* captured the recorded actions of what each participant did in any one session. (study-2). **They expressed the sensemaking strategy**
Google-collection	A closed-corpus of search results specifically generated for use by the participants in study-2
'In-play'	Resource instance is visible and in use (study-2)

Term:	**Meaning:**
Information behaviour	Describes the broad activity associated with information needs through to information usage; such activity might involve computer-based and/or human information resources
Information searching	This is to do with the user's micro-level behaviours as they engage with an information system, e.g., the search query interface of a computer-based retrieval system. It is a sub-set of seeking
Information seeking	This is where the focus is on user's observable behaviours as they locate and interact with the information sources in order to obtain and use the desired information
Information use	Information usage typically requires users to extract, organise, represent and integrate, i.e., make sense of the located information for their own specific problem/task needs.
Sensemaking	This thesis defines sensemaking as *"the strategies and behaviours evident when users collect, evaluate, understand, interpret, and integrate new information for their own specific problem/task needs"*

Term:	**Meaning:**
Sensemaking strategy	This dissertation proposes that sensemaking can be viewed as a strategy inferred from a sequence of typed behaviour *episodes* that represent a user's session. Each session is associated with a sensemaking goal, e.g., to evaluate, understand and interpret located web-based content and extract and integrate/ use it for their task needs. The research found that end-users have distinct and individual sensemaking strategies when characterised this way. (Chapter 8)
Session	This is (a) what the users did in one sitting that was recorded, (b) the expression of (a) as a sequence of *episodes* (c) the expression of (a) as a sequence of *episode-types*
Strategy (general sense):	A sequence of activity intended to achieve a goal; a plan for purposeful behaviour, whether explicit or implicit
Topic-comprehension task	Such tasks characteristically require intense information gathering, interpretation and (re)representation, and can often involve higher order cognition skills such as synthesis. This type of task is typical of everyday sensemaking tasks that exploit the ready availability of web-resources
Workspace	This project uses the term to describe an area used by the participants for intermediate workings, e.g., it can be an electronic workspace such as a *Word* application or *pen&paper*. Its main purpose is to provide a facility for users to gather and represent and re-represent extracted source into their own meaning and usage.

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Appendices: Table of Contents

Appendix A

Study 1: Task

Task Instructions (email prior to the observation) and repeated at beginning of observation

Thank-you for agreeing to be a participant for our current study into 'web-based information search and usage' behaviours.

As discussed, the first part of the study asks you to complete a questionnaire (attached) and the second part is an interview, which will last no longer than one hour. I hope to use audio recording (with your permission) during the interview.

Web-searches are used for all sorts of reasons, but the types of searches of particular interest to this study, are those undertaken with the specific goal of finding information about something (e.g. a research topic), rather than searching to find a particular named journal or article in a journal.

During the interview, I would like us to talk about, and walk-through, some examples from your recent searches, so that I might observe both how you conduct the searches and how you use any found sources to further your understanding of the search topic.
Wherever possible, I would like to collect examples of material found, and generated, from the search exercise(s).

The questionnaire is attached and I would appreciate if this could be completed and returned, prior to the interview.

Please get in touch if you have any questions.

Many thanks
Ann Abraham
PhD student, Computing
Room M211, ext. 59757
Email:a.m.abraham@open.ac.uk

Appendix A

Study 1: Pre-Questionnaire

'Web-based Information Search and Source Usage' Behavioural Study

Thank-you for agreeing to participate in this study aimed at gathering information about '*Web-based Information Search and Source Usage'* behaviours.

This questionnaire, which is the first part of the study, is designed to gather information about some general 'Search and Usage' behaviour patterns.

Confidentiality is guaranteed. Your name or any identifying information will not be used in any reports of our research. All data will be anonymised and will be kept secure at all times.

It would be appreciated if the could complete the questionnaire and return it, prior to our interview to
Ann Abraham
Rm M211,
Email: a.m.abraham@open.ac.uk.

Section 1: About you

Name:

Gender:	**Stage of PhD:**
Male / Female	*Pre (i.e. MSc) / First / Second / Final / Post-Doc*

Please circle or delete as appropriate

Academic Background – The nature of your academic background or equivalent work- experience from post-compulsory level onwards, may be significant for this study.

Please ***Tick*** **All** that applies and state other where appropriate.

Institution Type/ Qualification	**'A' levels or equiv.**	**Higher Diploma or equiv.**	**First Degree or equiv.**	**Post Grad degree or equiv.**	**Other?**
School					
16-18 Tertiary College					
Post-16 College					
University					
Other?					

For each case above, please state in which country the qualification or equivalent was predominantly gained

Country					

Please state your current discipline

……………………………………………………………………..

How many years internet experience do you have?

…….

How many years computing experience do you have?

…….

On a scale of 1-5, where 1 stands for novice and 5 stands for expert, how would you evaluate your Web-search expertise?

……..

Section 2: About the web-based search process

Please base your answers to the following questions, on your **typical** behaviour

How often do you use web-based search tools (inc. engines) for information searches related to your research activities?
Please circle the closest option

Several times per day *Once per day* *Couple of times per week*

Several times per month *Less than once per month*

Which search engine do you use for such searches?

Primary search engine: …………………………………

Others: …………………………………

Which web browsers do you use for such searches?

Primary web browser: …………………………………

Others: …………………………………

Do you use any academic/bibliographic databases?

Yes/No

If Yes, which ones? ………………………………………

Do you use the Bookmarks/Favourites tool of your browser(s)?

Yes/No

Do you use any of the following features for navigation?
Please circle all that apply

Multiple-windows *Multiple-tabs* *Browser back-button*

Others? **Please state** ……………………………………..

Do you use any of the following search tools' advanced features
Please tick all that apply

Advanced Feature/ Level of Usage	**Almost never (<5%)**	**Occasionally (5<50%)**	**Regularly (50<75%)**	**Almost always (75% >)**
" " (speech marks)				
+ **or** - *(Plus or Minus)*				
AND / OR / NOT (Boolean operators)				

Do you use any other search tools' advanced features (e.g. similar pages, recommendations, same authors etc..?

Yes/No

If *Yes*, please state …………………………

On a scale of 1-5, where 1 stands for '*not successful*' and 5 stands for '*successful*', how would you evaluate your success in finding required information?

……..

What informs your decision to end a search session (e.g. time, no of sources found etc.)?

……………………………….

Section 3: About the evaluation process

Please base your answers to the following questions on your ***typical*** *behaviour*

Which aspects of the search results lists do you particularly inspect or use when

i) using a general search engine e.g. Title, URL, summary or *other*

please state, indicating order of importance ……………………………

ii) using an academic database? e.g. Title, author, summary or *other*

please state, indicating order of importance ……………………………

Having selected a source from the search results list, do you evaluate it

i) from the screen?

never *rarely* *sometimes* *often* *almost always*

ii) from a paper-based version?

never *rarely* *sometimes* *often* *almost always*

Please circle the closest option in each case

Section 4: About the 'usage' process

Please base your answers to the following questions on your ***typical*** *behaviour*

What type of information do you extract (take and use) from a source?
Please circle all that apply and/or state other

Reference details *Structure (e.g. headings)* *Quotes*

Concepts *Text*

Other? **Please state:** …………………………………

Using the examples of extractions identified above as a reference point, please indicate which tool(s) you use when extracting information, from a source, for your own purposes (i.e. representing the information in the way most suitable for your sensemaking)
Please circle ALL that apply and/or state others

Word processor *Drawing/graphics tool*

Pencil & paper *Bibliographic tool*

Others? **Please state** …………………………………….

Which of the following best describes your usage behaviour
Please circle the closest option else state other

Search, and locate several sources before using any of them

Search, locate and use each source before searching for another source

Other? **Please state:** ……………………………………

(End – Thank you)

Appendix A

Study 1: Consent Form

'Web-based Information Search and Source Usage' Behavioural Study

Consent Form

I hereby agree to participate in the above named study, which will involve me completing a questionnaire prior to attending an interview session. I understand that the interview session will be audio-recorded and that notes will be taken.

I understand that all data gathered will be kept in the strictest confidence and will be kept secure at all times. I agree that the data may be used and reported in future internal or external documentation and it will be fully anonymised to ensure that it will not be traceable.

I retain the right to withdraw from this study at any time. In so doing, I may also choose to withdraw my permission to allow use of any previously gathered data, supplied by me.

Signed: ……………………………………………………………..

Date: ……………………

For any questions or further information about this study, please contact:
Ann Abraham
PhD student, Computing
Room M211, ext. 59757
a.m.abraham@open.ac.uk

Appendix B

Study 2: Task Topic - Straw Poll Spreadsheet Workings

Task: Prepare either an outline presentation or a 500 word essay on one of the following:				STUDY-2: Straw Poll: Which task & topic is of interest?																	
										SUB-TOTAL		NO 8	NO 9	No 10	No11	No12		TOTAL:			
Which task? Use 'p' or 'e'	p	e	e		either	e	e	either				p	e	p	e	p			e- 6; p-4; either-2		
Determine and discuss the key issues with respect to the implementation and the implications of ID cards in the UK						poss	√	poss		1 +2		√			√	√		4 + 2	p -4		
Identify and discuss the key issues and implications for introducing a centralised NHS electronic record system						poss	poss			2 poss								2 poss			
Identify and discuss the key considerations when choosing ISDN over dial-up remote access													√					1			
Determine the debate: Are the sources and potential sources of oil sufficient to satisfy the worlds future demand ?		√			poss		poss	√		2 + 2				√ 1				2+3			
Debate the key considerations for abolishing the 'House of Lords' and discuss the potential impact from at least two perspectives ?			√							1								1			
Discuss the merits or otherwise, of three alternative energy resources in terms of their key issues and considerations	√				poss			poss		1 + 2		poss		√ 1				1+4			

Notes from 23rd Sept (for easy ref.)

Information gathering type task

Require judgement

Specialist knowledge – in fact maybe both specialist and populist in nature **-Important**

May have practical element or current relevance

Varying complexity

The opinion element of the task is important

NOTES re Responses:

2 groups - grp 1 was 1 acad and 2 students (non UK students); grp 2 was 3 web producers (amles) and 1 admin (lady)

Grp 1 chose I topic each and fairly definmate about presentation or essay task

Grp 2 debated merits of each task type and felt that in time available, would get same results anyway e.g bullet points

Grp 2 wanted to narrow to 3 choices and some not able to say which one best

From those who narrowed in grp 2, one chose ID cards, one chose ID equal with NHS, another chose oil and energy as similar, the other two differentiated when pushed to a first choice e.g one said ID cards, one said oil

Entry No 8 was a RF who chose based on time & personal interests and felt ath given time prefernce was for a presentation

Entry No 9 was from tech staff who judged that ISDN cos prev knowledge, interst & time available Essay outline

Entry 10,11,12 were from 3 researchers - (2RF, 1 student) on 26/3/07 in refectory)

Appendix B

Study 2: Prepared Google-Collection

Google results – ID Cards – 28/03/07 (In Order as Returned by Google)

NO2ID:stop **ID cards** and the database state

From April 2007 the **UK** Identity & Passport Service begins to open **ID ...** the National Identity Register (NIR) that is the main aim of the '**ID cards**' scheme. **...**
www.no2**id**.net/ - 19k - 26 Mar 2007 - Cached - Similar pages

BBC NEWS | **UK** Politics | Blunkett backs **ID card** plan

Everyone in Britain over the age of 16 could be issued with a form of **ID card** under plans outlined by Home Secretary David Blunkett.
news.bbc.co.**uk**/1/hi/**uk**_politics/2084860.stm - 48k - Cached - Similar pages

Identity **Cards** Bill

This is the text of the Identity **Cards** Bill, as amended in Standing Committee D in the House of Commons on 21st July 2005. Identity **Cards** Bill **...**
www.publications.parliament.**uk**/pa/cm200506/cmbills/049/2006049.htm - 11k - Cached - Similar pages

ID Cards - **UK's** high tech scheme is high risk - News archive **...**

ID Cards - **UK's** high tech scheme is high risk. The likely cost of rolling out the **UK** government's current high-tech identity **cards** scheme will be £10.6 **...**
www.lse.ac.**uk**/collections/pressAndInformationOffice/newsAndEvents/archives/2005/**ID**Card_FinalReport.htm - 26k - Cached - Similar pages

Home Office | **ID cards**

ID cards will provide legal **UK** residents, including foreign nationals, with an easy and secure way of proving their entitlement to services and their right **...**
www.homeoffice.gov.**uk**/passports-and-immigration/**id-cards**/ - 21k - Cached - Similar pages

Id Cards Information

File Format: Microsoft Word - View as HTML
This report sets out the **rationale** for the review into the FoI Act. Its remit **...** Summary of work in progress on areas of the **ID Cards** Scheme highlighted by **...**
www.leeds.ac.**uk**/jmce/WP6**ID**bib.doc - Similar pages

UK Identity **Cards** - The Case Against

Detailed arguments against the proposed introduction of compulsory national **ID Cards** and the National Identity Register in the **UK**.
www.trevor-mendham.com/civil-liberties/**id**entity-**cards**/index.html - 11k - Cached - Similar pages

Identity and Passport Service

File Format: PDF/Adobe Acrobat - View as HTML
clear that further premises would be needed for the **implementation** of **ID**. **cards**. In order to ensure that the Identity and Passport service is not **...**
www.passport.gov.**uk**/downloads/Passport-Interview-Network-May2006_new.pdf

[British national identity **card** - Wikipedia, the free encyclopedia]
Registration will become compulsory for non-**UK** passport holders resident in the **UK** by 2013. The Home Office currently estimates **ID cards** will be available **...**
en.wikipedia.org/wiki/British_national_**id**entity_card - 80k - Cached - Similar pages

Compulsory **ID cards** for **U.K.** citizens | Tech News on ZDNet
Compulsory **ID cards** for **UK** citizens | All will be required to register within five years. Critics warn **UK** is sleepwalking towards a surveillance state. |
news.zdnet.com/2100-1009_22-6039076.html - 54k - 26 Mar 2007 - Cached - Similar pages

BBC - Action Network - **ID cards**: an Action Network briefing
A number of other countries have **ID card** schemes, though the **UK** scheme will be more technologically advanced. How will identity **cards** affect you? **...**
www.bbc.co.**uk**/dna/actionnetwork/A2319176 - 45k - Cached - Similar pages

UK Identity **Cards** and Social Exclusion
This report investigates the probable effect of the proposed **UK** national Identity **Card** system on people who are marginalised, who suffer social disadvantage **...**
www.privacyinternational.org/article.shtml?cmd%5B347%5D=x-347-228833 - 47k - Cached - Similar pages

Privacy International - National **ID Cards**
PI Launches **UK ID Card** Web Page, Releases Guide and FAQ on **ID Cards**. Privacy International launched a new web page on the **UK ID Card** controversy on July 13. **...**
www.privacy.org/pi/activities/**id**card/ - 27k - Cached - Similar pages

IPS
About the Identity and Passport Service · About **ID cards** and the National Identity Scheme · What are the benefits of the National Identity Scheme? **...**
www.**id**entity**cards**.gov.**uk**/index.asp - 10k

£1000 fine for failing to update identity **cards** | **Uk** News | News **...**
Daily news from the **UK**, business news, countryside news, **UK** technology news, obituaries and **...** 20 December 2006: **ID cards** will have to share old databases **...**
www.telegraph.co.**uk**/news/main.jhtml?xml=/news/2006/12/24/n**id**24.xml - 37k - 26 Mar 2007 - Cached - Similar pages

Don't like **ID cards**? Hand over your passport | the Daily Mail
Therefore, anybody who objects to **ID cards** on principle and wants to keep their personal details private must remain in the **UK** for the rest of their lives. **...**
www.dailymail.co.**uk**/.../articles/news/news.html?in_article_**id**=441329&in_page_**id**=1770&ito=newsnow - 26 Mar 2007 - Similar pages

Appendix B

Study 2: Task Sheet

Task Sheet Instructions (to be read-out)
The observation will last no longer than 1hr30mins.

You are being asked to complete a given topic comprehension/information gathering task and we ask that you think & talk aloud' throughout the observation.
For example, we would like you to

talk aloud the questions you are asking yourself
tell us ***what*** you are doing and ***why*** you are doing it.
tell us **if and when** you would have performed another/new/further **search** and why (although we don't want you to actually run any further searches!)

I may prompt occasionally but prompting will be kept to a minimum to avoid distracting you.

Your information sources will come from a filtered collection of results captured from a previous *Google* search query. As you will see they are shown as a list of *Google* results in the order they were returned by the search engine. Ctrl/Click on any result takes you to that Live WebPage as per normal.

If you wish to use paper for any working/scribbling/writing/drawing you do during the session, we ask that you use the given supply; the paper-sheets are numbered and we would ask that you use them in the given order please.

Please ask for paper versions of any sources you require.

Task (text on task sheet given to participants)**:**

Imagine that you have been asked to prepare and present a 15min talk for a mixed group of people from your local community, prepare an outline presentation on the following topic:

"Determine and discuss the key issues with respect to the implementation and the implications of ID cards in the UK"

Appendix B

Study 2: Post-Session Questionnaire/Debriefing

'Sensemaking in Web-Based Information Seeking' Behavioural Study

Debriefing Questions:

Name:
How many years internet experience do you have?
How many years computing experience do you have?
On a scale of 1-5, where 1 stands for '*not successful*' and 5 stands for '*successful*', how would you evaluate your success in finding required information typically?
How often do you use web-based search tools (inc. engines) for information searches? *Several times per day* *Once per day* *Couple of times per week* *Several times per month* *Less than once per month* How would you best describe the types of tasks you do regularly? *E.g. work related, research related, personal interest?*
On a scale of 1-5, where 1 stands for *novice* and 5 stands for *expert*, how would you evaluate your Web-search expertise?
Would you say that the way you evaluated and referenced the sources today e.g. from screen and/or paper, was typical behaviour? Yes No **If Not typical**, what was different today?

Would you say that the way you selected and used sources today was typical of your behaviour for this type of task i.e.

Search, and locate several sources before using any of them

Search, locate and use each source before searching for another source

If NOT typical what was different today?

Were the range of tools available to develop your deliverable sufficient? Yes/No

Is there anything else you would normally use but not offered today?

If so, has this made a difference to your progress?

Has this made a difference to your final deliverable?

Thank-You!

Appendix B

Study 2: ‘Call for Volunteers’ Email

Apologies for any cross-posting.

Hi
My research project is investigating ‘sensemaking in web-based environments’, and we are looking for volunteers (please!) to participate in an empirical study.

What type of people are we looking for?
Anyone who has experience of seeking information from web-based sources; for example in work-related research such as literature reviews, or other work-related or social tasks that involve seeking information, such as evidence & fact finding for reports, making decisions about and completing on-line purchases, etc..

What is involved?
A single session spent on a simple information seeking task to identify issues on a given theme; this observed session will last no more than 1hr 30mins.

When will sessions take place?
When are you free in April, May? We will be as flexible as Lab facilities allow. *NB* - we may have to extend into June.

Why not express your willingness today?
We know you are busy people, but please consider giving us 1hr 30mins of your time: email me at a.m.abraham@open.ac.uk. We would really appreciate the help.
If you have any further questions please contact me.
Many Thanks
Ann

Appendix B

Study 2: Consent Form

"Sensemaking in Web Based Information Seeking" Behavioural Study

Consent Form

I hereby agree to participate in the above named study, which will involve me completing a questionnaire prior to attending an interview session. I understand that the interview session will be audio-recorded and video recorded and that notes will be taken.

I understand that all data gathered will be kept in the strictest confidence and will be kept secure at all times. I agree that the data may be used and reported in future internal or external documentation and it will be fully anonymised to ensure that it will not be traceable.

I retain the right to withdraw from this study at any time. In so doing, I may also choose to withdraw my permission to allow use of any previously gathered data, supplied by me.

Signed: ………………………………………………………..

Date: ……………………

For any questions or further information about this study, please contact:
Ann Abraham
PhD student, Computing
Room M211, ext. 59757
a.m.abraham@open.ac.uk

Appendix C
Study 2: Set of Eight Sequences of Episodes (Analysis Step 2)

P1: 1. plan [_what to Do+ req T/S + what to Use_] 2. *(*(seek +*eval(s) + eval(u)) + compile) 3. seek + *eval(s) + *eval(u) 4. plan _[what to Use + review slides + req T/S]_ 5. eval(u) 6. plan [_review slides_] 7. eval(u) + compile 8. plan [what To Use/r_eview+ review(slides)_]	**P2:** 1. *(*(seek +*eval(s) + *eval(u)) + compile) 2. *(seek+ eval(s) + *eval(u)) 3. *eval(u) + seek + eval(s) + eval(u) + compile 4. plan _[review slides_] 5. eval(u) + compile + *eval(u) + *(*(seek + eval(s) +eval(u))+ compile) 6. *(*(seek + *eval(s) + eval(u)) + compile) 7. *(seek + eval(s) + eval(u)) 8. plan [_review slides + ref source_]
P3: 1. plan _[what to Use_] 2. *(seek + eval(s) + eval(u) + compile) 3. plan _[review slides]_ 4. eval(u) + *(*(seek + *eval(s) + eval(u)) + compile) 5. plan _[review slides+ req T/S_] 6. *(*(seek + *eval(s) + eval(u))+ compile) 7. plan [_review slides_] 8. seek + eval(s) + eval(u)	**P4:** 1. plan _[req T/S]_ 2. seek + eval(s) + eval(u) + compile 3. plan _[what to Use + review slide s+ what to Do_] 4. *(*(seek + *eval(s) + eval(u)) + compile) 5. plan [_review slides_] 6. eval(u) + compile + *(seek + *eval(s) + eval(u)) 7. plan [_review slides_] 8. eval(u) + seek + *eval(s) + eval(u) + compile + *(seek + *eval(s) + eval(u)) 9. plan [_review slides_]
P5: 1. plan _[req T/S + what to Do + what To Use]_ 2. *(seek +*eval(s) + eval(u) + compile)+ seek+ *eval(s) 3. plan [_outline + req T/S_] 4. eval(u) + *compile + *(seek + eval(s) + *eval(u) + *compile) 5. plan [_review p&p+ req T/S]_ 6. compile 7. *(seek + eval(s) + eval(u) + compile)	**P6:** 1. plan [_what to Use_] 2. *(seek +eval(s) + eval(u)) 3. *(seek + eval(s) + *(eval(u) + compile)) 4. *(seek + eval(s) + *eval(u)) 5. plan [_what to Do +ref source + review p&p]_ 6. *compile
P7: 1. plan _[what to Use + req T/S]_ 2. *(seek + eval(s) +eval(u)) 3. plan [_what to Use + what to Do]_ 4. eval(u) + compile + seek +*eval(u) + eval(s) + *(*eval(u) + compile) 5. plan _[review slides + what to Use]_ 6. *(*(*eval(u) + compile) + *(eval(u) + seek + eval(s))) + *eval(u) + compile + eval(u) 7. plan _[review sources + review Collection +refs source + what to Use(Live Google)]_ 8. *(*eval(u) + eval(s)) + *eval(u) + compile 9. plan [_review slides +Live Google seek +refs source+ review slides]_ 10. *(*eval(u) + compile) + eval(u) + seek + eval(s) + *(*eval(u) + compile) 11. plan [_what to Use_] 12. *eval(u) 13. *(seek + *eval(s)) + eval(u) + seek + *eval(s) + seek + *eval(u) 14. plan [_review slides_]	**P8:** 1. plan [_req T/S + what to Do]_ 2. plan _[what to Use]_ 3. *(seek + eval(s) + eval(u) + compile) 4. plan _[what to Use]_ 5. seek + *eval(s)+ eval(u) + compile 6. plan [_review slides + req T/S_]

Appendix C
Study 2: Set of Eight Sequences of Episode Types (Analysis Step 3)

P1:
1. plan [*what to Do+ req T/S + what to Use*]
2. *(*(seek +*eval(s) + eval(u)) + compile)
3. seek + *eval(s) + *eval(u)
4. plan *[what to Use + review slides + req T/S]*
5. eval(u)
6. plan [*review slides*]
7. eval(u) + compile
8. plan [what To Use/*review+ review(slides)*]

P2:
1. *(*(seek +*eval(s) + *eval(u)) + compile)
2. *(seek+ eval(s) + *eval(u))
3. *eval(u) + seek + eval(s) + eval(u) + compile
4. plan [*review slides*]
5. eval(u) + compile + *eval(u) + *(*(seek + eval(s) +eval(u))+ compile)
6. *(*(seek + *eval(s) + eval(u)) + compile)
7. *(seek + eval(s) + eval(u))
8. plan [*review slides + ref source*]

P3:
1. plan *[what to Use]*
2. *(seek + eval(s) + eval(u) + compile)
3. plan *[review slides]*
4. eval(u) + *(*(seek + *eval(s) + eval(u)) + compile)
5. plan *[review slides+ req T/S]*
6. *(*(seek + *eval(s) + eval(u))+ compile)
7. plan [*review slides*]
8. seek + eval(s) + eval(u)

P4:
1. plan *[req T/S]*
2. seek + eval(s) + eval(u) + compile
3. plan *[what to Use + review slide s+ what to Do*]
4. *(*(seek + *eval(s) + eval(u)) + compile)
5. plan [*review slides*]
6. eval(u) + compile + *(seek + *eval(s) + eval(u))
7. plan [*review slides*]
8. eval(u) + seek + *eval(s) + eval(u) + compile + *(seek + *eval(s) + eval(u))
9. plan [*review slides*]

P5:
1. plan *[req T/S + what to Do + what To Use]*
2. *(seek +*eval(s) + eval(u) + compile)+ seek+ *eval(s)
3. plan [*outline + req T/S*]
4. eval(u) + *compile + *(seek + eval(s) + *eval(u) + *compile)
5. plan [*review p&p+ req T/S]*
6. compile
7. *(seek + eval(s) + eval(u) + compile)

P6:
1. plan [*what to Use*]
2. *(seek +eval(s) + eval(u))
3. *(seek + eval(s) + *(eval(u) + compile))
4. *(seek + eval(s) + *eval(u))
5. plan [*what to Do +ref source + review p&p]*
6. *compile

P7:
1. plan *[what to Use + req T/S]*
2. *(seek + eval(s) +eval(u))
3. plan [*what to Use + what to Do]*
4. eval(u) + compile + seek +*eval(u) + eval(s) + *(*eval(u) + compile)
5. plan *[review slides + what to Use]*
6. *(*(*eval(u) + compile) + *(eval(u) + seek + eval(s))) + *eval(u) + compile + eval(u)
7. plan *[review sources + review Collection +refs source + what to Use(Live Google)]*
8. *(*eval(u) + eval(s)) + *eval(u) + compile
9. plan [*review slides +Live Google seek +refs source+ review slides]*
10. *(*eval(u) + compile) + eval(u) + seek + eval(s) + *(*eval(u) + compile)
11. plan [*what to Use*]
12. *eval(u)
13. *(seek + *eval(s)) + eval(u) + seek + *eval(s) + seek + *eval(u)
14. plan [*review slides*]

P8:
1. plan *[req T/S + what to Do]*
2. plan *[what to Use]*
3. *(seek + eval(s) + eval(u) + compile)
4. plan *[what to Use]*
5. seek + *eval(s)+ eval(u) + compile
6. plan [*review slides + req T/S*]

Legend:
'*Episode* Type' descriptors:
SeekToEvaluateForCompile
SeekToEvaluateToCorroborate
EvaluateForCompile
Compile
Plan[+ indicative purpose]

Appendix C

Study 2: Eight Session Sensemaking Strategies Expressed as a Sequence of Episodes Labelled as Types (Analysis Step 4)

Participant p1: user session

PlanEpisode

SeekToEvaluateForCompile

1. plan [*what to Do* + *req T/S* + *what to Use*]
2. *(*(seek +*eval(s) + eval(u)) + compile)
3. seek + *eval(s) + *eval(u)
4. plan *[what to Use + review slides + ref T/S]*
5. eval(u)
6. plan [*review slides*]
7. eval(u) + compile
8. plan [*what to Use/review+ review(slides)*]

EvaluateForCompile

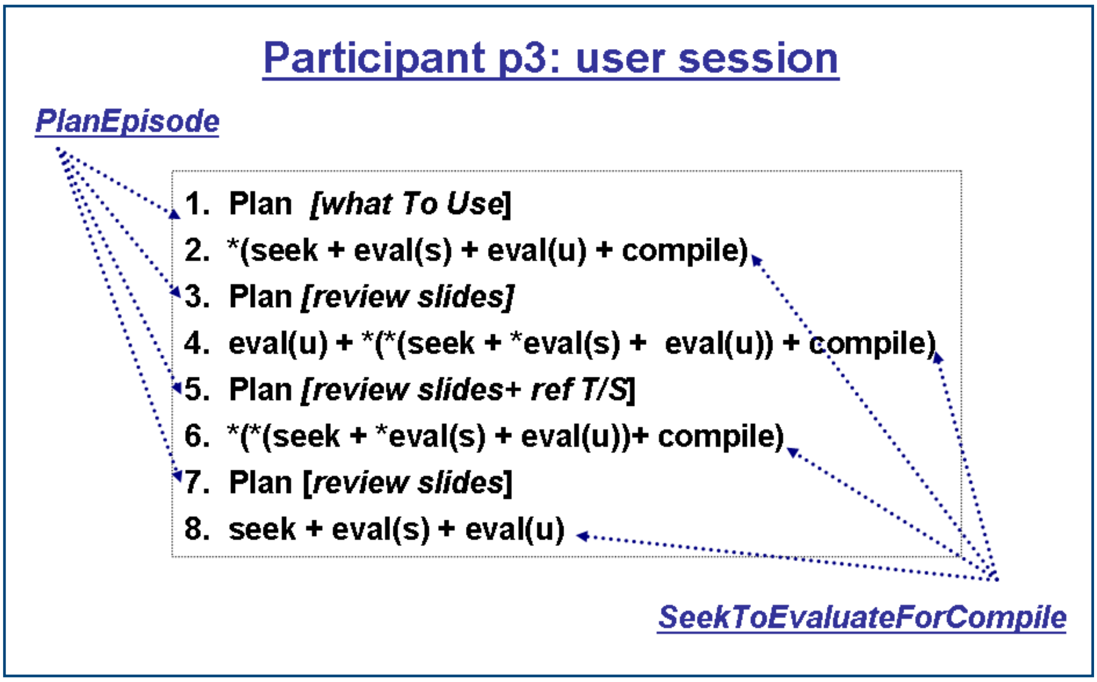
Participant p2: user session

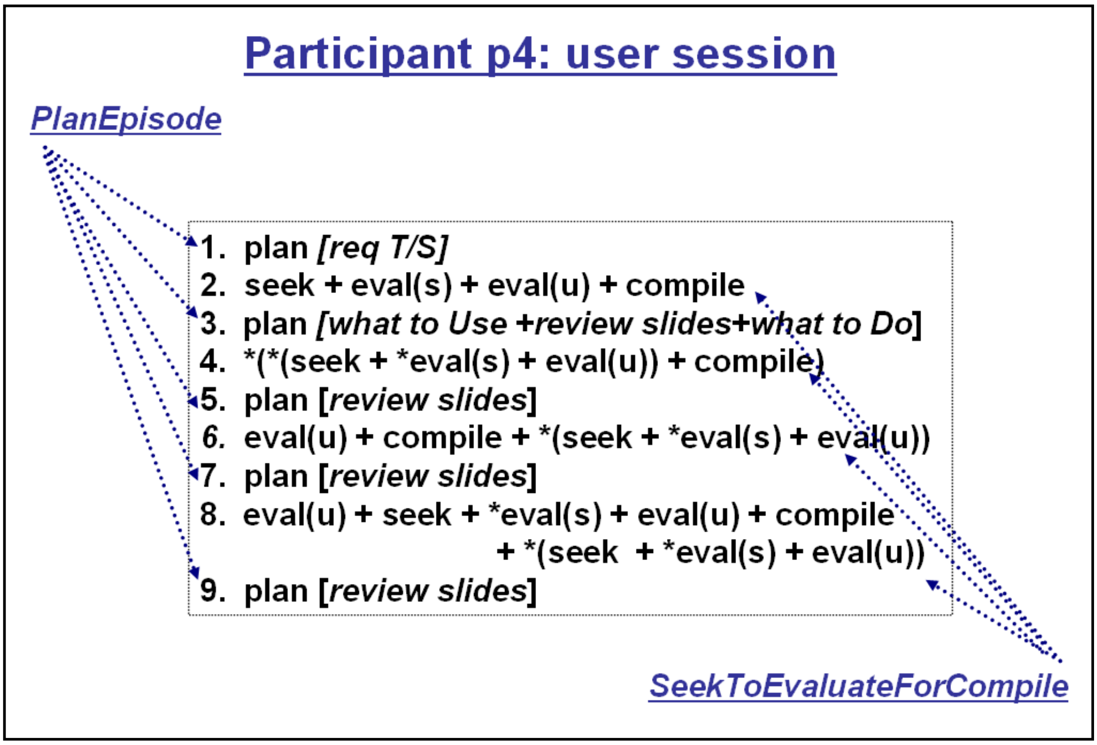
SeekToEvaluateForCompile

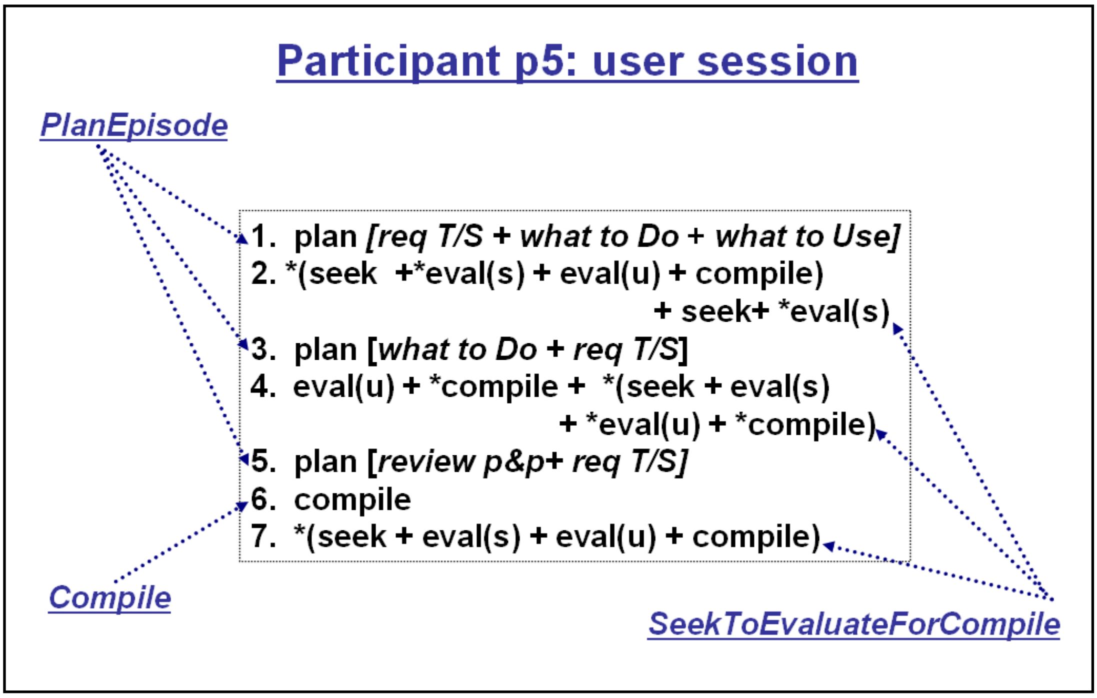
SeekToEvaluateForCorroborate

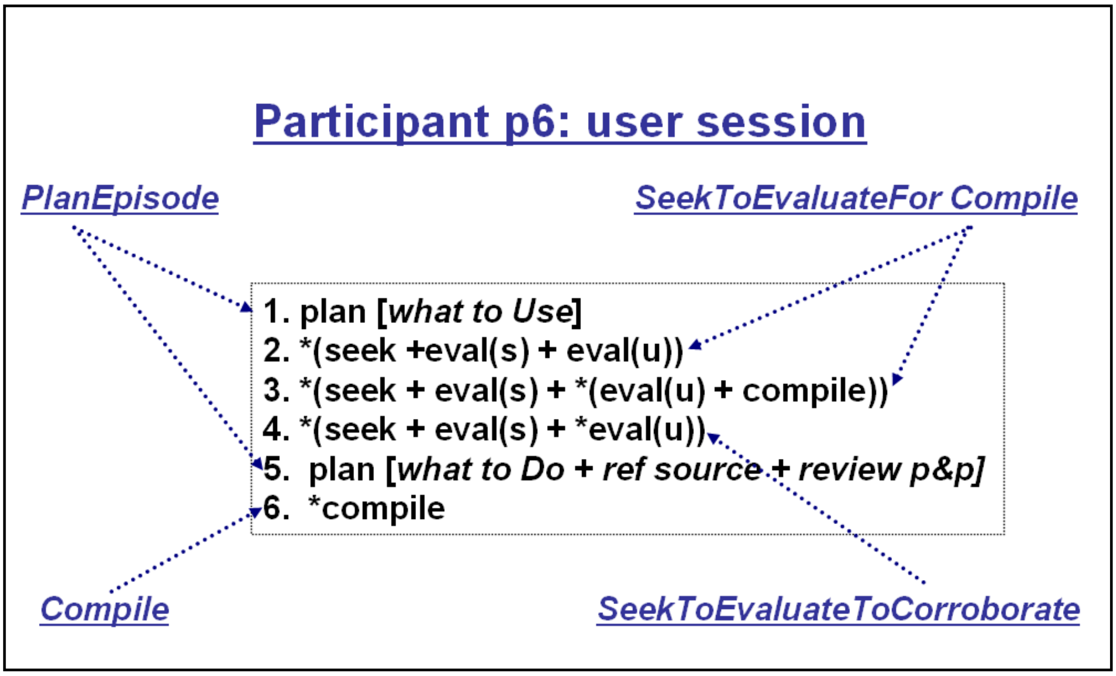
1. *(*(seek +*eval(s) + *eval(u)) + compile)
2. *(seek+ eval(s) + *eval(u))
3. *eval(u) + seek + eval(s) + eval(u) + compile
4. plan *[review slides]*
5. eval(u) + compile + *eval(u) +
   ((seek + eval(s) +eval(u))+ compile)
6. *(*(seek + *eval(s) + eval(u)) + compile)
7. *(seek + eval(s) + eval(u))
8. plan [*review slides + ref source*]

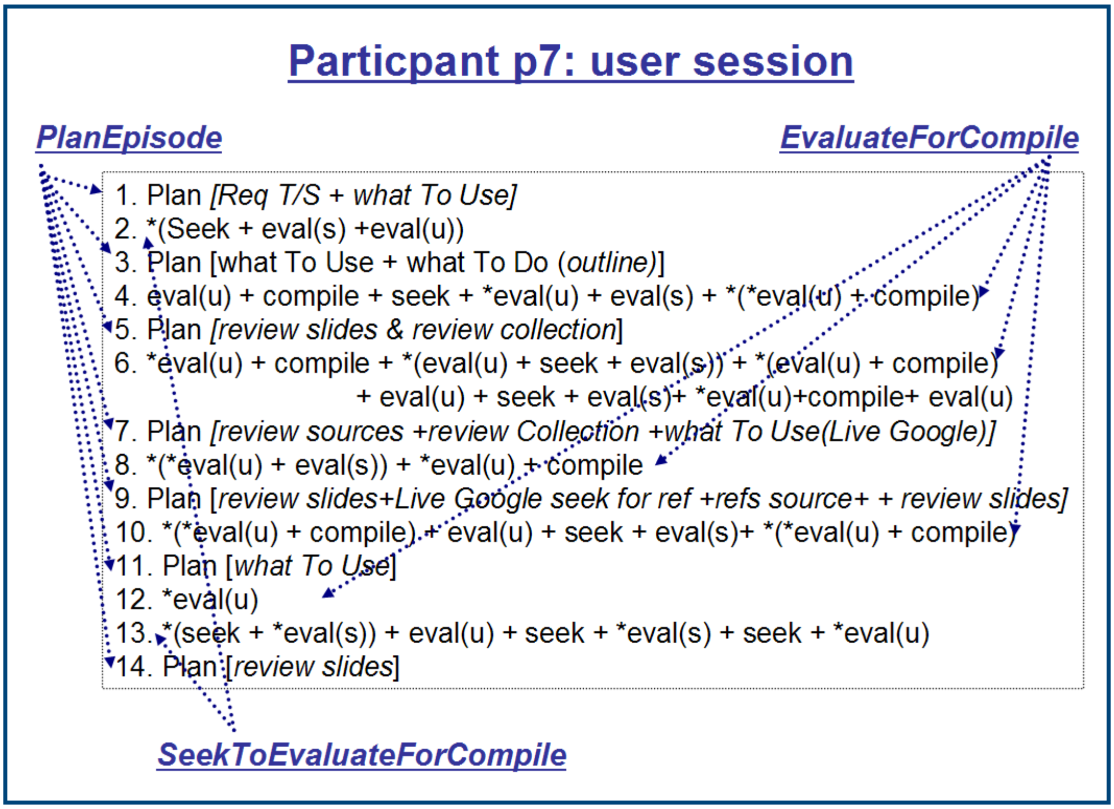
PlanEpisode

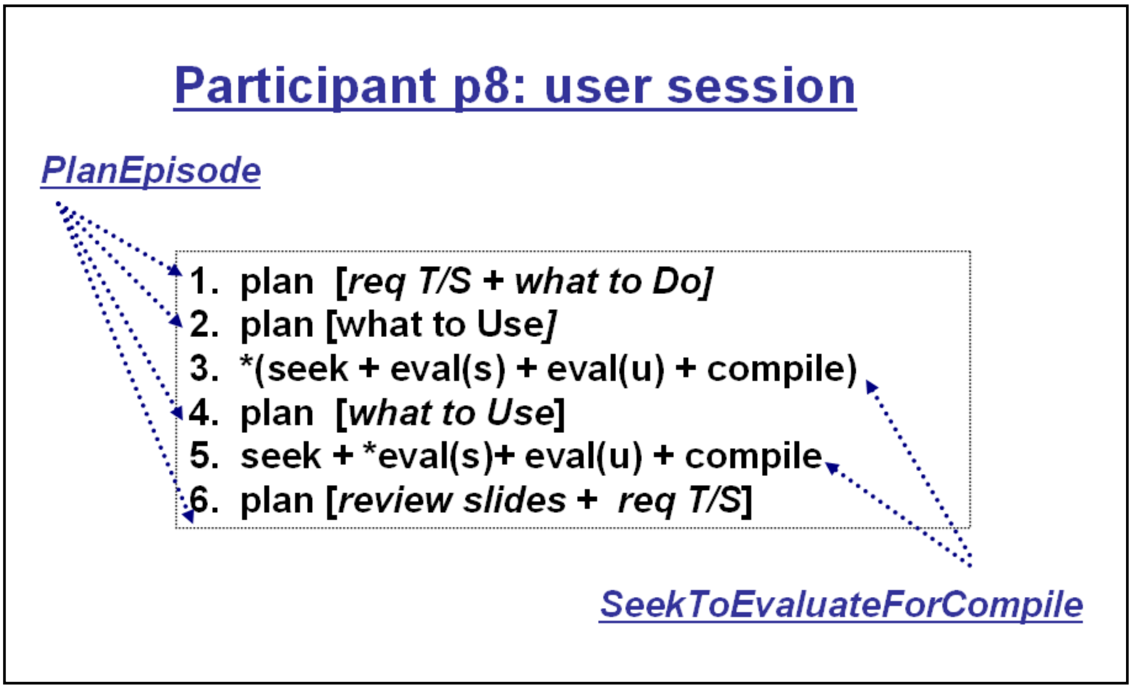

Participant p3: user session
PlanEpisode
1. Plan [what To Use]
2. *(seek + eval(s) + eval(u) + compile)
3. Plan [review slides]
4. eval(u) + *(*(seek + *eval(s) + eval(u)) + compile)
5. Plan [review slides+ ref T/S]
6. *(*(seek + *eval(s) + eval(u))+ compile)
7. Plan [review slides]
8. seek + eval(s) + eval(u)
SeekToEvaluateForCompile


Participant p4: user session
PlanEpisode
1. plan [req T/S]
2. seek + eval(s) + eval(u) + compile
3. plan [what to Use +review slides+what to Do]
4. *(*(seek + *eval(s) + eval(u)) + compile)
5. plan [review slides]
6. eval(u) + compile + *(seek + *eval(s) + eval(u))
7. plan [review slides]
8. eval(u) + seek + *eval(s) + eval(u) + compile
+ *(seek + *eval(s) + eval(u))
9. plan [review slides]
SeekToEvaluateForCompile


Participant p5: user session
PlanEpisode
1. plan [req T/S + what to Do + what to Use]
2. *(seek +*eval(s) + eval(u) + compile)
+ seek+ *eval(s)
3. plan [what to Do + req T/S]
4. eval(u) + *compile + *(seek + eval(s)
+ *eval(u) + *compile)
5. plan [review p&p+ req T/S]
6. compile
7. *(seek + eval(s) + eval(u) + compile)
Compile
SeekToEvaluateForCompile


Participant p6: user session
PlanEpisode
SeekToEvaluateFor Compile
1. plan [what to Use]
2. *(seek +eval(s) + eval(u))
3. *(seek + eval(s) + *(eval(u) + compile))
4. *(seek + eval(s) + *eval(u))
5. plan [what to Do + ref source + review p&p]
6. *compile
Compile
SeekToEvaluateToCorroborate


Particpant p7: user session
PlanEpisode
EvaluateForCompile
1. Plan [Req T/S + what To Use]
2. *(Seek + eval(s) +eval(u))
3. Plan [what To Use + what To Do (outline)]
4. eval(u) + compile + seek + *eval(u) + eval(s) + *(*eval(u) + compile)
5. Plan [review slides & review collection]
6. *eval(u) + compile + *(eval(u) + seek + eval(s)) + *(eval(u) + compile)
+ eval(u) + seek + eval(s)+ *eval(u)+compile+ eval(u)
7. Plan [review sources +review Collection +what To Use(Live Google)]
8. *(*eval(u) + eval(s)) + *eval(u) + compile
9. Plan [review slides+Live Google seek for ref +refs source+ + review slides]
10. *(*eval(u) + compile) + eval(u) + seek + eval(s)+ *(*eval(u) + compile)
11. Plan [what To Use]
12. *eval(u)
13. *(seek + *eval(s)) + eval(u) + seek + *eval(s) + seek + *eval(u)
14. Plan [review slides]
SeekToEvaluateForCompile


Participant p8: user session
PlanEpisode
1. plan [req T/S + what to Do]
2. plan [what to Use]
3. *(seek + eval(s) + eval(u) + compile)
4. plan [what to Use]
5. seek + *eval(s)+ eval(u) + compile
6. plan [review slides + req T/S]
SeekToEvaluateForCompile

Appendix C

Study 2: Sample Slides from Participant p3 Task Deliverable (6 of 15 Slides Including Title Page)

For identity cards:

- The government and supporters of the scheme argue that identity cards are necessary to prevent identity theft and reduce benefit fraud. They say that identity cards would:

- **Prevent illegal immigration:** Lack of a card allows illegal immigrants to arrive and disappear, according to the government.
- **Prevent illegal working:** Identity cards would enable employers to verify if people are allowed to work and it would be easier to prosecute employers who break the law, says the Home Office.
- **Aid anti-terrorism measures:** Identity cards would make it harder for terrorists and organised crime rings to use false and multiple identities, argues the Metropolitan Police Commissioner.
- **Tackle identity theft:** A National Register with unique biometric information for each person would make fraud much harder, according to CIFAS, the UK's fraud prevention service.
- **Reduce benefit fraud and abuse of public services:** Identity cards would ensure that public services are only used by those entitled to, says the Home Office.
- **Enhance sense of community:** The government believes that identity cards would create a sense of shared citizenship, belonging and security.

Slide 3

Against identity cards:

- Opponents argue that identity cards won't improve security in this country. They say that identity cards would:

- **Lead to loss of privacy:** A massive database with an unprecedented amount of personal information would be created with giving government the power to "extend surveillance" of the population, says No2ID.
- **Be costly and impractical:** The true cost of the scheme is unpredictable and the Home Office has a bad track record with large-scale IT projects, says the Liberal Democrats.
- **Worsen harassment of ethnic minorities:** They would provide another pretext for stop-and-search, often directed at ethnic minorities, argues the civil liberties group Liberty.
- **Have little impact on counter-terrorism:** Terror networks could forge cards or papers enabling people to get cards, and they haven't prevented attacks elsewhere, says Liberty.
- **Have little effect on illegal working:** Employers who are already willing to break the law won't be put off by identity cards, says campaigning organisation No2ID.
- **Lead to 'function creep':** MPs on the Home Affairs Committee expressed concerns that the functions of the card could grow as it stores more personal information.

Slide 4

NO2ID **The problems with "ID Cards"**

- **Not just a card. The card is the least of it...** #
  - ***The proposed identity management system has multiple layers***
  - ***Massive accumulation of personal data***
  - ***Lifelong surveillance and the meta-database***
  - ***Overseas ID cards are not comparable***
- **The Government has not made a case. There is no evidence the system will produce the stated benefits. Less liberty does not imply greater security.**
  - ***Terrorism***
  - ***Illegal immigration and working***
  - ***Benefit fraud and abuse of public services***
  - ***"Identity fraud"***
- **Overcomplicated, unproven technology**
  - ***Computer system***
  - ***Biometrics***

Slide 9

Benefits (HO and passport service)

- help protect cardholders against identity theft and fraud
- provide a reliable way of checking the identity of people in positions of trust
- make travelling in Europe easier
- provide a secure way of applying for financial products and making financial transactions, including those made over the internet
- offer a secure and convenient way of proving your age
- help to confirm your eligibility for public services and benefits – and reduce fraud relating to these services and benefits
- help in the prevention of organised crime and terrorism
- help combat illegal working and reduce illegal immigration to the UK
- allow the police more quickly to identify suspects and people they arrest.

Slide 11

Possible discussion?

Issues in July 2002

- Compulsory to have card, but voluntary to carry it
- Voluntary scheme
- Scheme targeted at particular groups
- Whether each should have a unique personal number.
- Should number be National Insurance or new one?

Have we moved on?

Slide 13

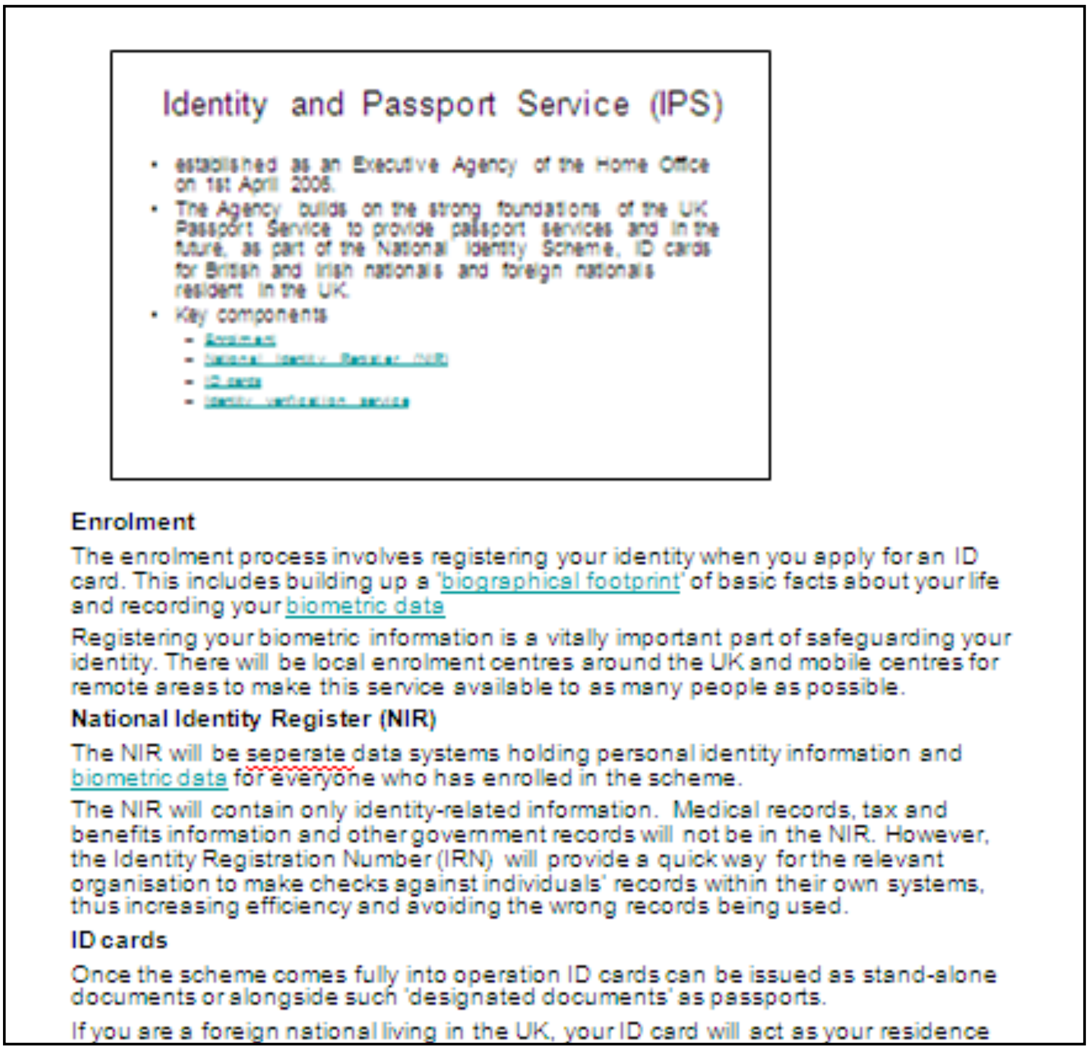
Who thinks what

-
- NO2ID is the main campaign group opposing identity cards. It has an ongoing petition protesting against the introduction of identity cards and a regularly updated web log.
- Liberty believes that any benefits from identity cards are outweighed by the financial and civil liberties costs. Its website has more information on identity cards.
- Stand is a lobby group opposing identity cards. It has resources on the issue.
- The Law Society is sceptical of the scheme. It says the police don't have problems identifying individuals but linking them to crimes. Read its full report.
- The Information Commissioner, in charge of data protection, has expressed strong concerns about the effects of the National Identity Register on individual privacy, in particular the 'data trail' which will track when and where a person uses their card. Find out more details of the Information Commissioner's concerns about the identity cards bills and response to the initial consultation.
- Rethink, a mental illness charity, says those with mental illness might not be able to afford a card and could have problems accessing services. Read its report.
- The Financial Services Authority supports the scheme on financial grounds. It says cards would help the disadvantaged – who find it hard to prove identity and address – do basic things like set up bank accounts. You can read its report on identity cards.
- The Police Federation supports identity cards because they enable easy street identification and help prevent fraud.
- The Confederation of British Industry says cards will benefit UK businesses.
- Of the political parties who have stated views, the Green Party has a briefing on its website. The Liberal Democrats has declared its opposition to the cards and the Scottish National Party both opposes them and believes that the cards should be a devolved issue allowing for separate legislation in Scotland. The Conservative Party is also opposed to identity cards.

Slide 14

Appendix C
Study 2: Sample Slide from Participant p3 and Use of *NoteView*

NoteView shows page holding text in support of the slide
(this was the first slide generated: slide 6 of 15)



Appendix C
Study 2: Sample from Participant p3 Showing Use of *MSWord*

MsWord used as a workspace to hold selected material (this is a sample extract from a 7-page document created to support slides 9 and 10)

total life history of every individual, to be retained even after death.

Lifelong surveillance and the meta-database #

Every registered individual will be under an obligation to notify any change in registrable facts. It is a clear aim of the system to require identity verification for many more civil transactions, the occasions to be stored in the audit trail. Information verified and indexed by numbers from the NIR would be easily cross-referenced in any database or set of databases. The "meta-database" of all the thousands of databases cross-referenced is much more powerful and much less secure than the NIR itself.

Overseas ID cards are not comparable #

Many western countries that have ID cards do not have a shared register. Mostly ID cards have been limited in use, with strong legal privacy protections. In Germany centralisation is forbidden for historical reasons, and when cards are replaced, the records are not linked. Belgium has made use of modern encryption methods and local storage to protect privacy and prevent data-sharing, an approach opposite to the Home Office's. The UK scheme is closest to those of some Middle Eastern countries and of the People's Republic of China—though the latter has largely given up on biometrics.

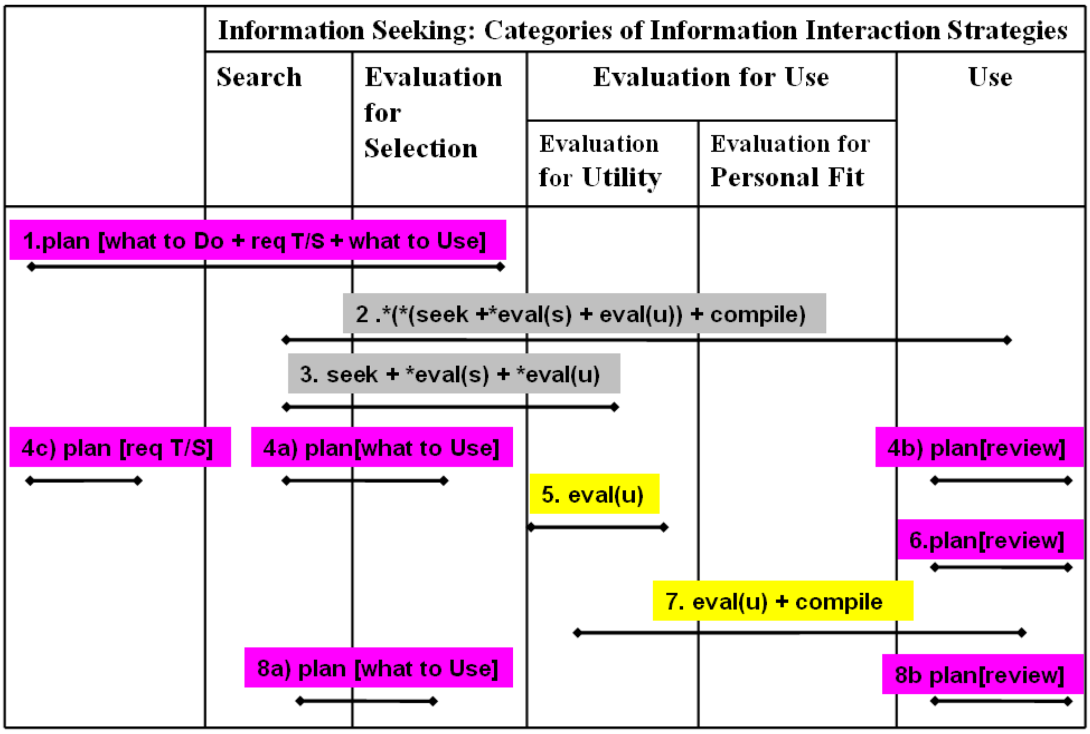
The Government has not made a case. There is no evidence the system will produce the stated benefits. Less liberty does not imply greater security. #

Terrorism #

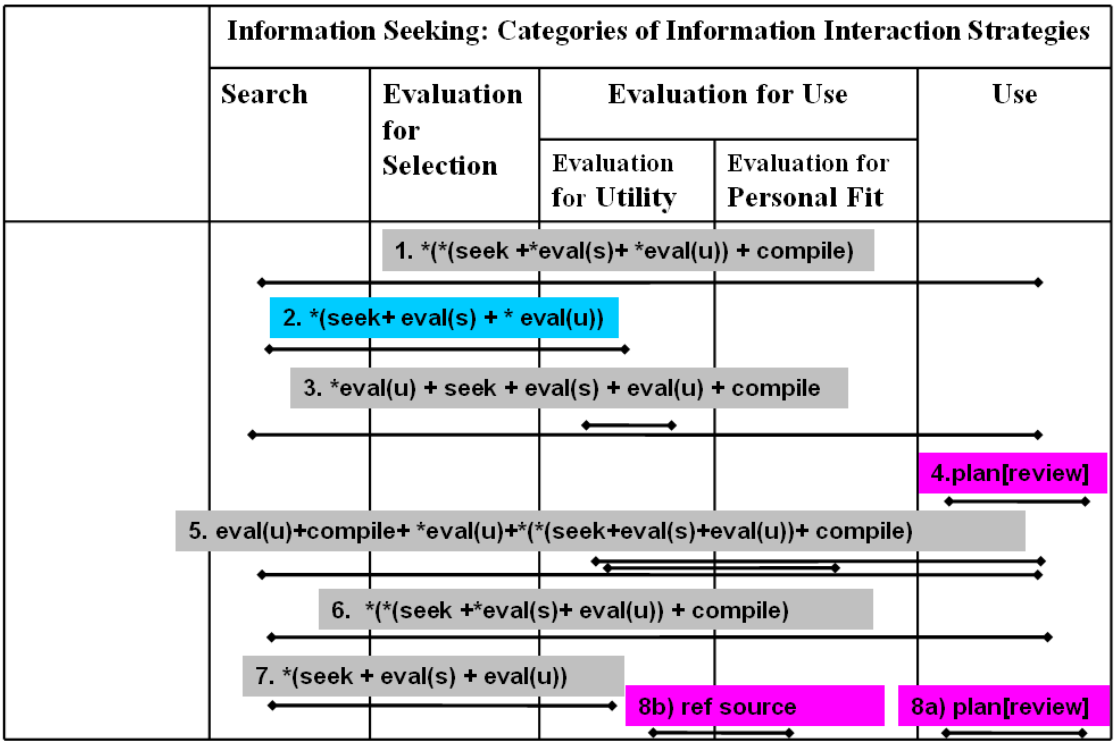
ID does not establish intention. Competent criminals and terrorists will be able to subvert the identity system. Random outrages by individuals can't be stopped. Ministers agree that ID cards *will not* prevent atrocities. A blank assertion that the department would find it helpful is not an argument that would be entertained for fundamental change in

Appendix C
Study 2: Mapping Colour-Coded *Episode-Types* onto Empirical Framework (Analysis Step 5)

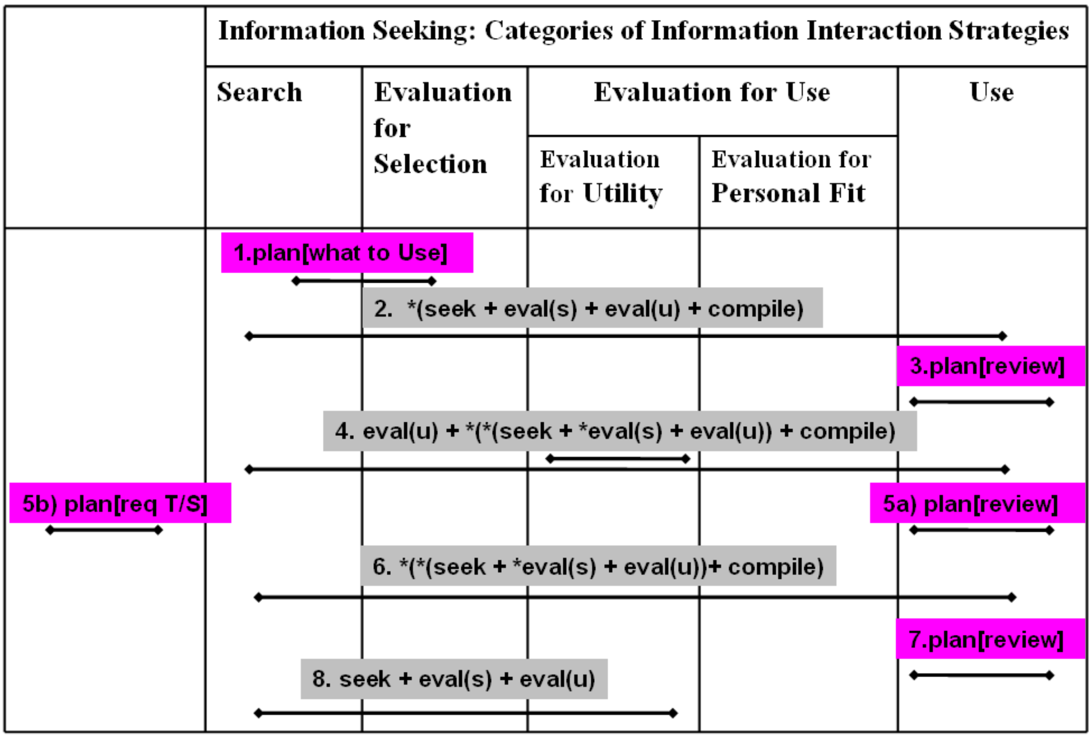
P1: sensemaking strategy mapped to framework



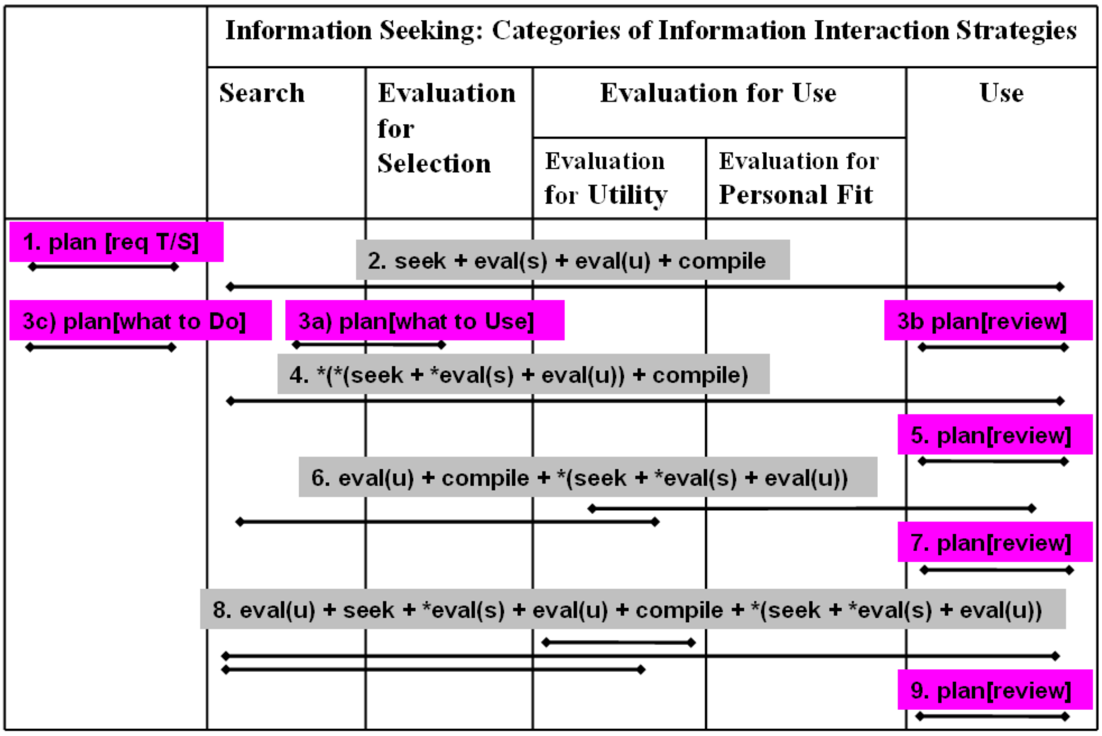
P2: sensemaking strategy mapped to framework



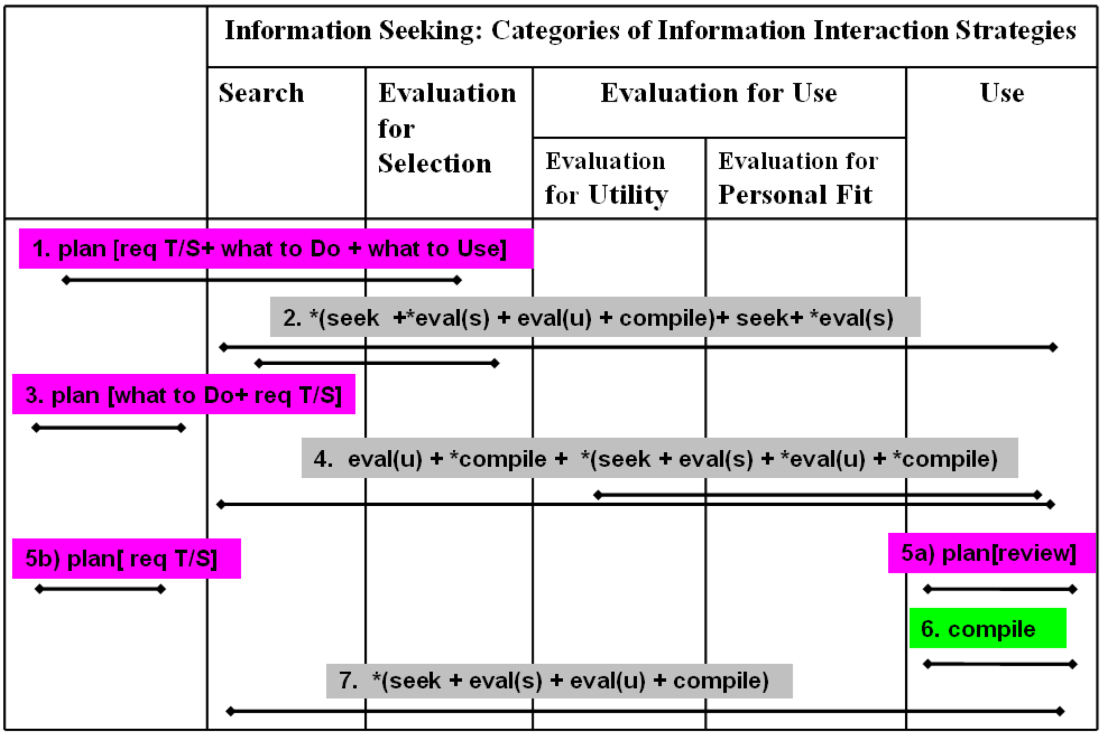
P3: sensemaking strategy mapped to framework



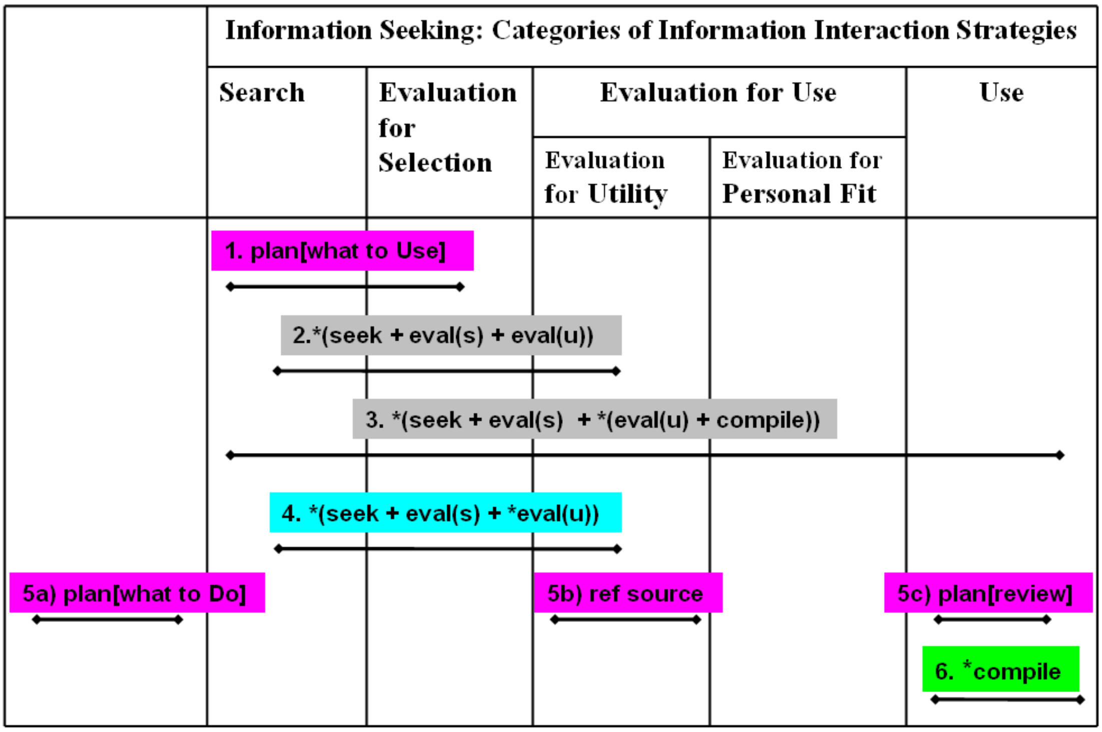
P4: sensemaking strategy mapped to framework



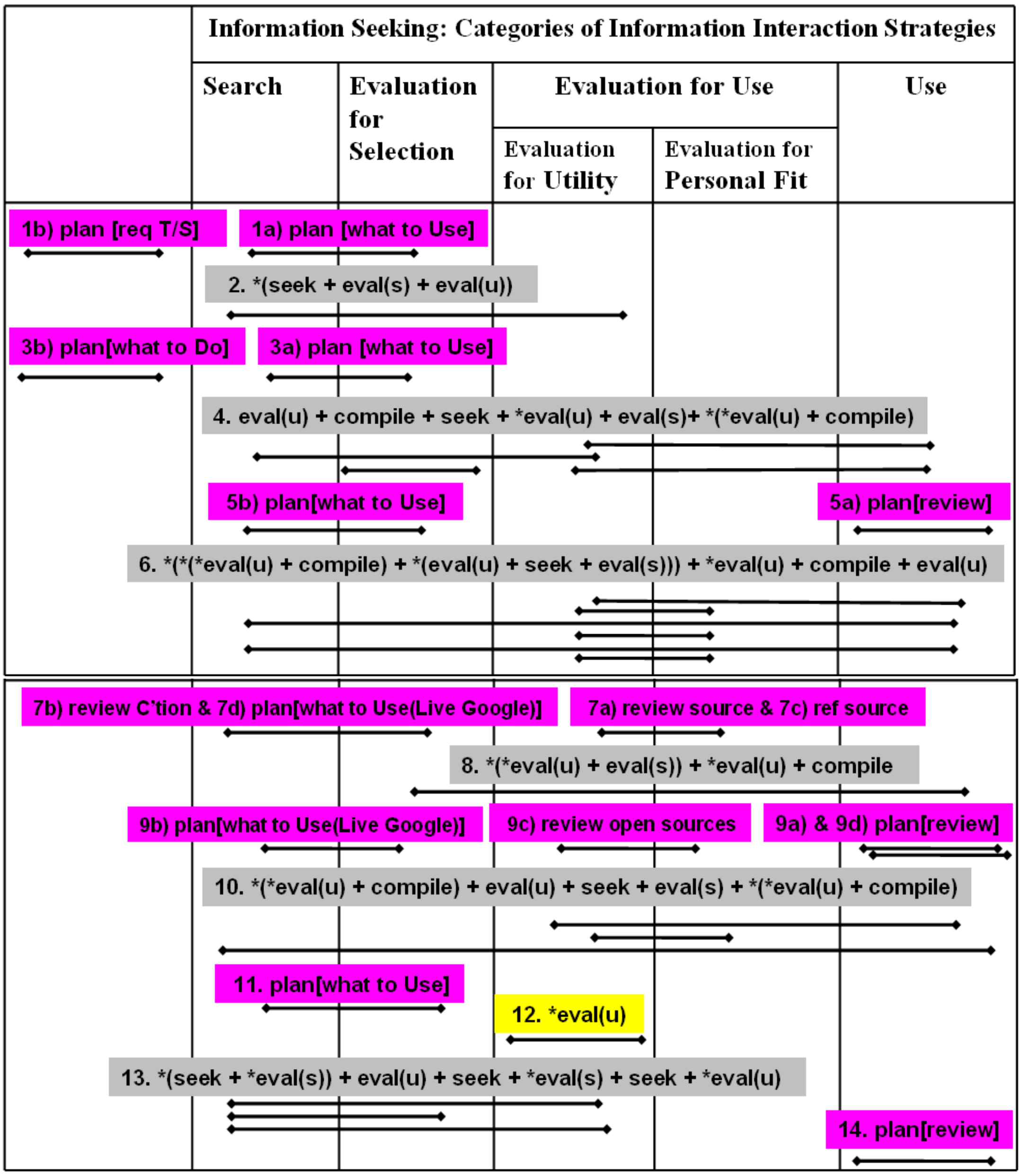
P5: sensemaking strategy mapped to framework



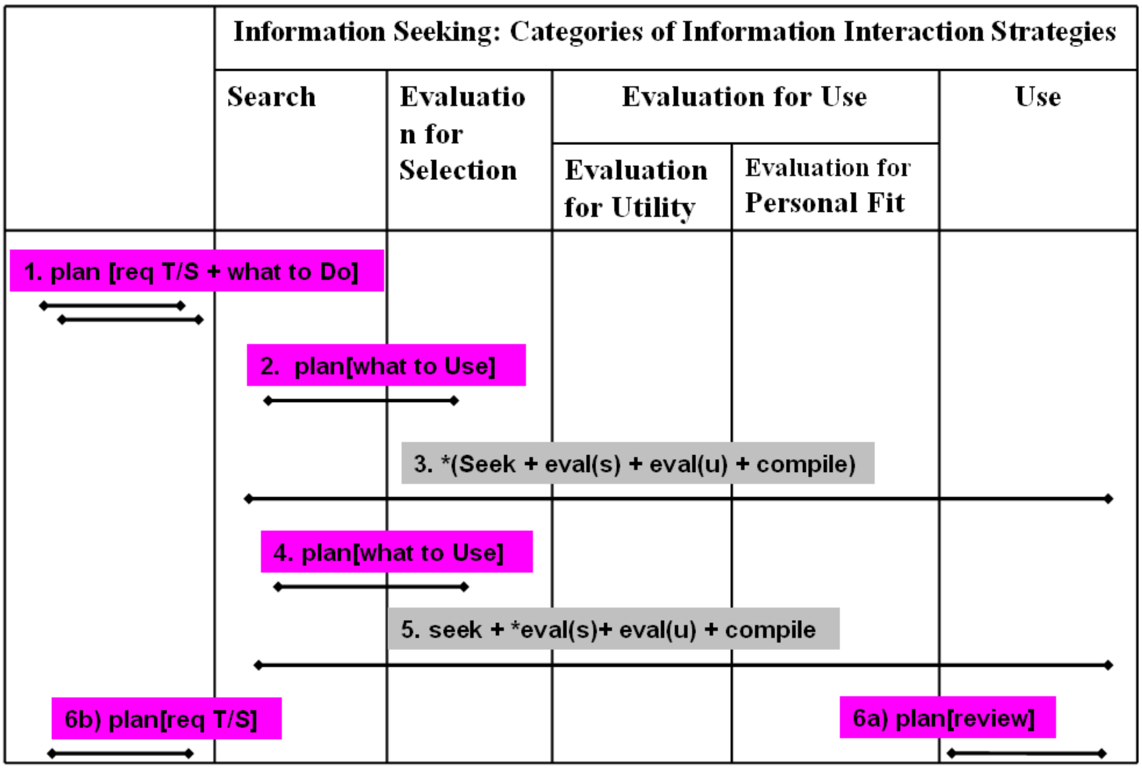
P6: sensemaking strategy mapped to framework



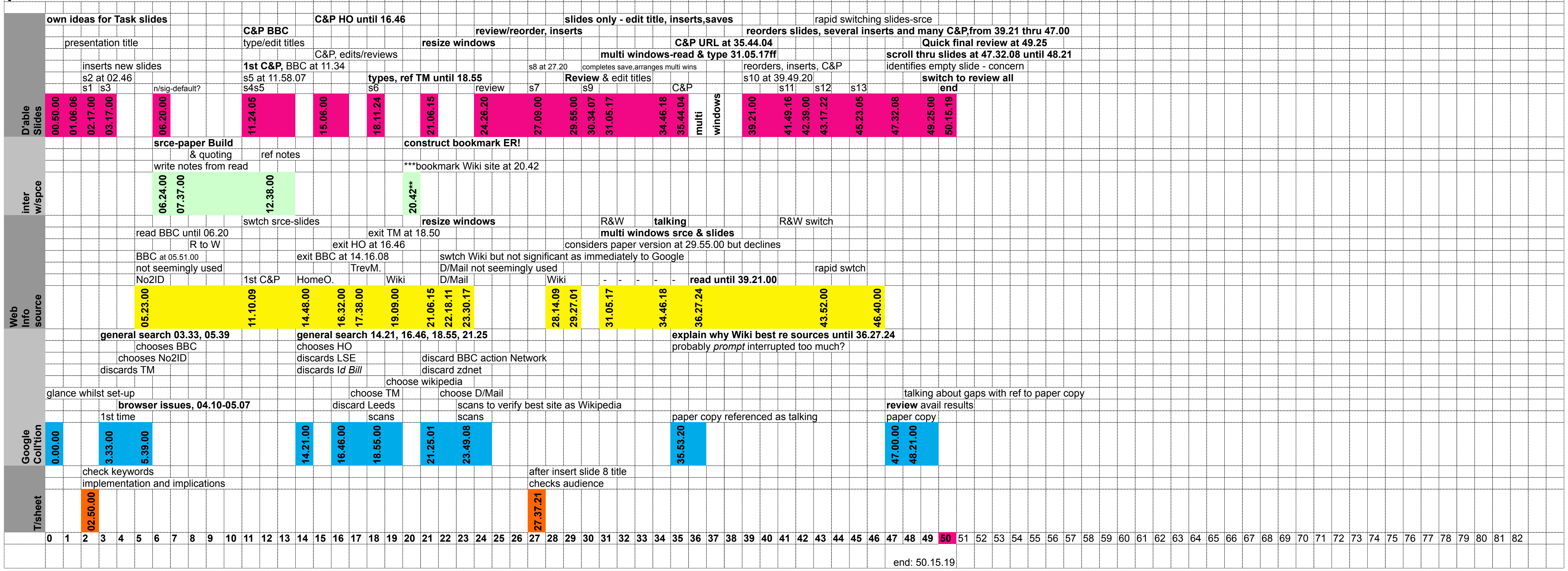
P7: sensemaking strategy mapped to framework



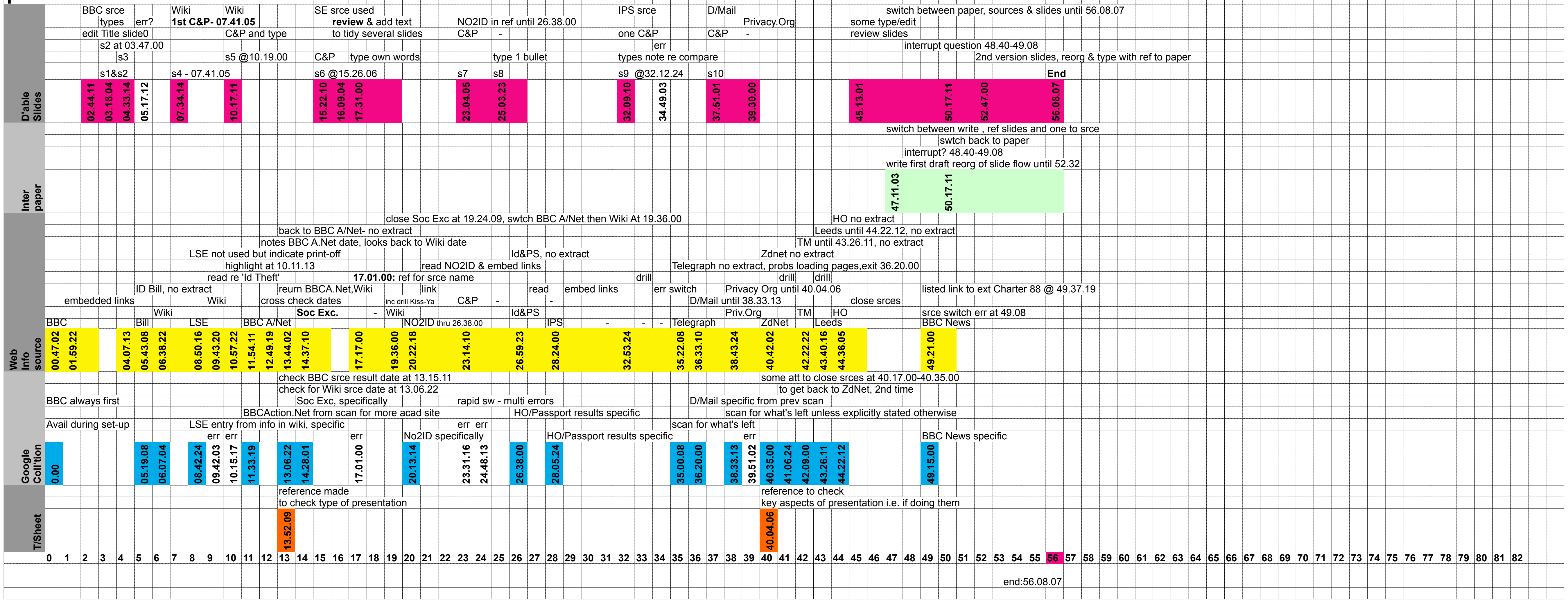
P8: sensemaking strategy mapped to framework



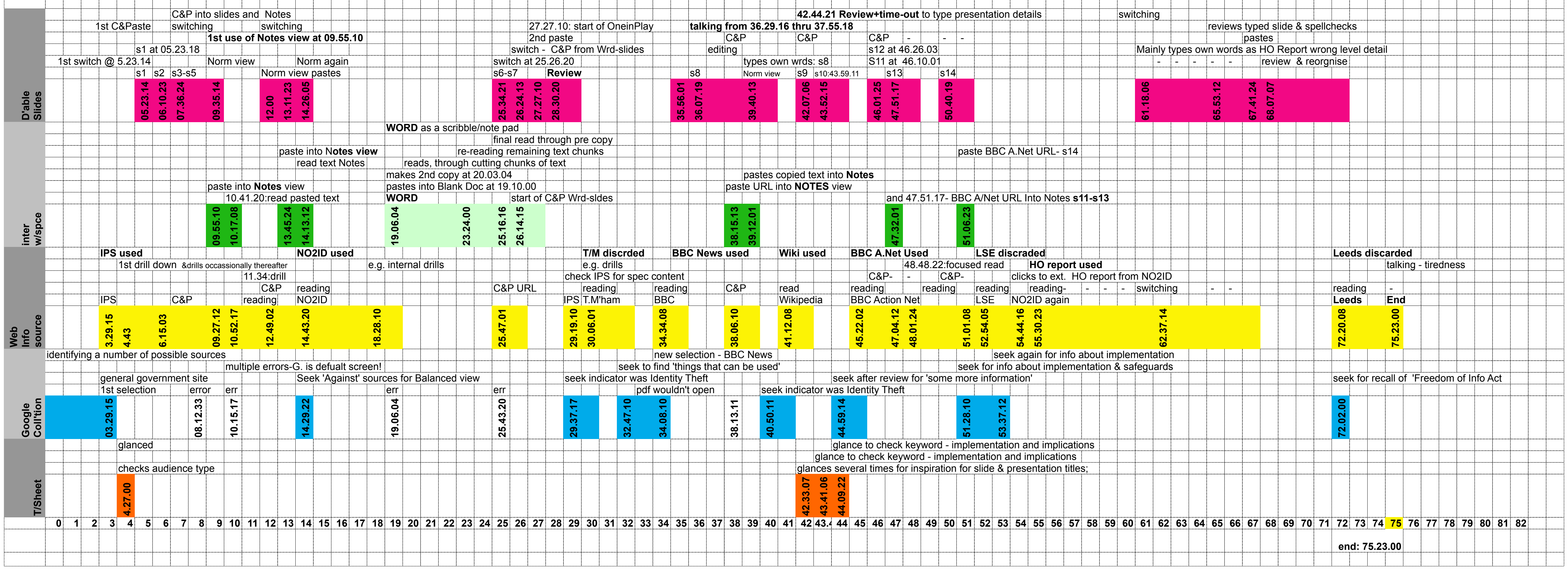
p1: Timeline 1 minute intervals

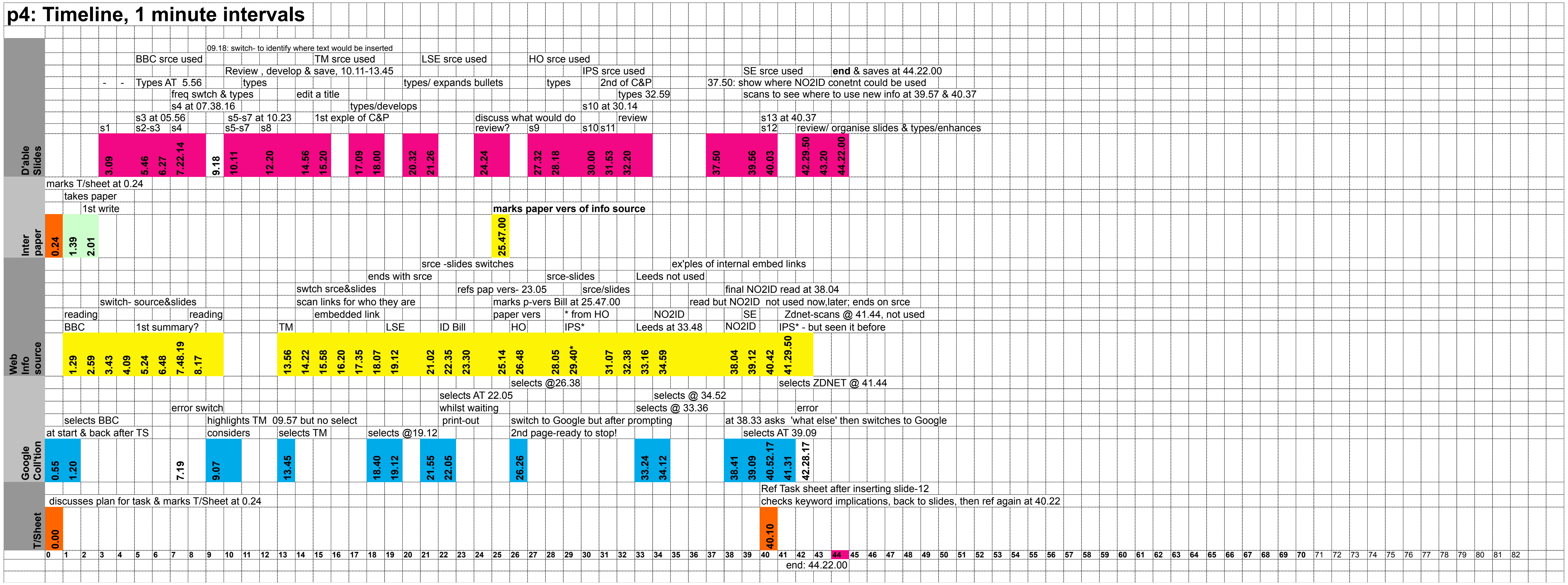


p2: Timeline 1 minute intervals

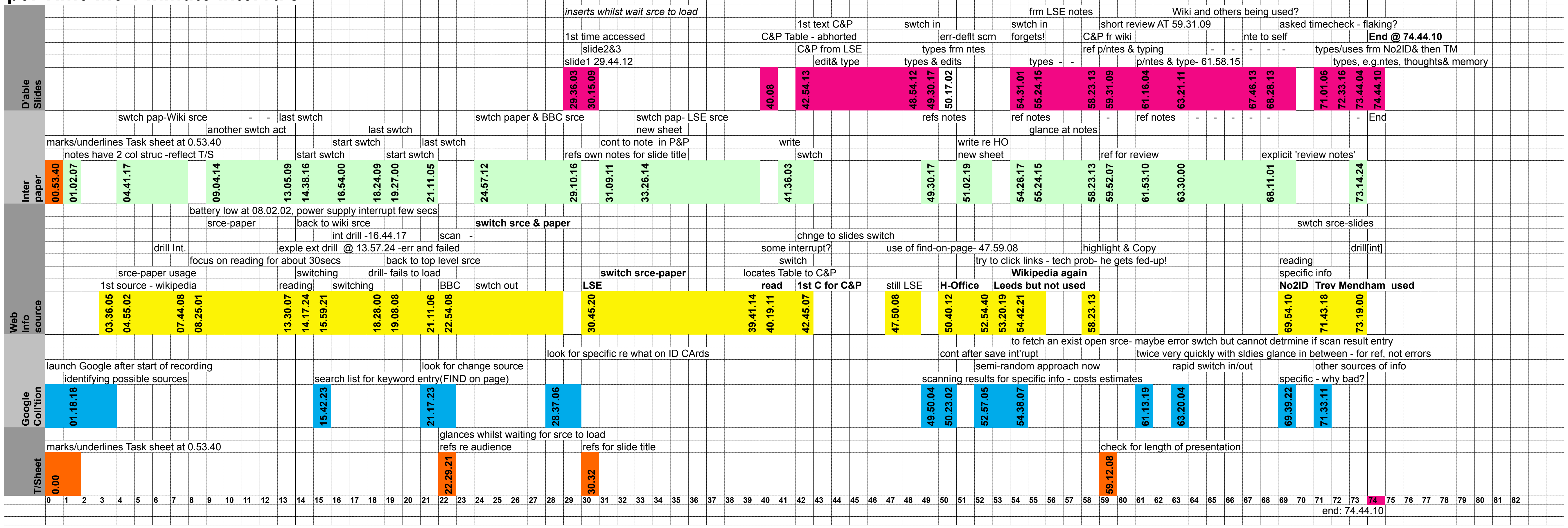


p3: Timeline 1 minute intervals




p4: Timeline, 1 minute intervals
09.18: switch- to identify where text would be inserted
BBC srce used
TM srce used
LSE srce used
HO srce used
Review , develop & save, 10.11-13.45
IPS srce used
SE srce used
end & saves at 44.22.00
- - Types AT 5.56
types
types/ expands bullets
types
2nd of C&P
37.50: show where NO2ID conetnt could be used
freq swtch & types
edit a title
types 32.59
scans to see where to use new info at 39.57 & 40.37
s4 at 07.38.16
types/develops
s10 at 30.14
s3 at 05.56
s5-s7 at 10.23
1st exple of C&P
discuss what would do
review
s13 at 40.37
s1
s2-s3
s4
s5-s7
s8
review?
s9
s10
s11
s12
review/ organise slides & types/enhances
D'able Slides
3.09
5.46
6.27
7.22.14
9.18
10.11
12.20
14.56
15.20
17.09
18.00
20.32
21.26
24.24
27.32
28.18
30.00
31.53
32.20
37.50
39.56
40.03
42.29.50
43.20
44.22.00
marks T/sheet at 0.24
takes paper
1st write
marks paper vers of info source
Inter paper
0.24
1.39
2.01
25.47.00
srce -slides switches
ex'ples of internal embed links
ends with srce
srce-slides
Leeds not used
swtch srce&slides
refs pap vers- 23.05
srce/slides
final NO2ID read at 38.04
switch- source&slides
scan links for who they are
marks p-vers Bill at 25.47.00
read but NO2ID not used now,later; ends on srce
reading
reading
embedded link
paper vers
* from HO
NO2ID
SE
Zdnet-scans @ 41.44, not used
BBC
1st summary?
TM
LSE
ID Bill
HO
IPS*
Leeds at 33.48
NO2ID
IPS* - but seen it before
Web Info source
1.29
2.59
3.43
4.09
5.24
6.48
7.48.19
8.17
13.56
14.22
15.58
16.20
17.35
18.07
19.12
21.02
22.35
23.30
25.14
26.48
28.05
29.40*
31.07
32.38
33.16
34.59
38.04
39.12
40.42
41.29.50
selects @26.38
selects ZDNET @ 41.44
selects AT 22.05
selects @ 34.52
error switch
whilst waiting
selects @ 33.36
error
selects BBC
highlights TM 09.57 but no select
print-out
switch to Google but after prompting
at 38.33 asks 'what else' then switches to Google
at start & back after TS
considers
selects TM
selects @19.12
2nd page-ready to stop!
selects AT 39.09
Google Coll'tion
0.55
1.20
7.19
9.07
13.45
18.40
19.12
21.55
22.05
26.26
33.24
34.12
38.41
39.09
40.52.17
41.31
42.28.17
Ref Task sheet after inserting slide-12
discusses plan for task & marks T/Sheet at 0.24
checks keyword implications, back to slides, then ref again at 40.22
T/Sheet
0.00
40.10
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82
end: 44.22.00

p5: Timeline 1 minute intervals



p6: Timeline 1 minute intervals

D'able Slides

begin to add detail | interrupt to save
review, outline | interrupt at 72.44.21 swtch off mic by accident
inserts s4&s5 then deletes slides | types from notes
1st Time | types titles | **1st paste**- no editing of paste
s1 | s2&s3 | s4&5&6&7 | s8 | drawing | s9 | **END**

54.48.17 | 55.22.15 | 57.19.06 | 58.08.08 | 59.11.01 | 60.09.13 | 63.17.13 | 65.55.22 | 68.44.23 | 70.51.21 | 72.44.01 | 73.53.20 | **75.33.09**

Inter paper

sound lost: interrupt at 04.52.10 | interrupt again at 15.20.24 | last note at 31.17.00
notes from BBC | makes note to self - 'check with BBC' at 31.00.00 | cannot determine if glancing at paper notes
notes from Wiki | notes from Guardian | thinking | begins to add detail paper-slides | int'rupt at 72.44.21 he swtch off mic!
write notes frm ZdNet | stops | draw own IDCard until 19.07.09 | notes from Wiki | reads/refs notes onwards | restart 73.15.13

04.25.11 | 07.44.01 | 10.31.04 | 14.14.16 | 15.10.00 | 17.27.03 | 18.11.23 | 19.26.15 | 26.44.00 | 31.17.00 | 33.35.13 | 55.27.00 | no refs - thinks | 59.39.22 | 60.09.13 | 71.08.22 | 72.44.21 | 73.15.13

Web Info source

T/graph & D/Mail seemingly not used | ref list in Wiki for srces re Pro & Cons
scroll to end for refs | tech prob witth Firefox @ 34.59.04 | link from Wiki to **pdf** doc **not loading[52.12.10]**; no longer there
restart-zdnet | **start again at 16.28.14** | **drills** -> **gov site re NIR** at 44.24.03
04.52.10 lost sound!!!! | **lost sound again 15.20.24** | ***Wiki NIR*** *content via IE* | err?or rapid swtching from 45.37.18ff to nav back to NO2ID at 46.00 | complex navigate example at 69.29.05 i.e.
Zdnet | swtch paper/source | **IPS FAQ** at 40.05.19 | 54.53.17 switch back to check a heading? | browse thru Wiki,D /Mail, use F/fox & IE, before get to srce
daily mail | **error**-D/Mail tabbed at 09.44.11? | swith pape/source | Guardian via Wiki | drills down | **IPS** via HO at 38.47.08 | rapid swtches | review, summing-up,srce- slide outline | **1st C&P of detail** deliberately not held in notes
telegraph | zdnet | Wiki | BBC *via Wiki* | Wiki (RefList) | **Wiki** | NIR(wiki) | **H/O** | NIR(Wi | NO2ID | Wiki | Wiki | IPS-FAQ

02.52.17 | 03.14.04 | 04.11.01 | 06.40.23 | 10.10.04 | 11.07.09 | 13.37.18 | 15.20.24 | 16.28.14 | 19.07.09 | 23.16.11 | 25.00.22 | 31.17.00 | 32.22.16 | 33.42.02 | 34.59.04 | 35.47.02 | 38.17.13 | 40.05.19 | 42.28.08 | 44.01.19 | 46.00.00 | 49.00.00 | pdf | 53.16.11 | 54.00.00 | 69.48.08 | 70.22.01

Google Coll'tion

on screen at start | IE to reaccess Wiki | google one of interfaces tabbed whilst going back to desired wiki NIR page
work through,identify several poss sources | c&p HO link | look for a most recent article- but specific detail?
& again at 03.53.14 | ctrl&click fails | specific seek; pastes a url but then uses a tab source | e.g.rapid switch- nav from srce to slides- err?
general seek | seek NIR specific | google, one of interfaces tabbed, poss ERR, whilst going back to the desired FAQ No2ID page

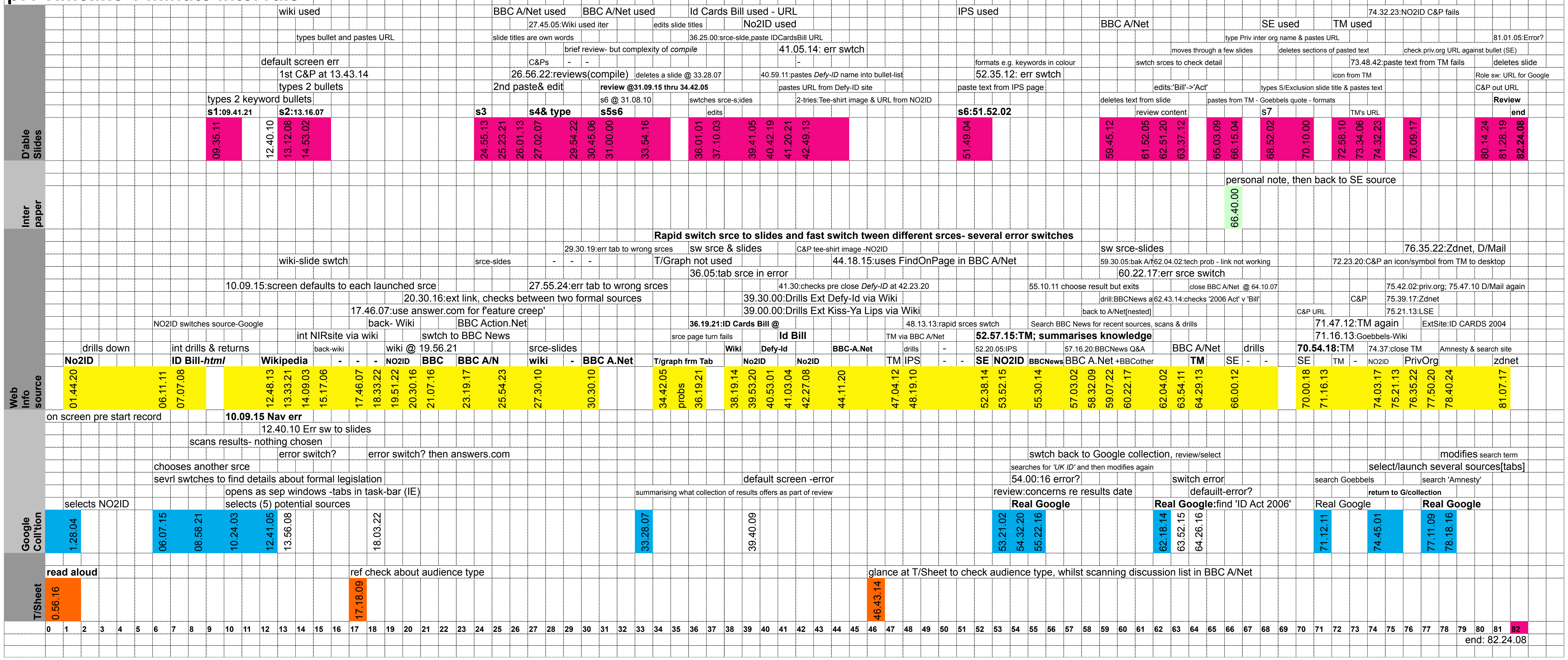
03.07.24 | 09.46.11 | 35.22.17 | 37.43.01 | 42.09.10 | 43.28.13 | 45.37.18 | 48.14.21 | 70.43.01

T/Sheet

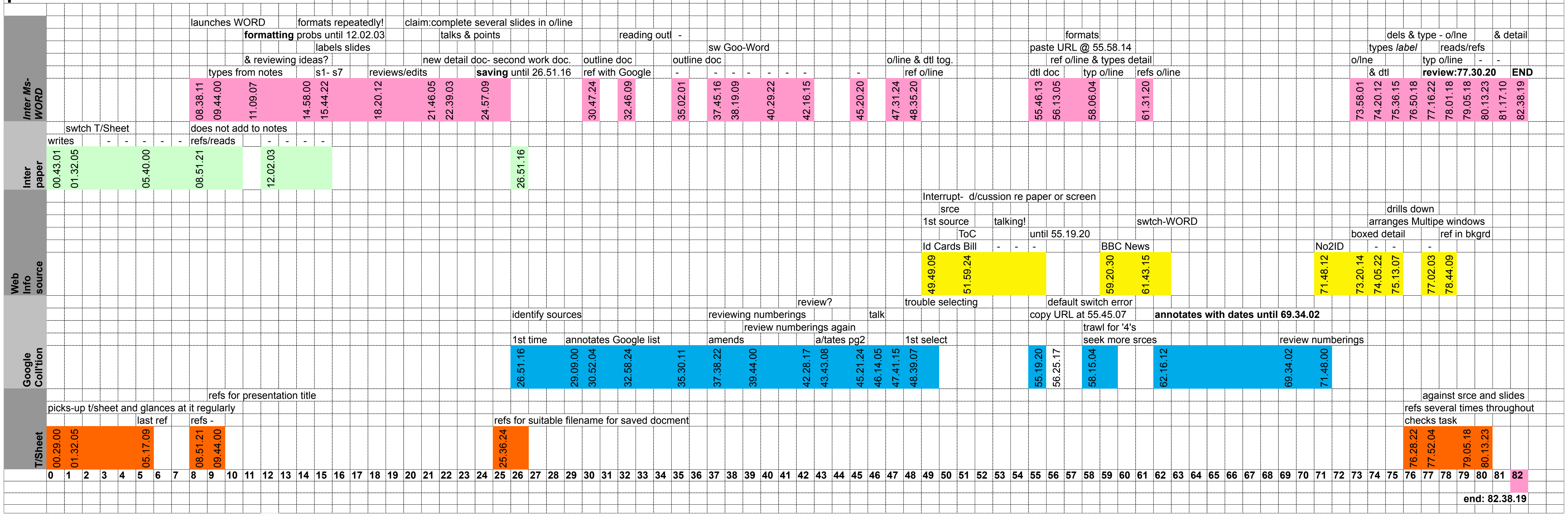
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82

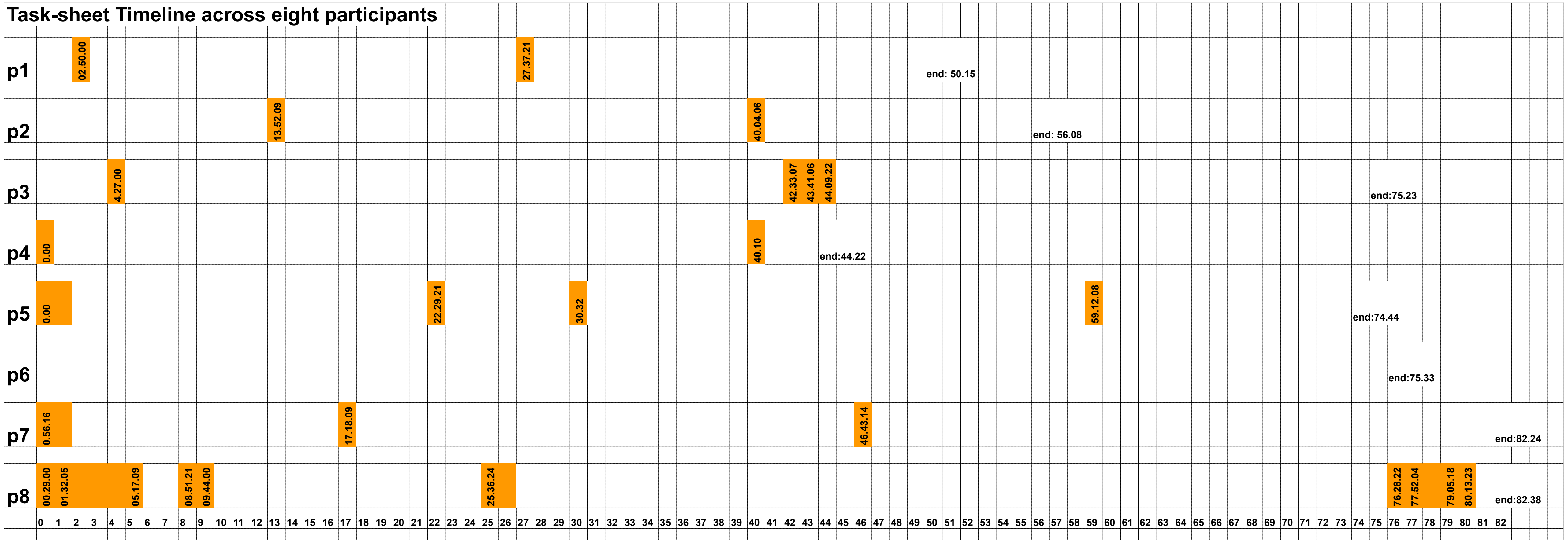
end: 75.33.09

p7: Timeline 1 minute intervals

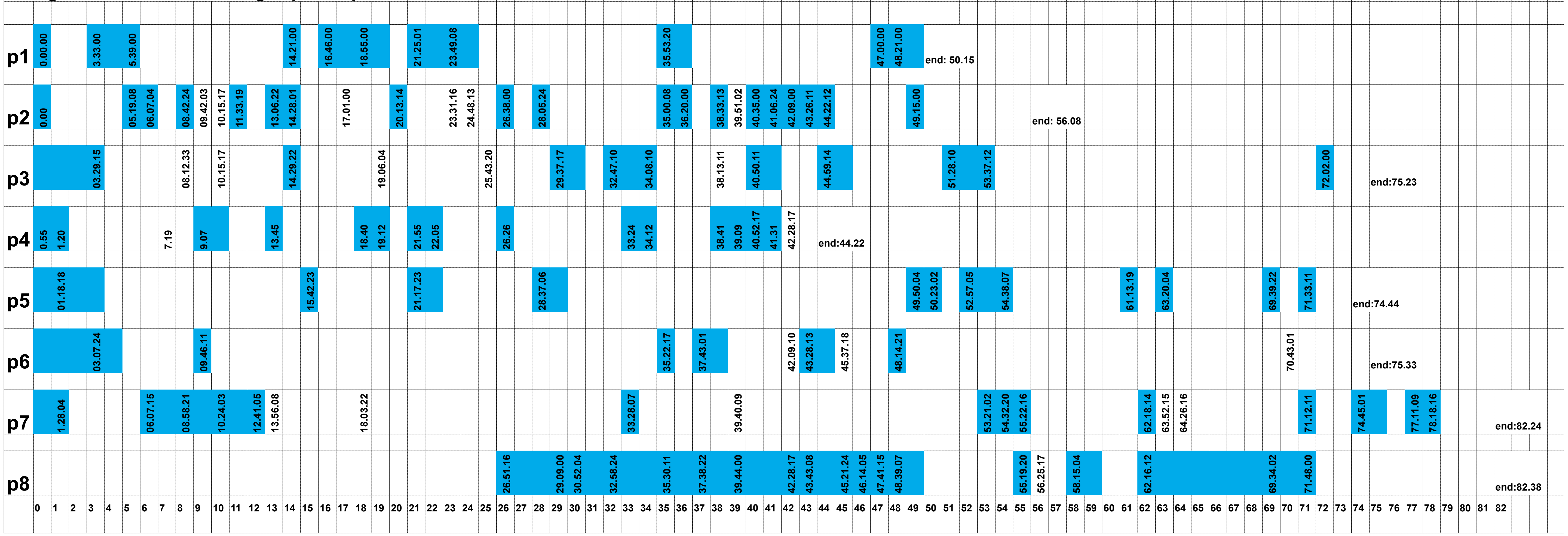


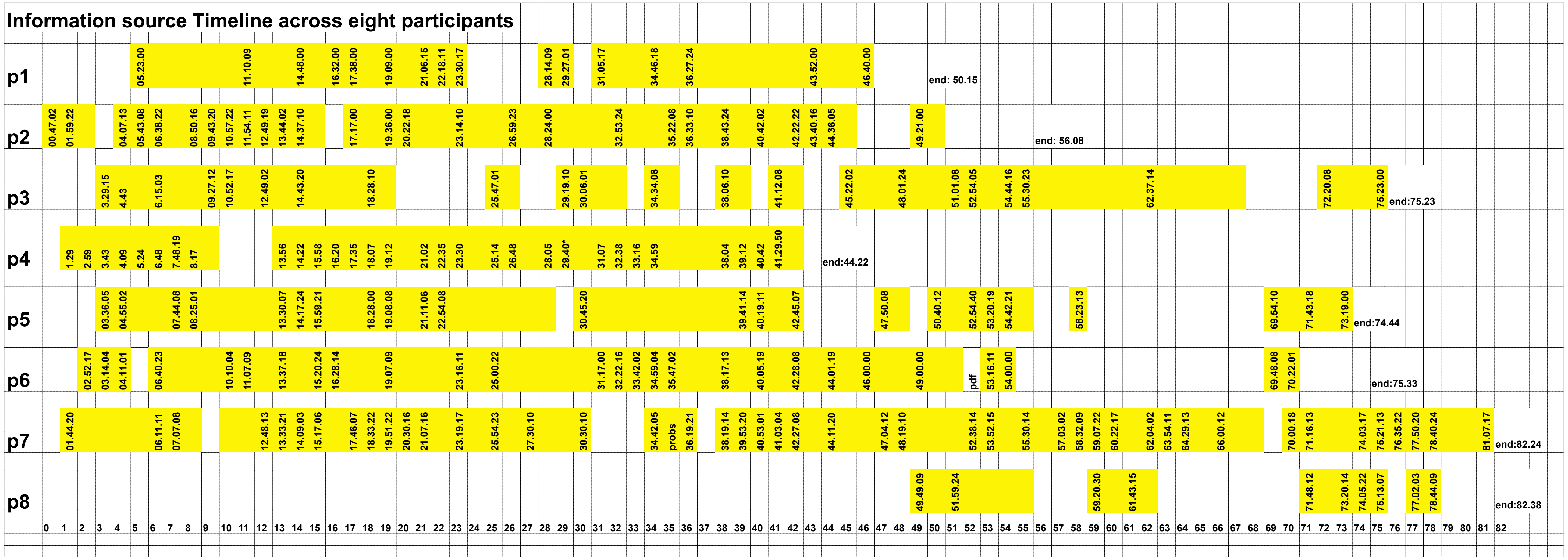
p8: Timeline 1 minute intervals



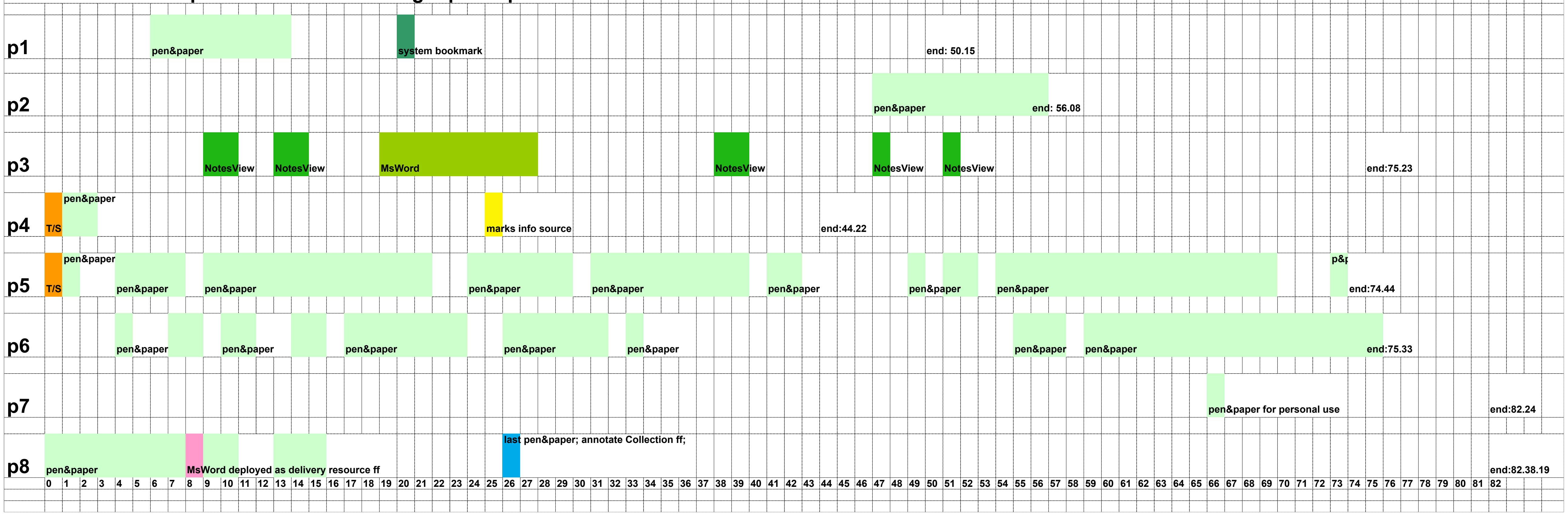

Task-sheet Timeline across eight participants
p1
02.50.00
27.37.21
end: 50.15
p2
13.52.09
40.04.06
end: 56.08
p3
4.27.00
42.33.07
43.41.06
44.09.22
end:75.23
p4
0.00
40.10
end:44.22
p5
0.00
22.29.21
30.32
59.12.08
end:74.44
p6
end:75.33
p7
0.56.16
17.18.09
46.43.14
end:82.24
p8
00.29.00
01.32.05
05.17.09
08.51.21
09.44.00
25.36.24
76.28.22
77.52.04
79.05.18
80.13.23
end:82.38
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82

Google Timeline across eight participants




Information source Timeline across eight participants
p1
05.23.00 11.10.09 14.48.00 16.32.00 17.38.00 19.09.00 21.06.15 22.18.11 23.30.17 28.14.09 29.27.01 31.05.17 34.46.18 36.27.24 43.52.00 46.40.00
end: 50.15
p2
00.47.02 01.59.22 04.07.13 05.43.08 06.38.22 08.50.16 09.43.20 10.57.22 11.54.11 12.49.19 13.44.02 14.37.10 17.17.00 19.36.00 20.22.18 23.14.10 26.59.23 28.24.00 32.53.24 35.22.08 36.33.10 38.43.24 40.42.02 42.22.22 43.40.16 44.36.05 49.21.00
end: 56.08
p3
3.29.15 4.43 6.15.03 09.27.12 10.52.17 12.49.02 14.43.20 18.28.10 25.47.01 29.19.10 30.06.01 34.34.08 38.06.10 41.12.08 45.22.02 48.01.24 51.01.08 52.54.05 54.44.16 55.30.23 62.37.14 72.20.08 75.23.00
end:75.23
p4
1.29 2.59 3.43 4.09 5.24 6.48 7.48.19 8.17 13.56 14.22 15.58 16.20 17.35 18.07 19.12 21.02 22.35 23.30 25.14 26.48 28.05 29.40* 31.07 32.38 33.16 34.59 38.04 39.12 40.42 41.29.50
end:44.22
p5
03.36.05 04.55.02 07.44.08 08.25.01 13.30.07 14.17.24 15.59.21 18.28.00 19.08.08 21.11.06 22.54.08 30.45.20 39.41.14 40.19.11 42.45.07 47.50.08 50.40.12 52.54.40 53.20.19 54.42.21 58.23.13 69.54.10 71.43.18 73.19.00
end:74.44
p6
02.52.17 03.14.04 04.11.01 06.40.23 10.10.04 11.07.09 13.37.18 15.20.24 16.28.14 19.07.09 23.16.11 25.00.22 31.17.00 32.22.16 33.42.02 34.59.04 35.47.02 38.17.13 40.05.19 42.28.08 44.01.19 46.00.00 49.00.00 pdf 53.16.11 54.00.00 69.48.08 70.22.01
end:75.33
p7
01.44.20 06.11.11 07.07.08 12.48.13 13.33.21 14.09.03 15.17.06 17.46.07 18.33.22 19.51.22 20.30.16 21.07.16 23.19.17 25.54.23 27.30.10 30.30.10 34.42.05 probs 36.19.21 38.19.14 39.53.20 40.53.01 41.03.04 42.27.08 44.11.20 47.04.12 48.19.10 52.38.14 53.52.15 55.30.14 57.03.02 58.32.09 59.07.22 60.22.17 62.04.02 63.54.11 64.29.13 66.00.12 70.00.18 71.16.13 74.03.17 75.21.13 76.35.22 77.50.20 78.40.24 81.07.17
end:82.24
p8
49.49.09 51.59.24 59.20.30 61.43.15 71.48.12 73.20.14 74.05.22 75.13.07 77.02.03 78.44.09
end:82.38
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82

Intermediate Workspace Timeline across eight participants



Slides Timeline across eight participants