Information Assimilation In The Digital Age: Developing Support For Web-Based Notetaking Tasks

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INFORMATION ASSIMILATION IN THE DIGITAL AGE: DEVELOPING SUPPORT FOR WEB-BASED NOTETAKING TASKS

by

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A DISSERTATION

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As users turn to the World Wide Web to accomplish an increasing variety of daily tasks, many engage in Information Assimilation (IA), a process I define as the gathering, editing, annotating, organizing, and saving of Web information, and the tracking of ongoing Web work processes. Usability must be a major priority in the development of interactive systems to support IA. The term IA emerges from a number of background studies presented in this dissertation, including a review of the most important literature on notetaking and an ethnographic field study of how a group of biologists routinely engages in the process of notetaking. Despite evidence suggesting that Information Assimilation is critical to many Web users, a review of existing software applications indicates that it is currently not well supported. This leads to important new research questions: Why hasn't adequate IA software been developed yet? and Are software solutions possible? To explore

answers to these questions, I created a Web-based electronic notebook called NetNotes based on functional requirements derived from the initial background studies. Implementation of the NetNotes prototype highlights technical and user-centered design challenges associated with developing software for the Web, and also demonstrates that limited solutions to the problem of supporting IA do exist. Furthermore, NetNotes proves robust enough for use in an experiment to determine the extent to which it is an improvement over existing applications. In the final phase of this research, a between-subjects experimental evaluation of 20 scientific notetakers was conducted to ascertain how participants complete a set of IA tasks using the NetNotes prototype versus using their normal software applications. The experiment revealed that NetNotes users were significantly more productive completing certain tasks than participants who used their normal software (i.e., the control group), and that NetNotes users felt as though they had to expend significantly less effort than the control group to complete certain tasks. Nevertheless, no significant differences were discovered between the NetNotes group and the control group in terms of user satisfaction; additionally, for other sets of tasks, the differences in productivity and cognitive effort also were not significant.

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DEDICATION

To Eric, the secret of my success

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CHAPTER I

INTRODUCTION

More and more people are turning to the World Wide Web on a daily basis to accomplish a wide variety of tasks, including research, shopping, and banking. Unfortunately, despite the explosive growth, popularity, and accessibility of the Web, users do not have the proper software support to help them accomplish many of their tasks effectively and efficiently. In particular, Web users cannot readily engage in the process of *Information Assimilation (IA)*, which I define at a high-level as the ability to gather, edit, annotate, organize, and save information from multiple, disparate Web pages. Additionally, since Web users' tasks are often protracted and extend beyond one continuous browsing session, Information Assimilation also includes the ability of users to track their ongoing Web work processes so that they can easily recall and rejoin previous work at a later time. All too often, Web users are forced to depend on ad hoc and inconsistent methods to complete their critical IA tasks.

The process of IA just defined, although Web-based, is quite similar to the traditional process of notetaking with which many of us are already familiar. We know from years of experience that notetaking and its traditional implements—pen and paper—are integral to many of our daily tasks. For example, among other reasons, we take notes to help us remember things, to document events, and to organize our thoughts.

However, because we now rely on the Web to help us with many of our day-to-day tasks, we must re-examine the traditional paper-based notetaking paradigm, which suddenly becomes cumbersome and inefficient in the electronic environment. It is time to step back, look closely at our evolving Web activities, and work towards developing appropriate software tools to support these activities. I envision that a Web-based electronic notebook (e-notebook) designed specifically to support the process of IA would not only help users with their online notetaking tasks, but would also represent a significant improvement over existing applications.

Research Objectives

In this dissertation, I explore the area of Web-based notetaking and validate my conviction that many critical IA tasks are currently not well supported by existing software. I recognize that, in part, the lack of adequate software tools can be attributed to difficulties associated with implementing general Web-based software. However, I also believe that limited solutions to this problem do exist and are feasible to implement, which I demonstrate by developing a Web-based e-notebook prototype. Lastly, I conduct an experiment to show that software designed specifically to support IA (i.e., my e-notebook prototype) is an improvement over existing applications.

To achieve these goals, I examine each of the following research questions in turn:

1. What are Web users' critical notetaking—or IA—tasks?
2. Are these tasks well supported by existing software tools?

3. Why hasn't adequate software been developed yet?

4. Are software solutions even possible?

5. To what extent are these solutions an improvement over existing applications?

Dissertation Structure

The structure of both my dissertation work and of this document closely follows the research questions enumerated in the previous section. These research questions are therefore used to present an outline and summary of my dissertation work throughout the remainder of this section.

What are Web Users' Critical Notetaking (IA) Tasks?

The answer to this question revolves around my definition of the term Information Assimilation (IA). People engage in the Web-based process of IA for many of the same reasons that they take traditional notes: to remember specific information, to organize information in meaningful ways, to analyze information, to clarify thoughts, to distill large amounts of information down to essential elements, etc. To accomplish these higher-level goals, users may perform the following tasks that define IA:

- Gather information by copying and pasting elements—including plain and formatted text, images, lists, tables, and hyperlinks—from a Web page into an e-notebook while retaining original formatting and functionality (i.e., hyperlinks remain "live"),

- Edit original Web elements as stored in an e-notebook,
- Annotate e-notebook contents,
- Organize e-notebook contents in personally meaningful ways,
- Save e-notebook contents, and
- Track and store ongoing Web work processes so that they can be easily recalled and rejoined at a later time.

My identification and definition of the process of IA was primarily informed by two major research efforts that are described in Chapter II: an extensive literature review on the theory of notetaking, and an ethnographic field study of how a group of biologists routinely engage in the process of notetaking. During the literature review, I studied some of the most significant research on notetaking (John-Steiner, 1997; Mandler, 1979; Monty, 1990; Parunak, 1989) and learned why people take notes, what the components of notes are, what notes reflect, and what constitutes "good" notes. Although recording notes in the physical world (i.e., with pen and paper) and in the virtual world (i.e., electronically on a computer) are significantly different processes that incorporate very different resources and mediums, they are both linked by similarities in user intent. For this reason, plus the fact that little has been written about Web-based electronic notetaking, it seemed reasonable to launch my research on electronic notetaking and to develop a preliminary definition of IA and its functional requirements based on what is already known about traditional notetaking.

The focus of my ethnographic field study, which involved meeting over the course of a couple of weeks with four geneticists from the biology research lab at the University of Oregon, was to observe the role of notetaking in scientists' normal, everyday work lives. Scientists were chosen as the focus of my ethnography because they represent one group for whom notetaking is particularly important, and because one of the long-term goals of this research was to develop e-notebook support for a scientific Web site and relational database that these particular scientists routinely use. During the ethnography, I met with each scientist individually at his or her normal workspace and together we discussed the origination and composition of their notes, the rationale for their organization, and the typical reference and retrieval methods used. The results of this study, which are also detailed in an earlier paper entitled "CAJIN, An Electronic Laboratory Notebook" (Reimer, 1998), not only contributed significantly to my definition of IA, but also led directly to the identification of lower-level, practical functional requirements for Web-based e-notebooks. Again, details of this ethnography are presented in Chapter II.

Are these Tasks Well Supported by Existing Software Tools?

To gather insight into this research question, I performed a heuristic evaluation of a number of other Web-based software applications, including the two most widely used Web browsers (Netscape and Internet Explorer). The goal of this software review, which is described in Chapter III, was to determine how well applications currently support the process of IA. I discovered that although there has been a proliferation of Web-based applications over the last decade, surprisingly few applications exist that can be truly classified as Web-based notebooks. While some tools provide functionality for individual IA tasks, no systems fully support the process of IA in a complete and integrated way. Common Web browsers not only also fail to support IA, but they contain a number of extant usability problems as well. The impact of some of these problems, specifically as they relate to IA, helps to prioritize the most important functional requirements for an e-notebook. Details of these Web browser usability problems can be found in a separate paper entitled "Web Browsers: Shortcomings and Solutions" (Reimer, 1999).

Why hasn't Adequate Software Been Developed Yet?

Implementing Web-based e-notebooks that both support IA and that are tuned to usability is particularly challenging from a programming and systems standpoint, a conclusion I base on my heuristic software evaluation and after implementing my own Web-based e-notebook prototype system. At the end of Chapter III, reasons why developing software for the Web—particularly e-notebooks—is so difficult are identified and discussed. Major challenges include dealing with a wide variety of Web page components, with a complex array of underlying Web technologies, with new security concerns, and with a diverse and distributed user population.

Are Software Solutions Even Possible?

The challenges associated with developing Web-based e-notebooks as just mentioned are certainly daunting. Indeed, at this point it is highly unlikely that general solutions to many of these problems can be found and that a truly visionary e-notebook that completely supports IA for all Web sites can be implemented. However, limited solutions to this problem do exist, as I demonstrate by developing a Web-based e-notebook prototype system called NetNotes.

Prior to creating NetNotes, I developed another Web-based e-notebook called CAJIN (Computer Assisted Journal and Integrated Notebook). The design and implementation of CAJIN highlighted a number of technical and system design issues associated with developing software for the Web, and a follow-up usability study uncovered some additional user interface problems as well. Most importantly, CAJIN was instrumental in providing a solid foundation upon which to build NetNotes, the prototype of focus in this dissertation research. For example, although NetNotes is implemented separately from CAJIN, has an entirely new user interface, and contains new IA related functions, a number of the problems discovered while developing and studying CAJIN have subsequently been accounted for in the NetNotes prototype. Details of the CAJIN prototype are provided in "CAJIN, An Electronic Laboratory Notebook" (Reimer, 1998), and are largely omitted from this document.

The NetNotes prototype, which again is the focus of this dissertation research (as opposed to CAJIN), is described in detail in Chapter IV. NetNotes is programmed in Java (the Java Swing classes are used to represent the graphical user interface or GUI), and it works in conjunction with the Zebrafish Information Network (ZFIN)—a scientific Web site and relational database housing genetics information specific to the zebrafish species. At the price of a few minor server-side modifications, NetNotes incorporates many of the most critical IA functions for the ZFIN Web domain. Users can copy and paste text (plain and formatted), images, lists, tables, and hyperlinks from ZFIN into NetNotes; they can edit original Web elements in their notebooks; they can annotate, organize, and save their notes (including archiving Web pages); and they can keep track of their ongoing Web work processes. The development of NetNotes was successful on many fronts: it shows that limited solutions to providing Web-based IA support are feasible; it highlights some of the technical challenges generally associated with developing Web-based software; and it is robust enough to be used in an experimental study designed to examine how such software might improve Web usability.

To What Extent are these Solutions an Improvement Over Existing Applications?

Once NetNotes was successfully implemented, it was featured in an experimental study to determine how such a piece of software (i.e., one that supports IA) might be an improvement over existing applications. This between-subjects experiment, which is described in its entirety in Chapter V, studies 20 biologists from the University of Oregon divided randomly into two even groups. The first group of 10 biologists, representing the experimental group, was asked to complete a set of ZFIN-related IA tasks using the

NetNotes prototype. The second group of 10 biologists, representing the control group, was asked to complete the same set of IA tasks using their normal software. Members of the experimental group participated in the experiment in a controlled laboratory setting while control group participants completed the experiment at their normal Web workspace.

The experiment spanned two separate study sessions held approximately 2-4 weeks apart. The goal of the first session was to observe how participants were able to generate a set of Web-based electronic notes, while the second session focused on how participants used these notes to answer a set of related test questions. Prior to the experiment, I hypothesized that NetNotes users would be able to complete the given tasks more productively, with less cognitive effort, and with a higher degree of user satisfaction than the control group. The dependent measures used to evaluate these hypotheses included task completion percentages, time to complete the tasks, effectiveness of the notes created, number of software transitions, perceived effort, and user satisfaction.

As with many complex experiments where the outcome is not strongly suspected ahead of time, this experiment produced mixed results. NetNotes users were significantly more productive completing certain tasks than the control group, and they also felt as though they had to expend significantly less effort to complete certain tasks (i.e., they were more satisfied with the amount of effort they had to expend) than the control group. On the downside, however, no significant differences were discovered between the NetNotes group and the control group in terms of user satisfaction, and for other tasks, the differences in productivity and cognitive effort also were not significant. Despite the fact that it did not produce more significant results, this experiment did provide strong indications that users need better support for their Web-based notetaking tasks and that such support can ultimately make them more productive. Furthermore, this experiment also represents an important first step towards building a foundation for future work in the area of electronic notetaking and for designing related experiments. Based on this experience, subsequent experiments can be planned to tease out some of the effects that were not as strong as perhaps they could be. In the conclusion of this dissertation, Chapter VI, some ideas for new experimental designs as well as other potential areas of future work are discussed.

Summary of Methodology

Figure 1 presents a graphical summary of the methodology used throughout this work by showing each of the five main research questions along with the activities performed (i.e., processes) to answer each question and the major products of each step. While many of the research steps did overlap temporally, and some of them even occurred in parallel at times, the sequential outline of Figure 1 illustrates the basic order of the research. It should be noted that because this research was dependent on cumulative knowledge and experience, most of the process steps incorporate the products of previous steps as input.

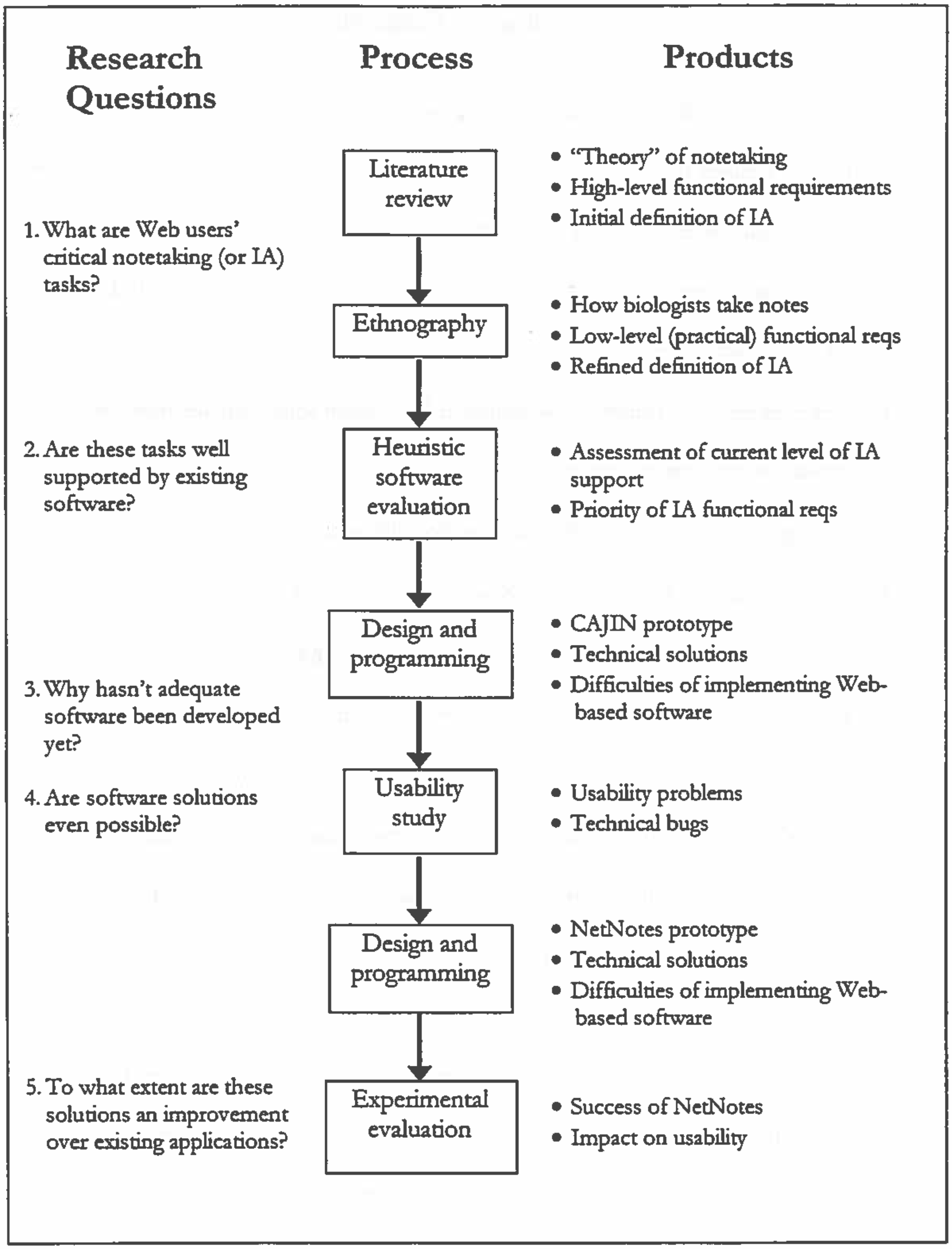

Figure 1. Summary of Research Methodology.

Research Contributions

I approach this research as a computer scientist with special interest in the field of Human-Computer Interaction (HCI). From this perspective, I am interested primarily in the design and development of useful and usable computer applications and interfaces. The unique contributions of this research to the fields of computer science, HCI, and the World Wide Web, include:

1. A definition of Information Assimilation (IA), along with evidence revealing it to be a critical process for Web users.
2. An analysis of specific e-notebook functionality necessary to enable IA.
3. A demonstration that current software does not meet users' IA needs.
4. A discussion of challenges associated with developing general Web-based applications.
5. Limited solutions to some of the implementation problems associated with developing Web-based e-notebooks.
6. A model Web-based e-notebook prototype system designed specifically to support IA.
7. The design and results of an experiment intended to show that IA software is an improvement over existing applications.

Conducting work in a field as dynamic and rapidly growing as the World Wide Web presents additional challenges for a researcher. For example, part of this dissertation work involves evaluating current Web-based software, and yet it is difficult to decide what is current given that this area of software development is particularly volatile and constantly evolving. The best a researcher can do in cases like this is to draw a line in the sand at a particular moment in time, which is what I have done. Another concern is the possibility that software developers or other research scientists will recognize the same problem I have and will find their own solutions. However, these concerns are true of any topical research project, and they not only reinforce the notion that this particular research is worth pursuing, but also that it has the potential to impact a large number of people. Furthermore, since this work is well grounded in both the theory and methodology of HCI, it is quite reasonable to expect that other researchers might eventually draw upon this work to further their own.

CHAPTER II

INFORMATION ASSIMILATION: NOTETAKING IN THE DIGITAL AGE

As we continue our rapid expansion into the digital age, and incorporate the World Wide Web into more of our day-to-day tasks than ever before, it is time to step back and consider the new ways in which we use the Web and the subsequent software support we need. For example, many of us regularly engage in the process of notetaking to help us with our daily tasks in the absense of the Web; therefore, it seems likely that we would also need to rely on some form of notetaking when we move to the online environment. However, this presumption summons new questions, including: What evidence is there to support the belief that notetaking is an important part of Web usage?, Does the process of notetaking change when we move to the Web environment?, and What kinds of tools do we need to support our Web-based notetaking? In this chapter, I set out to address these and other questions that arise in the discussion of notetaking on the Web.

One of the key concepts of this chapter—and indeed of this entire dissertation—is the phrase *Information Assimilation*, or simply IA. I define IA to refer to the process that many users engage in when they use the Web—a process that involves gathering, editing, annotating, organizing, and saving information from multiple disparate Web pages, and keeping tracking of long-term, ongoing Web work processes. As previously mentioned, the process of IA is analagous to the traditional process of notetaking except that IA is Web-based and traditional notetaking is not.

Other researchers have identified processes that are similar to IA, but with decidely different focuses. For example, Marshall and Shipmann (1997) define "Information Triage" as "the process of sorting through relevant materials"—such as those retrieved from the Web—"and organizing them to meet the needs of the task at hand" (p.124). However, whereas IA centers around the capture and subsequent editing and integration of smaller units of Web elements (e.g., a paragraph containing formatted text, hyperlinks, and images), Information Triage deals with the retrieval, manipulation, categorization, and scanning of collections of entire documents. Furthermore, Marshall and Shipmann acknowledge that the activity of Information Triage is "often time-constrained, and requires quick assessment based on insufficient knowledge" (p. 124); this contrasts sharply with IA, whose processes are often prolonged and extended over some period of time.

The first two major sections of this chapter present research that is central to my definition of IA, beginning with an empirical review of the process of traditional notetaking; before we can speculate about electronic Web-based notetaking, we must first understand what we can about traditional notetaking. Complementing this empirical review, the second major section of this chapter describes an ethnographic study that I conducted which focuses on how a real group of scientists take notes. While the empirical review reveals some general reasons why people take notes and what "good" notes are, the ethnographic study highlights the current notetaking practices of an actual user group, including specific components of notes, their organization, and how they are retrieved.

Using what we learn from the literature review and from the ethnographic study, we are then able to define a preliminary list of tasks that notetaking software should support. However, before we can finalize this list of tasks or functional requirements, we must first revisit the process of Web-based notetaking, or IA, and consider the ways in which traditional notetaking and IA differ. Once we understand these differences, we are finally able to define a low-level list of IA requirements that should be addressed by software in the form of a Web-based e-notebook. This list is presented late in the chapter, and it will be used again in Chapter III to evaluate how well existing software applications support the process of IA on the Web.

Pen and Paper: An Empirical Look at Traditional Notetaking

The empirical literature review summarized in this section is primarily informed by Melissa Monty's doctoral dissertation entitled "Issues for Supporting Notetaking and Note Using in the Computer Environment" (1990). In her research, Monty explored issues relating to notetaking and retrieval, and how these factors affect the development of electronic notebooks. Vera John-Steiner's book, "Notebooks of the Mind" (1997), which provides an account of the creative thought processes of historical figures (processes that often involved the recording of notes), also contributed heavily to this review.

During this literature review, I focused on two main questions: Why do people take notes? and What are "good" notes composed of? Although the reasons people engage in notetaking are varied, most of them can be classified as belonging to one or more of the following categories:

- to assist recall
- to think
- to organize information
- to process information
- to document events

The remainder of this section examines each of these categories in more detail, and then closes with a discussion of what "good" notes are.

Notetaking to Assist Recall

We record notes to assist both our prospective memory, or that memory which helps us to remember something that will occur in the future, and our retrospective memory, that which helps us to remember something that has occurred in the past (Baddeley & Wilkins, 1984; Meacham & Leiman, 1982). Prospective reminders include a post-it note stuck on a computer that prompts one to return a phone call, or a hastily scrawled note on the back of an envelope that reminds one to pick up dry cleaning on the way home from work. These reminder notes, or mental affordances (Norman, 1988), augment our normal cognitive processes by providing clues that would otherwise be absent. As another example, consider that situation where you must remember to take something particular with you the next time you leave the house. You might position the object next to your car keys or wallet or in some other location where it can't be missed. Strategically positioning the object in an unavoidable location creates an immediate visual clue that causes us to recall our intention to bring the object along with us. Similarly, we often use such strategic positioning with notes: we place the post-it, for example, not inside a drawer or folder, but on the computer screen we might be staring at all day. In her comprehensive research involving issues of notetaking and retrieval, Monty (1990) refers to such strategic positioning of reminder notes as "forced retrieval" (p. 38), which she claims necessary for the easy access of notes and for effective working environments.

Notes that serve retrospective memory may also take a variety of forms. One example of a retrospective reminder is notes which one hopes will later help in reconstructing the details of a particular event. When students take notes during a lecture, they expect that subsequent review of those notes will help remind them almost completely of the material presented. Another manifestation of taking notes to assist retrospective memory is the recording of specific, otherwise difficult to remember details. Such details might include writing down the call number of a library book prior to seeking it out, noting a person's e-mail address for the first time, or listing the ingredients and measurements for a new recipe. Without jotting these details down and using notes to serve as memory cues, it becomes increasingly difficult to recall the material accurately and completely, a problem exacerbated by the passage of time.

While the passage of time and subsequent fading of memory provide important reasons as to why we record notes that later become retrospective, another incentive is that ideas and thoughts often occur in a rather abrupt and unexpected manner. For most people, if these sudden notions are not immediately written down, they are lost forever. We might imagine the prolific author waking up in the middle of the night and scribbling down ideas that came to him or her during a moment of half-consciousness, or the poet recording words and phrases as he gathers inspiration during the appearance of a beautiful sunset. The sense of urgency that creates the need for rapid notetaking is reflected by mathematician Kline, who, when interviewed by Rosner and Abt for their book "The Creative Experience" (1970), commented:

> When one is mentally relaxed, ideas seem to come more freely as one works....As a matter of fact, these approaches and ideas are likely to occur with such rapidity and suddenness that one can't pursue each one seriously at the moment. (p. 91)

It is precisely because we are not able to immediately explore all of the ideas that come to us in such a rapid fashion that we rely on notetaking. We typically record the general gist of a notion so that later, when we have more time to consider it and mull it over, we can hopefully remember our original thoughts.

Notetaking is Thinking

Writing is thinking, we might say, a notion cleverly suggested by the musing attributed to F. B. Blanshard (1949), "How do I know what I think till I hear what I say?" (p. 76). When we think, we participate in an internal monologue with ourselves; when we write, and as we consider other voices and writings—those that either support or dissent from our own ideas—that internal monologue becomes an external dialogue: it becomes a discourse community (Gage, 1991). Oftentimes, when we write our thoughts and ideas down on paper, we are seeking clarity and, eventually, a complete, cohesive piece of work.

A writer's common frustration occurs with the realization that despite the presence of many of the critical individual kernels of thought, the components are not easily united to form a cohesive body. The process of trying to attain this cohesion magnifies any lapses of research or gaps of thought. Karl Gauss pinpoints this difficulty when he says, "I have had my results for a long time; but I do not yet know how I am to arrive at them."[1]

The interest in posthumous examination of the notes of many of history's most luminous thinkers is testament to the fact that the act of writing is a manifestation of the act of thinking. To see a person's notes is, in a sense, to see the directions, the permutations, the developments of that person's thought processes. In stressing the critical role that notebooks can play in scientific thinking, John-Steiner (1997) says that:

> ...to comprehend the development of a line of argument in science, or the interplay between theories and evidence, the student of creativity needs to rely both upon published papers and private documents. Often the latter yield information about the thought activity itself. (pp. 214-215)

Finally, since notes often materialize as a result of thought, they can be difficult to record, a problem lamented by biologist Agnes Arber (1964): "The biologist's picture of what he has observed, and his thoughts about it, can be imparted only by rows of little conventional marks on paper—a limited repertoire, the significance of which depends entirely on an agreed tradition" (p. 48). It is a difficult task, indeed, to narrow the wanderings of the human mind into a reflective and sensible piece of prose.

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[1]Quoted in Arber, A. (1964), p. 47.

Notetaking to Organize Information

The process of compiling notes as a means of organizing information is closely related to the process of thinking about that information. For example, before beginning to write a paper, an author will frequently organize the information into some sort of outline form. Such an outline is intended to help the author draw together all related information into one centralized location, a convergence that at least aims at a well-structured and cohesive final product or paper. Since one of the purposes of an outline is to facilitate consistency and logical progression in one's writing, it is critical that they are both readily accessible and highly flexible. As the author progresses through the paper, he or she can continually re-evaluate the paper's emerging outline or table of contents until a satisfactory structure for the paper is developed.

Again, at the same time that outlines or organized notes help an author to develop structure, they also bring attention to any missing information. Because the topics are to varying degrees arranged and considered in a sketchy, fragmented, and oftentimes merely suggestive manner, it quickly becomes evident what might be lacking. Thus, in addition to providing an organizational medium, notes also assist the writer because of what they fail to show.

Notetaking to Process Information

Notes also serve to process information in ways that can increase comprehension and memorability. Studies conducted on the effects of classroom notetaking on learning show that certain factors, such as the speed of the lecture (Aiken, Thomas, & Shennum, 1975), how familiar the subject matter is to the notetaker (Peper & Mayer, 1986; Shrager & Mayer, 1989), and whether or the notes are reviewed (Dyer, Riley, & Yekovich, 1979; Hartley & Davies, 1978; Shrager & Mayer, 1989; Wittrock, 1974), can impact how effective the notes are in helping the notetaker process and learn the material. For example, if a student is forced to expend an abnormally large amount of cognitive effort during the process of recording his or her notes, or if the lecture pace is too fast, then significant portions of the lecture material and related notes might be missed altogether. As a different example, consider that situation in which a student records lecture notes carefully and thoroughly; if that same student fails to review those notes in a timely fashion or not at all, then he or she probably will not process and learn the material sufficiently, regardless of how comprehensive the notes are. However, setting aside such factors, many people are able to increase their comprehension of given material simply through the process of recording notes. Sometimes, if initial notes are made hastily, a notetaker will review them promptly and record them a second time, inserting freshly remembered details, perhaps re-grouping material, and finally making the notes more complete and accurate overall.

Notetaking to Document Events

Another fundamental purpose of notes is to document events, such as an employee taking minutes at a corporate meeting or a sports journalist preserving the flow of a baseball game. As such, these notes are often used later for legal, recreational, or professional purposes. The notes taken at a corporate meeting, for example, might serve to document issues discussed during the meeting as well as who the attendees were. In a courtroom, the stenographer records all of the proceedings related to a particular case, a record that is revisited frequently for a multitude of reasons after the case is concluded. Lawyers may look to previous court records in order to help them develop tactics or strategies for litigating similar cases; judges may review a court record to ensure that the law was followed in a particular instance; a newspaper may publish parts of a court record for the interest and benefit of the general public. Scientists also rely heavily on the documentation of certain procedures or experiments, documentation that may later become crucial for patent applications or for important scientific breakthroughs. Doctors note specific medicines and procedures administered to a patient, which creates a record that can play a vital role in that patient's future well being.

"Good" Notes

Having discussed some of the reasons why people take notes, a follow-on question is, What constitutes good notes? In general, good notes are those notes that best serve their intended purpose. As such, it is critical for notetakers to consider how, when, and for what purpose the notes they are recording will later be used. In other words, the production of notes and the perception, or later consideration, of those notes are closely interlinked (Monty, 1990). For example, consider a student who records notes during a lecture with the intention of studying from those notes for a future examination. In addition to making the notes as complete and accurate as possible, which prompt review and possible revision might facilitate, the student should also be guided by important cognitive tools, or heuristics, when recording the notes. According to Monty (1990), some of these cognitive heuristics include metamemory (Flavell & Wellman, 1973), or the knowledge of how one's own memory works, the importance of the information, memorability, and review context. If considered and applied conscientiously during the production of notes, cognitive heuristics serve to improve the quality of those notes, and can improve efficiency when the time comes for using the notes.

Keeping our previous example in mind, the student who records lecture notes while simultaneously guided by cognitive heuristics might incorporate the following considerations. Will he or she be the only person reviewing the notes? If yes, then abbreviations, shorthand notation, and personal memory cues might be advantageous strategies. Will the upcoming test include only certain topics or date ranges? If yes, then the student will want to make sure the topic headings and dates are accurately recorded and highlighted. Will specific names and dates be important information for the exam? If yes, the student will want to ensure that they were recorded accurately, perhaps by double-checking spelling if necessary. Does the student generally study most efficiently from outlines? If yes, then he or she might consider preceding the notes with some blank pages for the later creation of an outline or index. We might summarize this section by recalling Monty's (1990) assertion that "a notetaker's perceptions of the stimulus, the notetaker's goal for how the notes are to be used, and the notetaker's understanding of how memory works will affect the way the information is recorded" (p. 12).

In addition to the qualities of notes elucidated through Monty's production/ perception theory just described, notes can also be judged by how easily they can be reviewed, browsed, and searched (Kanare, 1985; Malone, 1983; Monty, 1990; Parunak, 1989; Treisman, 1982). Again, how accessible notes are, particularly in relation to their intended purpose, is a key factor in their ultimate usefulness.

An Ethnographic Study

While the review of notetaking just presented provides us with important clues as to why people take notes and what some of the more critical elements of notes are, it is not sufficiently detailed for identifying notetakers' specific tasks and requirements. Therefore, to complement and extend this general empirical review of notetaking, I conducted an ethnographic study of how a particular group of biologists at the University of Oregon incorporate notetaking into their daily work processes. As mentioned previously in Chapter I, scientific notetakers were the focus of this ethnography because for them, notetaking is particularly critical, and also because one of the long-term goals for this research is to develop e-notebook support for a scientific Web site and relational database that they routinely use. This ethnography ultimately produced an abundance of detailed information from an actual group of scientific notetakers about how they take notes, why they take notes, what the components of their notes are, how they organize their notes, how they use their notes, etc. Although some aspects of what we learn from this ethnography are unique to scientific notetaking, such as the legal implications associated with their experimental notes, much of what we discover can be generalized to include a large subset of the entire population of notetakers. In the Task Analysis section that follows, this expanded information is used to begin identifying the most critical elements of notetaking that should be supported by traditional notetaking resources and e-notebooks alike.

Methodology

An ethnography is a field study whereby an observer tries to integrate himself or herself into another community in order to observe some facet of the group's daily life from within. Ethnographic studies originate from the field of anthropology, and they can be conducted with varying degrees of formality. While I was able to incorporate some ethnographic methodology in my study, like establishing direct personal contact with the community, there are other ethnographic tenets that I was not able to follow for practical reasons, such as extending the study over a long period of time and associating with the community in a variety of different contexts (Agar, 1996).

My ethnographic study involved meeting over the course of a couple of weeks with four geneticists working in the biology department at the University of Oregon. I met with each geneticist individually at his or her normal workspace—as opposed to conducting the meetings and interviews in a neutral location—which allowed me the unique opportunity of observing notetaking practices from within. As we sat together in the individual's workspace, each geneticist retrieved and pointed out notes from his or her particular storage location (notebooks on shelf, file cabinets, etc.). In each case, we discussed the origination and composition of the notes, the rationale for their organization, and the typical methods used to reference or retrieve the notes. In addition to the analysis and discussion of physical notebooks, I was also shown other software and archival systems frequently used by the geneticists. These software systems included digital imaging software, such as Adobe Photoshop, and image archives stored on optical disks. Although I did not tape the biologists as they led me through their world of notes, I recorded my findings in my own notebook.

Discoveries

The biologists that I studied, besides being researchers in the field of genetics, are highly educated people who are generally very proficient with computers. In addition to using the software mentioned above, the biologists were also active with e-mail and were generally familiar with spreadsheet applications and charting software (which some of them used to maintain graphs of experimental data). Also significant was the discovery that the biologists rarely collaborate on notetaking; instead, these scientists are possessive and guarded with their notes and their notebooks. This vigilance is common among the scientific community in general, and quite understandable as notes are typically the only means a scientist has of verifying his or her experimental results, and therefore often have legal implications as well.

As illustrated in Figure 2, the biologists maintain the following notebooks: experimental notebooks, publication notebooks (or folders), protocol notebooks, group meeting notebooks, travel notebooks, and slide notebooks. A summary of each of these notebooks follows, along with brief descriptions of some of the other miscellaneous archiving systems used by the biologists. Included in each summary are the types of notes found in each notebook, and a description of how those notes are organized and used. We see real evidence that supports the empirical literature review, and ultimately, a link between the current notetaking habits of an actual community of users and the functional requirements for an e-notebook.

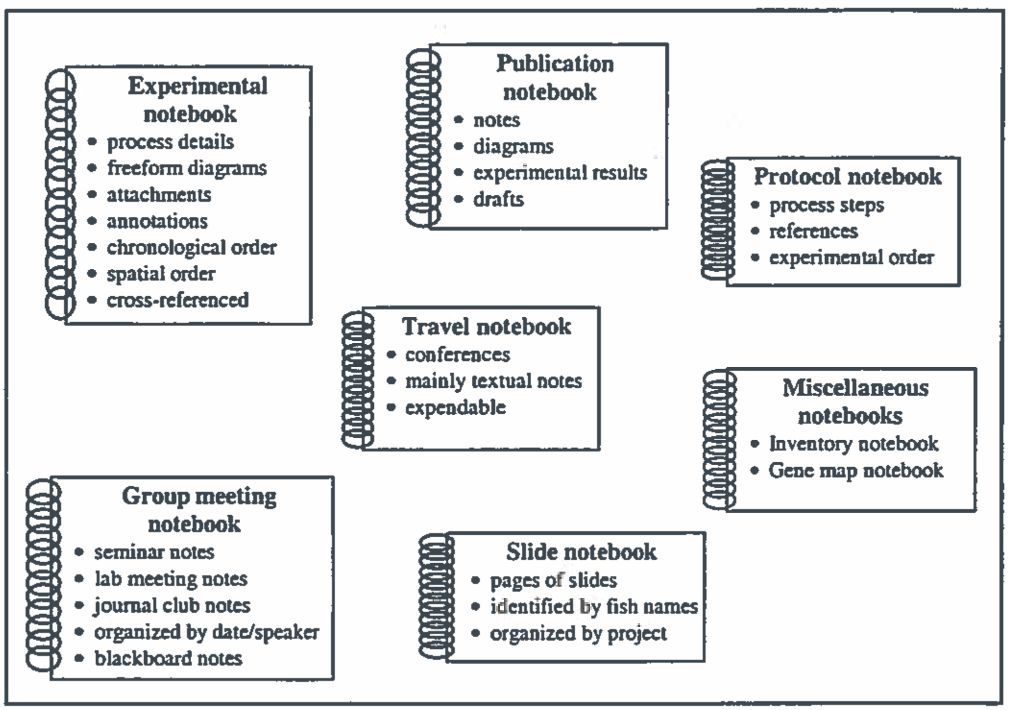

Figure 2. Summary of Biologists' Notebooks.

The Experimental Notebook

The most common type of notebook kept by the geneticists is the experimental or process notebook. This notebook, as its name suggests, is a collection of notes detailing a variety of experiments conducted by the geneticists. The notes within the experimental notebooks, which are contained in 3 ring binders, spiral wire bound or traditional stitched lab notebooks, are generally delineated by project. Within each subsection, the notes are stored in chronological order, and the page titles are usually derived from the combination of the date that the experiment was conducted on plus an additional code if necessary. For example, one geneticist whose notebook I viewed had performed multiple processes for different embryos on the date April 25, 1997. These note pages were entitled 97042501, 97042502, etc., with the date encoded first (in YYMMDD format), followed by the numbers 01,02, etc., referring to the different embryo processes.

The experimental notes typically contain enumerated lists detailing the step-by-step procedure followed for a particular process. Information such as sample names, references, protocols, probes, elapsed time, temperature, equations, results and comments, are carefully recorded for each step in the process. Freeform diagrams are often interspersed among the handwritten notes, as are post-it notes, photographs, computer generated graphs and tables, notes from other people, and various other printouts. Many of the attachments found within the notebook pages are further annotated by the notetaker, such as a photograph that is pasted in and then labeled, or a graph that has additional comments written on it. Often, the spatial layout of a notepage is utilized in a meaningful way. For example, multiple columns of numbers might be listed side-by-side to facilitate a natural left to right comparison of the data.

Occasionally, a geneticist will create a synopsis page that describes the overall purpose, summary and follow-ups for the following experiment, displaying it prior to the actual process notes. These synopsis pages are easily inserted into a 3-ring binder, but must be carefully anticipated by the notetaker when using a spiral bound or stitched lab notebook. Finally, notes often contain cross-references to related elements in other notebooks or archive systems. One set of notes viewed has cross-references to frames of pictures stored on optical disk, while another has cross-references to elements in a fish stock (inventory) notebook. Since it can be tedious and sometimes impossible to insert certain objects (such as pictures) into the page of a physical notebook, cross-referencing becomes an important tool for the notetaker to maintain continuity between his or her related notes and objects.

The Publication Notebook (Folder)

Most of the geneticists that I met with keep either notebooks or folders containing material related to in-progress or anticipated publications. These folders serve as a catch-all for notes, diagrams, pictures, experimental results, related publications, memos, emails, and rough drafts. By storing all this material in one central location, it is easier for the geneticist to begin or to continue work on a paper without having to re-locate the necessary material each time.

The Protocol Notebook

Most of the geneticists consulted maintain their own protocol notebooks. These protocol notebooks contain a list of proper steps that must be followed for various experiments, as well as a reference to the developer of the protocol. The protocols, which are mostly typewritten and inserted into a 3-ring binder, are sometimes organized according to the type of experiment that they refer to. The geneticist will usually review the appropriate protocol prior to conducting a certain procedure. Even though many of the protocols are standard procedures routinely followed by many different geneticists, a central group protocol notebook is not kept by any of the labs.

The Group Meeting Notebook

A notebook used specifically for group meetings such as seminars, journal clubs, and weekly lab (group) meetings is also commonly maintained. Most of the group meeting notebooks are labeled on the outside with the date range that the notes within encompass. While some of these group meeting notebooks are internally indexed or tabbed according to primary speaker and date (e.g., Ollie 14 II 96 indicates that Ollie was the primary speaker in the meeting held February 14, 1996), others are simply kept in chronological order without special delineations. The group meeting notebook contains primarily notes pertaining to a specific discussion or meeting, and typically has only a few freeform diagrams scattered throughout. If the discussion speaker explains a concept by drawing a diagram on the whiteboard, for example, the notetaker might copy that diagram into his or her notebook. Few items are pasted or stapled into these notebooks, and if the speaker hands out a memo or some other documentation, the notetaker will usually fold it up and store it in the inner flap of the notebook.

The Travel Notebook

Geneticists also commonly use travel notebooks to record notes at conferences or other non-local meetings. Because the geneticists worry that they might lose these travel notebooks, they usually buy new and inexpensive notebooks for each conference. Some geneticists set aside the first page of the notebook as a table of contents page, filling in the topic heading, date and page number during the actual process of recording notes. The notes in these travel notebooks are mostly textual, with few freeform diagrams and handouts scattered throughout.

The Slide Notebook

Slide notebooks, which contain pages of slides displaying pictures of different fish, the names of which are written on the slide's outer casing, are routinely kept by many of the geneticists. Some geneticists simply segregate the slides in these notebooks by project, while others use tabs to delineate projects. Occasionally, photographs will also be found intermixed with the slides in these notebooks.

<u>Other</u>

One geneticist I met with also keeps an inventory or fish stock notebook. This notebook, which is indexed by mutation type, contains listings of fish and their tank location. A standard typewritten form is used track these fish locations. Beaker labels are often attached to the form, and additional comments and diagrams are sometimes found on the backs of the forms. Another geneticist keeps a gene sequence or map notebook. This notebook contains typewritten descriptions of gene sequences, which are stored in alphabetical order.

In addition to the notebooks described above, many of the geneticists record various notes on to-do lists, desk calendars, post-it notes, and other random pieces of paper strewn about their workspace. Optical disks provide an important medium for the storage and retrieval of images for the geneticists. These optical disks store only images (no text), and are indexed by frame. As mentioned previously, sometimes these frames are cross-referenced in the experimental notebook of a geneticist. Some of the optical disks are 2-sided, a separation that is utilized when the geneticists store images related to a specific publication on one side of the disk, and images related to a second publication on the other side of the disk. These images are frequently downloaded from the optical disk to digital imaging software (Adobe Photoshop), where finishing touches are applied prior to publication.

Task Analysis

The details of the ethnographic study just described, along with some general information from the empirical review presented prior to that, allow me to begin defining some of the user tasks that an e-notebook should support. If the functional requirements of an e-notebook were to be based entirely on what we currently know about traditional notetaking, then users should be able to:

- enter/edit notes
- save notes in a secure location
- create superordinate and subordinate relationships (Mandler, 1979; Monty, 1990) in their notes (e.g., headings, sub-headings, etc.)
- create flexible organizations for their notes (e.g., easy to insert pages/notes, easy to rearrange notes, etc.)
- create outlines for their notes
- control the spatial layout of their notes
- include outside elements (e.g., pictures, graphs, etc.) in their notes and annotate them
- cross-reference their notes to other notes

However, it is important to recognize that the functional requirements identified thus far assume a direct mapping between traditional notetaking and electronic notetaking, which may not be entirely accurate. Before finalizing the list of requirements for an e-notebook, we must first consider how the process of notetaking and the components of notes may change when we move into the digital environment, particularly for the World Wide Web domain. This analysis is presented in the next section.

Paradigm Shift? From Traditional Notetaking to Information Assimilation

In contrast to what is known about traditional notetaking, little is known about how people actually take notes from the Web. This is the result, perhaps, of inadequate software support. Throughout the remainder of this section, I revisit the process of Information Assimilation (IA) and surmise how notetaking changes when we move into the Web environment. Once again, it is only by recognizing these differences that we can expect to fully understand Web notetakers' tasks and requirements for support. As has been suggested repeatedly throughout this research thus far, I envision that support for IA can best be provided by a Web-based e-notebook.

The Emergence of Information Assimilation (IA)

As recently as ten years ago, when students were asked to write a research paper, the approach they would typically take involved going to the library, tracking down sources, recording notes, and eventually integrating those notes to produce a final paper. Now, more often than not, students will accomplish a major portion of their research work using the Web. Rather than travel to a physical library, students can now use one of the many digital libraries available on the Web to look up papers, where they often have immediate access to entire texts, and they are able to copy and paste relevant selections into a word processing document for further manipulation.

As another example, consider a couple making arrangements for an upcoming trip. Instead of having to rely entirely on their local travel agent, this couple can now use the Web to research all aspects of their travels, and they can even make all necessary reservations and ticket purchases online. However, this couple must not only have sufficient access to the Web, as well as the time and resolve to conduct all the necessary research, but they should also have at their disposal tools that ultimately make their work easier. In this example, as in many others that we could mention, given proper access, knowledge, and tools, the Web can serve to empower people to make their own informed decisions as never before.

Even though the goals and tasks of the two previous examples vary widely, in both cases the Web users engaged in the process of Information Assimilation (IA), a process that should be facilitated with access to the proper tools. IA is a complex Web-based activity that involves gathering information from multiple Web sites (such as relevant research texts or different vacation package options as in the examples above), editing and annotating that information, creating personally meaningful organizations for it, saving it, and keeping track of ongoing work processes should they extend over some period of time. Because the Web is becoming an increasingly prominent means by which we accomplish many of our daily tasks, there is a natural transition from traditional paper-based notetaking—which is cumbersome and inefficient in the electronic environment—to IA on the Web. From this transition, many new questions emerge, including:

1. What are the differences between traditional notetaking and IA on the World Wide Web?
2. Does the process of notetaking change when we move to the Web environment?
3. Do the contents of our notes change?
4. Do we need different kinds of tools to support our Web-based IA activities?

The remainder of this major section suggests answers to these questions by identifying and discussing some of the key differences between traditional notetaking as we know it, and IA on the Web. Aside from the fact that the Web is still changing and evolving so rapidly that all the implications associated with the process of IA are unclear, in the remainder of this section I attempt to explain at least some of them. Based on answers to these questions, we can more accurately define the specific tasks that notetaking software should address. Furthermore, this analysis will also help us recognize which of these tasks are more critical than others, and thus which deserve increased attention and priority in an initial e-notebook prototype implementation.

Less Homogeneity and More Complexity

One of the most significant differences between traditional notes and the notes that result from the process of IA on the Web is the components of those notes. In many respects, Web notes are less homogenous and more complex than traditional notes because Web information is typically displayed as an incredible variety of diverse element types. For example, consider a recent snapshot of an Amazon.com Web page shown in Figure 3.

Figure 3. Element Types Found on a Typical (Amazon.com) Web Page[2,3].

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[2]Netscape Communicator browser window © 2001 Communications Corporation. Used with permission. Netscape Communications has not authorized, sponsored, endorsed, or approved this publication and is not responsible for its content.

[3]© 2001 Amazon.com, Inc. All Rights Reserved.

This singular Web page, which is not uncommon in either its complexity or in the number of different element types that it contains, is composed of plain text, formatted text, images, imagemaps, lists, tables, hyperlinks, form fields, pull-down menus and buttons. If a user wanted to gather and record certain notes about this page, those notes could potentially consist of any or all of these element types. Furthermore, there are a variety of different ways in which users may wish to save these elements in their e-notebooks, including statically, dynamically, linked, and programmed. Suggested definitions for each of these categories follow.

Static

When users wish to copy Web components into their notebooks statically, it essentially means that they want to take a snapshot of that information at a particular point in time, and they are not concerned with future changes to those elements. For example, if a user copies a paragraph of text statically from a Web page into a notebook, and that text undergoes future updates in the source Web page, those changes will not be reflected in the user's notebook. The static saving of Web information is even more important once we recognize the fact that the Web is constantly changing. Since users cannot depend on Web information staying stable from one minute to the next, they should not only be able to capture this information statically, but in some instances, they should also be able to verify its original existence. For certain researchers, such as scientists and other serious academics, being able to authenticate Web information and prove that it was published on a particular Web page (i.e., URL), at a particular date and time, can be a critical factor lending credibility to their work.

Dynamic

When users wish to copy Web components into their notebooks dynamically, they *are* concerned with any and all future changes to that information, and they want their notebooks to automatically reflect such changes. Again, using a paragraph of text as an example, if a user copies this information into his or her notebook dynamically, and it later changes in the source Web page, the new information would be updated automatically in the notebook. Users might use the dynamic copy as an efficient way of keeping track of the most current Web information without having to revisit the same pages over and over again. The Internet Scrapbook application (Sugiura & Koseki, 1998), which will be described in the next chapter, contains an automatic update function and provides a good example of how users can maintain a dynamic view of Web information.

Linked

When users copy Web elements into their notebooks as linked, they want to retain any and all underlying hypertext information that exists for those elements. For example, suppose a user copies a list of hyperlinks from a Web page into his or her notebook. If those elements are stored as linked, then the hyperlinks will still be active and usable from within the notebook. When the user selects or clicks on one of the copied hyperlinks from within the notebook, the Web page that the link points to will still load in a browser window (or in the notebook if the user wishes). Since much of what gives the Web its meaning can be attributed to its underlying hypertext structure, it is critical that users are able to preserve this structure for all Web elements copied into a notebook.

Programmed

Programmed elements that might be copied from a Web page into a user's notebook include components like applets, Javascript functions, and search forms. For example, suppose a user copies a search form from a Web site into his or her notebook. If that search form retains its underlying program capabilities, it would mean that the form could still be activated from within the notebook. In this case, the original Web site database would be searched (i.e., the database that the search form uses in its original Web location), and the results would appear in either the Web browser window or in the notebook depending on user preference.

So, while e-notebooks are complex in terms of both the types of elements users may wish to copy into them and in the variety of ways users may wish to save those elements, traditional notebooks usually only contain handwritten text with possibly a few external elements—like a picture or graph—pasted into them.

Tracking Work Processes Becomes Critical

Another major difference between traditional notetaking and IA on the Web is an increased focus on the users' ability to represent and track their ongoing work processes. In the traditional process of notetaking, it is usually relatively easy for a notetaker to remember and resume work when the process is temporarily suspended. These notetakers can use cues and techniques such as putting a reviewed or "looked-through" pile of books or papers off to one side of a desk or leaving books open to the current page. However, when conducting IA on the Web, it can be much more difficult for users to note where they are in their current work process. For example, it is usually awkward, confusing, cognitively overwhelming, and simply impractical from a resource perspective to keep multiple Web pages (i.e., browser windows) open simultaneously. Furthermore, Internet connections are often dropped unexpectedly, and browsing software must often be shut down after some period of time. The dynamic nature of the Web—whereby pages are constantly changing and being updated—only serves to exacerbate this problem.

Some of the most telling evidence that Web users need support for their ongoing work processes, and that this support is currently lacking from standard Web browsers, appears in a study conducted by Abrams, Baecker, and Chignell (1998). In their study, Abrams et al. (1998) analyze 322 survey forms and 50 bookmark files in an attempt to discover key elements of bookmarking behavior. A review of user quotes from the survey forms indicates that, in addition to using bookmarks for their designed purpose (i.e., to mark significant pages for future accesses), these users also bookmark pages as a way of representing and saving their long-term work activities. For example, one participant said that bookmarks tell "what I was doing over a period of many browsing sessions. I can keep track of what I was doing lately and a few weeks earlier" (p. 43), while another looked at bookmarked pages "as a history of using the Web" (p. 42). Abrams et al. conclude that, "In the absence of such (inter-session history) functionality, users are bookmarking pages to enable access to previous browsing sessions" (p. 43).

Even more evidence that tracking previous work processes is a critical function for many Web users can be found in another notable study. In their research, Tauscher and Greenberg (1997) analyzed six weeks of Web usage data from 23 users and discovered a high number of page revisits per individual (58% recurrence rate). Perhaps one of the reasons why users return to previously visited Web pages so frequently is because those pages are part of a longer term work process; this, in turn, suggests that these same users would greatly benefit from tools that help them track, remember and rejoin their ongoing work processes.

The following example illustrates the complexity and necessity of maintaining ongoing Web work process representations. Consider a person using the Web to conduct research on Greek architecture. This user starts his research by typing the keywords 'Greek architecture' into his favorite search engine, Google. Google promptly returns several thousand results, of which our researcher looks through the first twenty. Not satisfied with the information he has found thus far, the user enters the same keywords into the Altavista search engine and again gets several thousand results. Because the first twenty hits look different than those returned by Google, the user begins looking rather shallowly (i.e., traveling only one or two links deep at a time) through them as well. Now, imagine that this user is suddenly interrupted from his work, and he does not return to it for the next few days. At this point, it is critical that this user be able to somehow note what research he has already done (e.g., which search engines he has used, the keywords entered, etc.), which search results he has already browsed, the Web pages he found initially promising and that he would like to review further, and which Web pages he actually found relevant and useful. Given the absence of adequate tools to help this user recall his previous work processes, he will likely spend additional time later trying to remember what he was doing, he might repeat some of his work, or he might unintentionally skip over important results. As we will see in the next chapter, despite tools like browser bookmarks and history lists, users are currently unable to track their extended work processes on the Web as needed.

A Mixed Bag

With the transition from traditional notetaking to IA on the Web, there are many aspects of notetaking that we can expect the computer to facilitate. For example, e-notebooks are advantageous for almost all aspects of organizing and re-organizing a set of notes. Users should be able to readily insert and delete pages in their e-notebooks, move sections of text around, create headings and sub-headings, section off groups of notes, and create outline views of their notes. Many of these same functions, however, can be quite difficult to accomplish when ink and bound notebooks are used as implements—especially tasks that involve moving notes around and changing the initial structure of a set of notes.

Cross-referencing notes is another aspect of notetaking that may become easier in an electronic environment. During the ethnographic study, we learned that some biologists rely heavily on cross-referencing their notes, particularly because integrating or inserting new notes with their existing notes is so difficult in the traditional view. Even though inserting information into notes will be easier to accomplish electronically, cross-referencing will likely remain an important function. As previously mentioned, Web notetakers may wish to retain the cross-referenced hypertext structure commonly found embedded in Web information. Additionally, as users begin to accumulate an increasing volume of personal notes—a process that may well be facilitated by effective e-notebooks—linking those notes together via cross-references them may be essential for organization and efficient retrieval.

However, while there are numerous examples of how notetaking may improve in the electronic environment, we can also expect to lose some aspects of notetaking that we have come to depend on. To begin with, it will be more difficult to integrate non-digital elements (e.g., pictures and memos) with electronic notes. Certain notetakers, like the biologists showcased in the ethnographic review, not only routinely staple or paste these types of elements into their notebooks, but often annotate them as well. We know from other research that electronic annotation alone is a complex and difficult function to achieve effectively (Chang, Mackinlay, Zellweger, & Igarashi, 1998).

Attaining certain spatial layouts within notes, such as columns or tables, may also prove more difficult in an e-notebook than in a traditional paper notebook. Unless the desired spatial layouts are custom designed as specific components in an e-notebook page, or at least as objects that users can choose to put on a page when needed, formatting computerized notes into highly specialized layouts can be quite complex. As an extension of this same problem, it can also be hard for users to draw free-form diagrams in their electronic notes. Software developers typically have to decide on the type of elements (i.e., typed text or free-form drawing) that an electronic page will support ahead of time rather than allowing users the flexibility of easily integrating a variety of differently typed components on the fly.

Finally, Monty (1990) mentions a number of other relatively intangible elements that traditional notes might contain or reflect that will be virtually unachievable in electronic notes. For example, she discusses cognitive cues that may be evident in notepages to help notetakers remember or identify notes. Monty offers numerous examples of such cues, including the accidental cue of a coffee stain on a set of notes that may help the notetaker remember the situation of recording the notes, and the incidental cue of worn paper edges which may inform a notetaker of the heavy use and importance of a set of notes. Monty also discusses other things that traditional notes can reflect—such as change over time evidenced by scratched out notes or a variety of different pens being used—that may be lost in the homogeneity of electronic or computerized notes.

IA Requirements for an E-Notebook

In the previous section, important new questions were raised and distinctions made between the process of traditional notetaking and IA on the Web. To summarize, we learned the following:

- Web notes might contain more complex components than traditional notes including formatted text, images, imagemaps, lists, tables, hyperlinks, form fields, pull-down menus and buttons. Users may wish to copy these components into their e-notes statically, dynamically, linked, or programmed.
- It is important that Web notetakers are able to capture the underlying hypertext structure of Web information in their notes.
- It is important that Web notetakers are able to verify the original source (i.e., URL, date, and time) of Web information.
- It is critical that users are able to keep track of their ongoing Web work processes, including efficient ways of representing and storing suspended work.
- E-notebooks should contain functionality that renders them advantageous over traditional notebooks, including allowing users to:

  - insert and delete pages
  - move sections of text around
  - create headings and sub-headings
  - section off groups of notes
  - create outline views of their notes
  - cross-reference their notes

In addition to gaining a better understanding of the process of IA, one of the primary reasons why we focused on the differences between traditional notetaking and IA on the Web was so that we could more accurately define the list of user tasks or functions that a Web-based e-notebook should support. Because it would be erroneous to design an e-notebook based entirely on what is known about traditional notetaking, we instead use this knowledge as a starting point, and then supplement it with additional tasks based on how our needs change when we move into the online Web environment. So, updating the preliminary list of requirements defined earlier with what we just discovered about the process of IA, we arrive at a more accurate and detailed list of IA functional requirements for a Web-based e-notebook presented in Table 1.

In Table 1, the high-level functions of gather, edit, annotate, organize, save, and track ongoing work are used to categorize the requirements. It should be noted that while most of the previously identified tasks have been included in the list of functional requirements shown in Table 1, some requirements that are not considered of the highest priority for an initial e-notebook implementation have been omitted. For example, while it is crucial that users are able to copy and paste text, images, lists, tables, and hyperlinks from the Web into their e-notebooks, it is not as important initially that they can gather imagemaps, forms, pull-down menus, and buttons. Other noticeable omissions from Table 1 include the ability for users to have highly flexible control over the spatial layout of their notes and to include free-form diagrams in their e-notes; these functions are not of the highest priority for an initial prototype implementation.

Table 1. IA Functional Requirements for a Web-based E-Notebook

Functional Requirements

Gather

1. Users should be able to copy and paste text (both plain and formatted) statically from multiple, disparate Web pages into an e-notebook while retaining formatting.
2. Users should be able to copy and paste images statically from Web pages into an e-notebook page while retaining formatting.
3. Users should be able to copy and paste lists and tables statically from Web pages into an e-notebook while retaining formatting.
4. Users should be able to copy and paste hyperlinks from the Web into an e-notebook while retaining formatting and functionality (i.e., hyperlinks should remain "active" in e-notebook).
5. Users should be able to archive Web information by having the URL, date, and time of the original source information automatically included in their e-notes. Users should not be able to modify the source or the authentication stamp for such archived information.

Edit

6. Users should be able to delete any content from their e-notebooks, including original Web elements.
7. Users should be able to modify (change text, format text, etc.) any content in their e-notebooks (except images), including original Web elements.

Annotate

8. Users should be able to add text to or delete text from their e-notebooks.
9. Users should be able to emphasize or differentiate text in their e-notebooks by choosing between different font styles (e.g., bold, italic, underline) and sizes.
10. Users should be able to create automatic cross-references (i.e., links) from one section of their e-notes to another section of their e-notes.
11. Users should be able to create automatic cross-references (i.e., links) from their e-notes to any Web page.

Organize

12. Users should have multiple pages in their e-notebooks and should be able to copy Web information into any page they choose.
13. Users should be able to move text (plain and formatted) around in their e-notebooks while retaining formatting.
14. Users should be able to move images around in their e-notebooks.
15. Users should be able to move lists and tables around in their e-notebooks while retaining formatting.
16. Users should be able to move hyperlinks around in their e-notebooks while retaining formatting and functionality.
17. Users should be able to create separations between groups of notes.
18. Users should be able to name, insert and delete e-notebook pages.

Save

19. Users should be able to save text (plain and formatted) in their e-notebook while retaining formatting.
20. Users should be able to save images in their e-notebook.
21. Users should be able to save lists and tables in their e-notebook while retaining formatting.
22. Users should be able to save hyperlinks in their e-notebook while retaining formatting and functionality.
23. Users should be able to save archived Web information in their e-notebook.

Track ongoing work

24. Users should be able to track an ongoing Web work process in their e-notebooks so that they can easily remember the work they were doing at a later time.
25. Users should be able to track their current progress in an ongoing Web work process (i.e., users should be able to see how much of their initial work goals they have completed, and they should be able to gauge how much work is outstanding).
26. Users should be able to annotate an ongoing work process.
27. Users should be able to edit an ongoing work process (e.g., delete some portion of it, insert text into it, etc.).
28. Users should be able to restart and rejoin an ongoing Web work process from within their e-notebooks with minimal repeated work (i.e., users should not have to relocate Web pages of importance).

In the next chapter, we will take a closer look at the tasks listed in Table 1 to see how well each of them is supported by existing software. This evaluation will include standard Web browsers as well as other notable and relevant Web-based software tools.

Conclusion

This chapter is critical for understanding the foundations of notetaking and how the traditional process changes and becomes IA when we move into the digital environment. We began by studying traditional notetaking from an empirical perspective, where we learned that people engage in notetaking for a variety of reasons, including to assist memory, to think, to process information, to organize information, and to document events. This empirical review was supplemented by an ethnographic field study of how an actual group of biologists incorporate notetaking into their everyday work activities. From these two studies (i.e., the literature review and the ethnography), the definition of IA was finalized, and an initial list of requirements for e-notebooks was formed by identifying specific tasks and functions critical to the process of notetaking.

Recognizing that a list of Web-based notetaking requirements would be inaccurate if it was identified solely from what is known about traditional notetaking, however, we then turned to questions of how notetaking changes and becomes IA when we move into the online, Web environment. We saw that there are many important differences between the processes of notetaking and IA, differences that are critical to understand prior to developing Web-based support for IA (i.e., a Web-based e-notebook). For example, we discovered that Web notes may include more diverse components than traditional notes—components that an e-notebook should ideally support. We also recognized that due to the constantly changing nature of the Web, it is critical for some notetakers to verify the original source of Web information. We learned that keeping track of one's ongoing work processes takes on a new urgency when working in the Web environment. Finally, we identified a number of ways in which e-notebooks can be particularly advantageous as compared to traditional notebooks—including allowing users to re-organize and structure their notes more easily—but that other aspects may prove more difficult—such as inserting external elements, controlling certain spatial layouts, and retaining special cues.

By the end of the chapter, the cumulative knowledge of traditional notetaking in general, of how a particular user group records and retrieves notes, and of how notetaking transitions into IA on the Web, allows us to form a detailed list of requirements for a Web-based e-notebook (see Table 1). These requirements will be revisited frequently throughout the remainder of this research as they not only help us answer the next critical research question, How well does current software support the emergence of IA and users' evolving tasks?, discussed in Chapter III, but they also create the foundation for the NetNotes prototype described in Chapter IV.

CHAPTER III

SUPPORT FOR INFORMATION ASSIMILATION: WHERE ARE WE NOW?

In the previous chapter, we reviewed the process of notetaking from both an empirical perspective as well as from an ethnographic perspective. The empirical analysis highlighted some of the reasons why people take notes, while the ethnographic study uncovered specific notetaking practices that a group of biologists regularly engage in. These reviews, along with an analysis of how the process of traditional notetaking changes in the Web environment, ultimately resulted in a formal definition of IA, complete with a list of functional requirements necessary for software designed to support IA—such as a Web-based e-notebook.

The goal of this chapter is to determine the current level of software support for the process of IA. I performed a heuristic evaluation of a number of Web-based applications, including recent versions of Netscape Navigator and Microsoft's Internet Explorer, using the IA functional requirements identified in Chapter II as a basis. To facilitate this review, the IA requirements—listed in detail in Chapter II Table 1—are analyzed in terms of their high-level functional categories as follows. Web users should be able to…

1. Gather Web information (i.e., text, images, lists, tables, and hyperlinks) by copying and pasting it from multiple Web pages into an e-notebook; collect archival data pertaining to when and where original Web information was published,
2. Edit original Web elements as stored in an e-notebook,
3. Annotate e-notebook contents (e.g., add/delete text, highlight information, create cross-references, etc.),
4. Organize e-notebook contents (e.g., control the spatial layout, re-structure, combine similar information together, etc.),
5. Save the contents of an e-notebook, and
6. Track and save ongoing work processes.

The results of this software evaluation show not only that there are few relevant and integrated systems available for review, but also that none of them adequately supports the process of IA. While some applications contain bits and pieces of functionality that might be used to accomplish a few IA tasks, no current systems are fully integrated e-notebooks designed with the IA process in mind.

Web Browsers

As of this writing, Netscape Navigator 4.7 and Microsoft's Internet Explorer (IE) 5 are recent versions of the two most widely used Web browsers. I begin my assessment of the current state of IA software by examining the degree to which users can accomplish the critical IA tasks identified in Chapter II—and summarized above—using these browsing applications. While there are arguably many different ways in which each of these tasks might be accomplished with the browsers, I include only those methods that I feel a user is most likely to employ. It should be noted that because I am the only person involved in performing this software review, the results should be interpreted qualitatively.

Requirements 1 and 5: Gather and Save Web Information

Even the most basic of IA requirements—gathering and saving formatted text, images, lists tables, and hyperlinks from the Web—is currently difficult to achieve using standard browsing applications. While the copy and paste commands can be used to copy selected information from a Web page into another application, such as Microsoft Word or Windows Notepad, many of the formatted objects are typically lost in the transfer. Even those applications that correctly handle the copying and pasting of some formatted objects, like text and images, fail to do so consistently.

Users might also opt to save an entire Web page in HTML format, but this does not allow for the selection of certain portions of the page only, and the information is then only accessible for future use in applications that can interpret HTML code. Furthermore, images are often lost altogether when an entire Web page is saved as HTML, which may prompt users to the save images separately. However, the images must then be manually re-integrated with their related text using another application, which requires significant effort and the use of additional applications. Users can also print out Web pages as a way of saving information. However, this option, too, is problematic because users cannot readily combine the information with other electronic notes or annotations, it generates excess paper that must be further organized and stored, and it assumes that users have access to a printer. Lastly, users might choose to use a Web authoring tool, like Netscape Composer, to create a new Web page from pieces of existing ones. However, these tools are designed for the generation and publication of new information, not the long-term storage of existing data.

In addition to saving information from the Web, users may also need to prove that the information they gathered existed at a particular URL, date, and time. Currently, the only way users can keep verifiable records as to the state of the Web is to print out and retain hard copies of entire pages. Once again, though, printing hard copies of entire Web pages requires additional effort to organize, store, and retrieve, especially when only specific portions of the pages are actually needed. Web browsing software should provide better support for users, like the biologists profiled in the ethnographic study, who may need to maintain records validating the state of the Web.

Requirements 2, 3, and 4: Edit, Annotate, and Organize Notes

Since standard Web browsers lack any sort of accompanying notebook, the ability of users to perform the key IA activities of editing, annotating, and organizing their Web notes depends entirely on the functionality of other software applications. In the most recent GVU WWW survey (Kehoe & Pitkow, 1998), 27.6 percent of cases reported not being able to efficiently organize gathered information as among the biggest problems in using the Web. Persistent users might be able use word processing software to edit certain types of Web information—like plain text—and then document management systems to organize and retrieve it, but this assumes that users have the necessary access to a variety of desktop applications and the technical knowledge to use these applications in an integrated fashion.

Requirement 6: Track Ongoing Work Processes

Standard Web browsing software is also significantly impaired by its inability to support protracted and/or fragmented work processes. While Web users may complete work in one continuous, uninterrupted session, it is equally likely that their work will span a longer period of time and multiple browsing sessions. In this latter case, it is essential that users have the ability to recall and rejoin the work of a previous Web session quickly and easily.

As previously noted, the Abrams, Baecker, and Chignell (1998) bookmark study reveals that many Web users use bookmarks (named favorites in IE) to represent their inter-session history because no other suitable functionality exists. That these users will adapt a tool designed for something very different to compensate for missing functionality suggests the obvious need for ongoing work activity support. It is not surprising, then, that the limitations Web users find with bookmarks also renders them inadequate for representing long-term work processes. For example, users from the Abrams et al. (1998)

study say that "bookmarks aren't descriptive enough" (p. 47) and that they "aren't great describers of the actual content" (p. 47). If current bookmark functionality is considered insufficient for identifying and describing single Web pages, then it is surely unsatisfactory as a tool for representing more complex, ongoing work processes. Furthermore, one can imagine that a crucial component of depicting longer-term activities is being able to organize and arrange representations in a spatially/visually meaningful way. Again, trying to use bookmarks in this capacity is problematic as users complain that long lists of bookmarks are hard to maintain, visualize, browse, and categorize (Abrams et al., 1998). In fact, organizing bookmarks is one of the top 3 Web problems with bookmarks as reported by 4770 respondents in the 10th GVU WWW survey (Kehoe & Pitkow, 1998).

Using the bookmarking tool to represent protracted work processes has other limitations as well. Users are unable to identify specific portions of Web pages that are of particular interest since bookmarks flag entire Web pages only; bookmarks can only mark dynamic Web page content and cannot be used to keep track of the information on a particular Web page at a particular moment; and users may wish to have more flexible ways of identifying the various parts of their work process other than simply by page titles (e.g., an icon). The findings of both the Abrams et al. (1998) study and the 10th GVU WWW survey (Kehoe & Pitkow, 1998), along with the other limitations pointed out here, make it evident that bookmarking is problematic and seriously inadequate as a tool for representing long-term work activities.

The detailed history list found in most Web browsers provides an alternative to bookmarks that users might consider to help them recall and rejoin a previous work session. For example, a user could copy items from the detailed history list (in Netscape, the detailed history list displays the title, location or URL, first and last visited date/time, expiration date, and visit counts for a Web page), paste them into a text file, and then save and reuse them to piece together previous work at a later time. However, this option is also unsuitable for a number of reasons: the items can only be copied-and-pasted one at a time (in Netscape at least), which makes it both tedious and time-consuming for a user to copy the browsing history for an entire session; duplicate items are displayed in the list; there is no graphic representation depicting how the user browsed the listed Web pages or how the pages relate to one another; a user would have to retype the URLs to load the pages in the subsequent browsing session; and the title and URL location may not be sufficient information for the user to recall a previous work process page.

Web Notebooks

There has been such a proliferation of Web-based applications over the last decade that trying to review even just a portion of them to determine whether or not they contain any functionality that might support IA is a difficult and overwhelming process. Shockingly, despite the fact that my research on this topic has spanned many years and that I have reviewed numerous Web-based software products and a significant portion of the literature, I have encountered few applications that can truly be classified as Web-based notebooks. While some tools provide functionality that allows users to complete some IA tasks in a piecemeal fashion, these tools are ultimately based on different design goals (than supporting IA) and there are no completely integrated packages that can be said to fully support the IA process.

In this section, three applications that come the closest to being classified as Web-based notebooks are described. While these descriptions are not structured quite as formally as in the previous section on Web browsing software (i.e., with the high-level IA tasks forming the sub-headings), for each application presented, I comment on how users might accomplish the same key IA tasks that this entire software evaluation is based on. It should be noted that for practical and financial purposes, the remainder of this system review considers only software described in prevalent literature sources (i.e., conference proceedings and journals), and does not include products sold commercially.

Nabbit

The Nabbit prototype (Manber, 1997), whose primary purpose is to allow users to collect information from the Web and to create new individual pages from that information, does support the process of IA to some extent. Users can copy and paste text (both formatted and plain), images, lists, tables and hyperlinks from other Web pages into their own personal pages, and they can annotate any of their copied and pasted Web selections. Nabbit also automatically inserts the source of the copied/pasted information and the date and time of the copy. Figure 4, which is a sample Web page created using Nabbit, shows various types of Web information that can be copy/pasted (table, hyperlinks, list), the source and date/time stamp, and the inclusion of annotations.

However, while Nabbit appears to be the most effective application I have reviewed in terms of providing support for IA, it falls short of fully supporting this process for a number of reasons. It is unclear whether users can edit pages once they have been created, modify their own annotations, or add notes to an existing page without having to repeat the copy and paste process. In this sense, while Nabbit seems useful as a tool for collecting Web information, it ultimately fails to support a user's need to assimilate that information by modifying it further and by integrating it with other notes. Nabbit also does not appear to provide any special functionality that helps users track their ongoing work processes. Lastly, while the prototype aids in the generation of individual Web pages, it does not form an integrated notebook. If users wish to gather, organize, and save multiple pages of related notes, then they must do so using software separate from the Nabbit application.

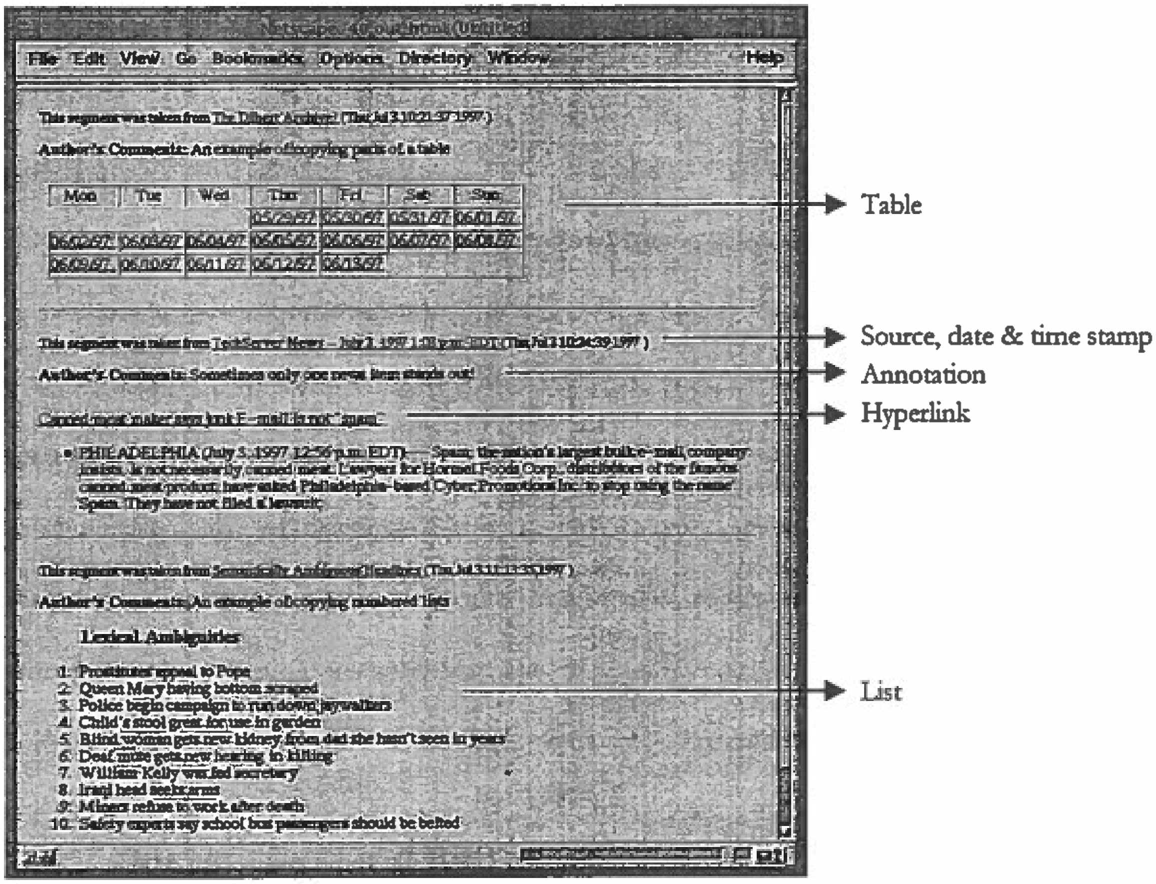

Figure 4. Web Page Created in Nabbit[4].

[4]From "Creating a personal Web notebook," by U. Manber, 1997, *Proceedings of the USENIX Symposium on Internet Technologies and Systems,* (pp. 183-192). Also available at: http://www.usenix.org/publications/library/proceedings/usits97/full_papers/manber_creating/manber_creating_html/manber_creating.html.

The Internet Scrapbook

The Internet Scrapbook (Sugiura & Koseki, 1998) is similar in functionality to Nabbit, but it too was not designed specifically to support the process of IA. The main functionality of the Internet Scrapbook is to automatically refresh or make current Web selections that users have copied and pasted into their own personal Web pages. Like Nabbit, the Internet Scrapbook supports IA in that users can gather and save text, images, lists, tables, and hyperlinks from the Web. However, the Internet Scrapbook lacks edit and annotation functionality, it does not help users track their ongoing work processes, and it stores Web information as individual pages rather than as an integrated notebook.

WebBook

WebBook (Card, Robertson, & York, 1996) is another related prototype system, but again, one that has been designed for a different purpose than to support IA. WebBooks (see examples in Figure 5 & 6) allow users to gather and organize multiple Web pages from different locations and to store these pages together as one cohesive unit or book. Users can generate WebBooks in a variety of ways, including from bookmark lists, search results, relative URLs on a Web page, etc. Unlike Nabbit and the Internet Scrapbook, applications that created individual Web pages only, WebBooks are designed using the book metaphor. For example, as illustrated in Figures 5 and 6, users can "flip" through WebBook pages, and the 3D graphic images closely resemble physical books.

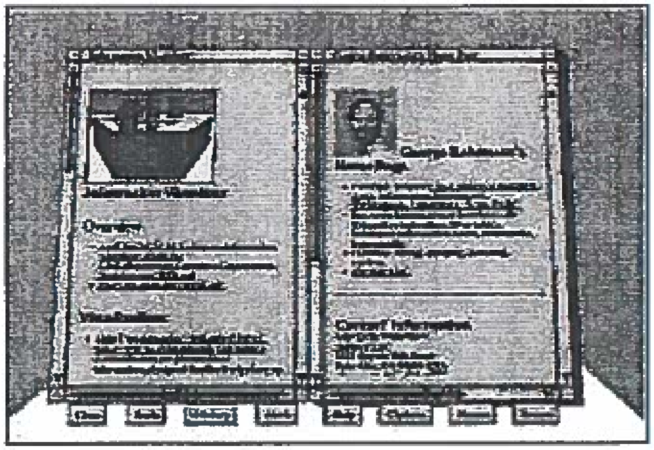

Figure 5. A Sample WebBook[5].

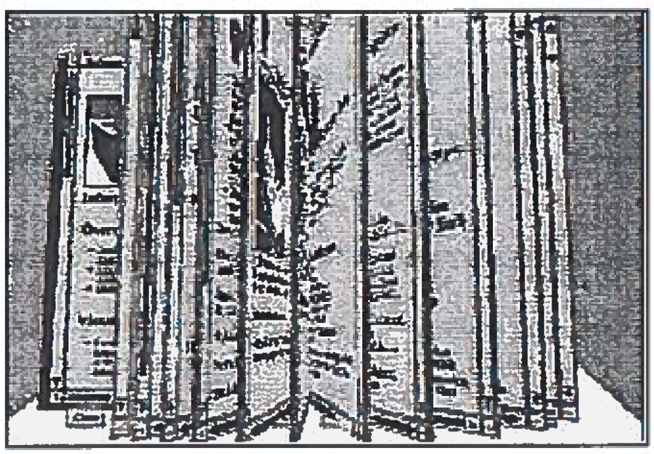

Figure 6. Flipping Through Pages of a WebBook[5].

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[5]From "The WebBook and the Web Forager: An information workspace for the World-Wide Web," by S. Card, G., Robertson, & W. York, 1996, *Proceedings of the ACM CHI '96 Conference on Human Factors in Computing Systems,* p. 112-113. Also available at: http://www.acm.org/sigs/sigchi/chi96/proceedings/papers/Card/skc1txt.html. New York: ACM Press. © 1996 ACM. Reprinted with permission.

WebBooks can be stored amongst themselves and other individual Web pages in the Web Forager information workspace (Card et al., 1996).

Despite its novel design and impressive graphical appearance, however, the WebBook application does not address a number of critical IA areas. To begin with, WebBook pages are not saved locally on a user's system, but are instead reloaded from the Internet each time they are accessed. So, it is more that the structure of WebBooks can be saved rather than their actual content. Also, users cannot collect portions of existing Web pages (only entire pages), they cannot edit or annotate the information in a WebBook, and there are no special tools for tracking ongoing work. WebBooks are nice in that they form cohesive "books" of related Web pages, but they, too, ultimately fail to support IA because users cannot further personalize or modify the information contained within them.

Other Software

This section concludes the software evaluation part of the chapter by describing a few other Web-based software systems that, in one way or another, arguably support a part of the IA process—namely the tracking of ongoing work processes.

Web Browsing History Displays

Information visualization as it relates to the World Wide Web is a large field of research. Much of this research is concerned with developing efficient algorithms and novel displays for large networks of information, such as the Web. Examples of these types of visualizations include the Navigational View Builder (Mukherjea & Foley, 1995; Mukherjea, Foley, & Hudson, 1995), the hyperbolic browser (Lamping, Rao, & Pirolli, 1995), the perspective wall (Mackinlay, Robertson, & Card, 1991), cone trees (Robertson, Mackinlay, & Card, 1991), and treemaps (Johnson & Shneiderman, 1991).

However, there are also a number of other applications that fall into the area of information visualization that are applicable to this discussion in that they might potentially be used to keep track of a Web user's inter-session browsing history, or ongoing work processes. These applications—examples of which include MosaicG (Ayers & Stasko, 1995), Pad++ (Bederson, Hollan, Stewart, Rogers, & Vick, 1998), PadPrints (Hightower, Ring, Helfman, Bederson, & Hollan, 1998), Webmap (Domel, 1994), and WebNet (Cockburn & Jones, 1996)—generate graphical representations or overview diagrams of a Web user's browsing history (i.e., those Web pages visited by the user during a browsing session). While the details provided by each of the graphic displays vary, in general, these applications can help users understand how they arrived at their current (Web) location, remind them of where they have been, and help them return to previously visited pages. As an example, Figure 7 shows an overview of the Graphic History View in the MosaicG application. In this particular overview, visited Web pages are indicated by node icons—each displaying page title, URL, and thumbnail image—and the tree graph illustrates parent/child relationships among the nodes, and thus the overall relationship of the visited pages.

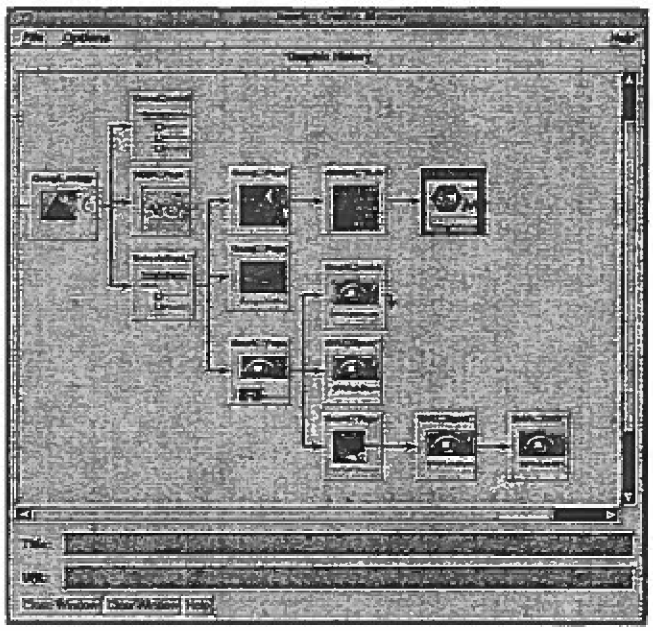

Figure 7. Graphic History View in MosaicG[6].

[6]From "Using graphic history in browsing the World Wide Web," by E. Ayers, & J. Stasko, 1995, *Proceedings of the Fourth International World Wide Web Conference*. Available at: http://www.w3.org/Conferences/WWW4/Papers2/270/. Copyright © 1995 World Wide Web Consortium, (Massachusetts Institute of Technology, Institut National de Recherche en Informatique et en Automatique, Keio University). All Rights Reserved. http://www.w3.org/Consortium/Legal/.

As just mentioned, Web browsing history display applications are included in this evaluation because arguably, they could be used to keep track of a user's ongoing Web work processes—one of the most critical IA tasks. In particular, users of MosaicG, Webmap, and WebNet are able to save some form of their browsing history for later access, although the details of what is included in this save are not entirely clear from the literature and do vary from application to application. However, assuming that some reasonable semblance of a browsing history tree structure can be saved and reloaded, these representations might help users remember their previous work. Furthermore, in cases where users can recall previous work based on a saved browsing history display, they can also easily rejoin their work by clicking on a tree node, which causes the associated Web page to automatically load in a browser window.

Unfortunately, upon closer inspection, we realize that generally, these applications are really not that well suited for the personalized tracking of long term work activities for a number of reasons. In some instances, the browsing history cannot be saved between sessions, and in other cases, users cannot directly manipulate the automatically generated graphical views (i.e., users cannot delete nodes, restructure parts of the tree graph, select which pages to include and which to exclude, include annotations, etc.). Because these views can get very large very quickly, the fact that users cannot trim or personalize parts of the displays will certainly detract from their ability to recall what they were doing during a previous browsing session, and to locate exactly where they were in the overall process.

Document Management Systems

Document management systems represent another notable group of Web-based applications used to manage Web pages in some sort of virtual workspace environment. For example, in the Data Mountain application (Czerwinski et al., 1999; Robertson et al., 1998), users can drag and drop Web pages into a 3D workspace for storage. This 3D workspace provides landmarks and audio cues to the users, and the application attempts to capitalize on spatial memory so that users can easily recall a page based on their own personal placement of it in the workspace. The Web Forager (Card, Robertson, & York, 1996), shown in Figure 8, is another 3D workspace application where users can store WebBooks (previously described) alongside singular Web pages. One of the novel features of the Web Forager workspace is its hierarchical arrangement; users can organize the environment based on their interaction rates with the documents in it. Web pages (or WebBooks) can be positioned in a focus place for direct interaction, in immediate storage for items in use but not currently in focus, or in tertiary storage for those items not currently being used.

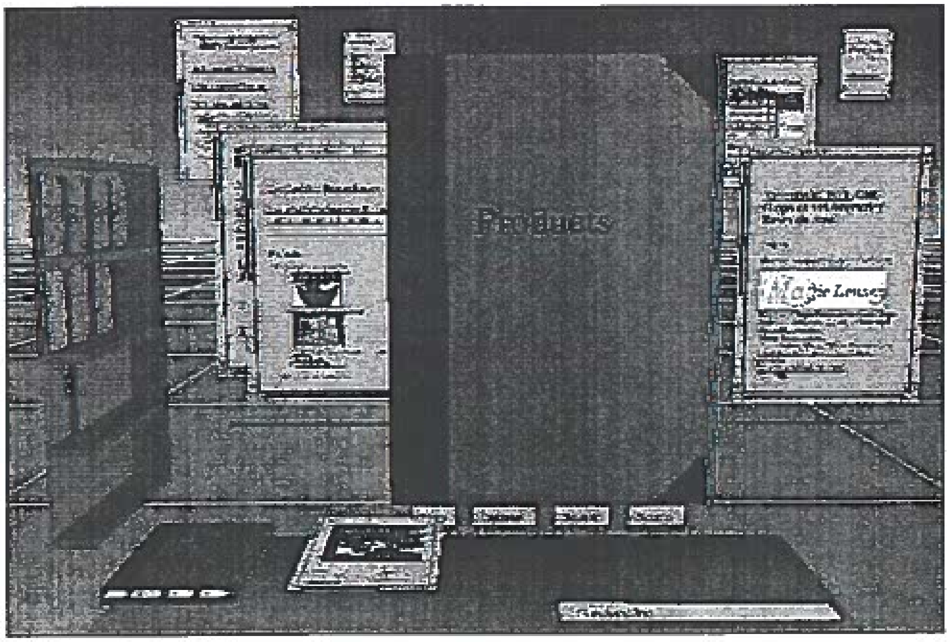

Figure 8. Web Forager 3D Workspace[7].

Once again, document management systems are included in this software review because they do satisfy, in some respects, the IA activity of saving an ongoing work process. For example, both WebBooks and the Web Forager workspace can help users remember and rejoin previous activities that span more than one browsing session. Presumably, the combination of WebBooks and the organization of the Web Forager

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[7]From "The WebBook and the Web Forager: An information workspace for the World-Wide Web," by S. Card, G., Robertson, & W. York, 1996, *Proceedings of the ACM CHI '96 Conference on Human Factors in Computing Systems,* p. 115. Also available at: http://www.acm.org/sigs/sigchi/chi96/proceedings/papers/Card/skc1txt.html. New York: ACM Press. © 1996 ACM. Reprinted with permission.

information space represent a user's current work process during any given browsing session. If this is true, when a user is ready to end a browsing session, he or she can simply bookmark the current page in the active WebBook, and then position the book in the forefront of the Web Forager workspace. Then, at some later time, that user can quickly locate the most recently accessed WebBook, go directly to the bookmarked page, and rejoin the work with relative ease. However, big limitations of the Web Forager and of many document management systems in terms of their ability to support IA include: users cannot gather selections of Web pages to store in their notes, they cannot edit or change the stored Web pages in any way, they cannot integrate the pages with other notes, and they cannot store the pages of information locally.

Why Do So Few Web-based E-Notebooks Exist?

In the previous sections, a number of Web-based applications were analyzed and shown to be largely deficient in supporting users' IA tasks. Why is this? One possibility is that other researchers have not yet identified the process of Web-based notetaking, or IA, as being critical to so many users, and thus have not yet worked towards developing the appropriate support tools. A more likely explanation, however, is that designing useful and usable software for the Web is a difficult undertaking. What follows is not an exhaustive list, but rather an acknowledgment of some of the more pressing challenges that Web software developers face, particularly those interested in the creation of Web-based e-notebooks.

Complex Technologies that are Constantly Changing

Perhaps the biggest challenge associated with designing Web-based applications is contending with the many, constantly changing aspects of the Web, and with the fact that there is no central control imposed or standards that must be followed to publish something in the Web domain. The unprecedented speed at which the Web is expanding and evolving makes it difficult to even define the Web, and can render attempts at designing software for it seem futile. Applications that incorporate today's technology and that are based on current implementations of the Web might well become obsolete in the Web environment of tomorrow.

One particularly problematic area for the creators of Web-based e-notebooks is the increasing variety and complexity of Web page source code and their embedded components. Five years ago, most Web pages were coded using only HTML, and they contained relatively simple components such as formatted text, images, lists, tables, and hyperlinks. Today's developers, however, face much more complicated implementations that can include DHTML, XML, and CSS, along with Web pages that routinely integrate forms, applets, and any number of other customized programmed objects. As discussed previously in Chapter II, commonly used search forms, which are considered programmed Web objects, highlight this problem. If a user wants to copy a search form from a Web site into his or her e-notebook while retaining the functionality of the form, then developers face complex implementations that somehow maintain an active link between the e-notebook and the original Web site database.

Many Web sites also now incorporate a dizzying array of underlying technologies—including databases, networks, and operating systems—which makes the development of software that relies on them even more difficult. Another issue confronting Web-based software developers is that applications are often expected to function similarly across various platforms (Mac, PC, Unix, etc.) and with various Web browsers. For example, variations in the appearance of Web pages may cause variations in how the elements look in an e-notebook, which is an issue that designers and developers alike must consider.

Security Restrictions

Depending on the functionality embedded within any particular Web site and the underlying system architecture, security can also be quite problematic for Web application developers. For example, imagine a user who copies and saves a Web page containing executable content into his or her e-notebook. Every time that notebook page is re-accessed or reloaded, the embedded program can execute. How will this untested code running again and again on the local system, which surely presents new security breaches, be controlled?

To further illustrate security issues that Web developers must be cognizant of, consider the Java security model that is based on the notion of a sandbox (Oaks, 1998). The sandbox model defines which client's resources are accessible by a Java program, and it is usually the responsibility of the system administrator to establish the boundaries of the sandbox. A minimal sandbox, which contains resources necessary for a program to execute, contains a CPU, I/O devices (e.g., screen, keyboard, mouse), and memory. A program might also have access to additional resources, however, such as the file system, Web server, other machines on the network, a network printer, and data that flows across the network.

The boundaries of the sandbox, and thus the extent to which each resource is protected, can severely restrict the functionality a developer builds into a Web-based program. This is particularly true for programs not installed on the client machine but instead that execute on an un-trusted server across the Internet. For example, remote programs would likely not be given access to a client machine's file system, which means a user will not be able to execute a simple Save command.

Diversity of Users

Due to the potentially enormous user population, Web-based application developers that are tuned to issues of usability must consider the various learning styles of an extremely wide range of users. For example, Chen and Rada (1996) conducted a meta-study of 23 hypertext usability studies, and one of their goals was to determine how efficient and effective hypertext was for various users. Part of this research provides a fascinating look at factors which can "have influential power on users' browsing strategies and the outcome of interactions" (p. 129) while using hypertext systems (such as the Web). Among the user differences that Chen and Rada identify as having the potential to significantly effect how successfully users interact with a hypertext system are:

- *Differences in cognitive style.* An example illustrating different cognitive styles is a user that has an internal locus of control (LOC)—where user believes he or she controls events in system—versus a user that has an external LOC—user believes context controls events in system.
- *Differences in spatial ability.*
- *Differences in domain knowledge.*

It is not hard to imagine how user differences such as these might influence a usability-conscious software developer. For instance, within the category of spatial ability listed above, some researchers have discovered that users with lower visualization ability tend to use top-level table of contents selections frequently (Campagnoni & Ehrlich, 1989). Therefore, if hypertext system developers had a smaller, better defined user group to work with and they knew that the people in that group had low visualization ability, then they would probably opt to use top-level table of contents structures throughout the application where applicable. Because Web users are so numerous and therefore exhibit such an enormous range of learning styles and abilities, it is quite impractical to design systems that adequately meet all of their various usability needs.

User Testing Difficulties

Finally, as anyone familiar with user-centered design methodology can attest to, conducting frequent feedback and testing sessions of software with actual users is a critical part of the design process. Because the Web-based software population is so large and is distributed across the entire world, it is often impossible to involve a significant portion of users in the design process. One option is to gather and utilize local groups of Web users; however, developers must understand that these local groups not only represent a minuscule subset of the actual users, but also that there might be some inherent skew due to user demographics that affects the testing results. Another option available to Web-based software developers who wish to incorporate user feedback in the design process is to use the Web itself as the feedback medium, but this too is problematic. For one thing, issues like self-selection and (non-random) sampling will bias the results, as happens with the GVU survey (Kehoe & Pitkow, 1998) cited throughout this paper. Another problem with this approach is that the developer must have a working version of the software in order to distribute it via the Web and get useful feedback from users. This means that the developer will not be able to garner user comments until quite late in the design process when changes can be very costly.

In addition to the difficulties of gathering user feedback throughout the design process, Web-based software developers face the additional problem of establishing goals and benchmarks against which to test their software. Smith, Newman, and Parks (1997) identify and discuss this particular challenge in their paper about hypermedia usability. As Smith et al. note, the time needed for users to complete specific tasks is a commonly used measure of software effectiveness. However, when Web-based software is being evaluated, network bandwidth and traffic can have a large affect on the overall time, and thus can severely distort the results. Another common software evaluation measure is the number of errors committed by users as they attempt to complete given tasks. Unfortunately, this measure does not take into account the dynamic nature of both the content and structure of the Web. For example, the steps involved in completing some task may be more circuitous at one point in time than at another. This can result in a random number of errors as the user has to contend with varying amounts of information, and it will also impact the overall time needed to complete the tasks. Lastly, using either time or number of errors as testing measures undermines one of the intended purposes of the Web and of hypermedia networks in general, which is to explore the information space based on one's own pace and preferred route.

Conclusion

This chapter presents an empirical evaluation of how well existing Web-based software—including browsers, e-notebooks, graphical history displays, and document management systems—addresses users' IA needs, and motivates the need for new software to be developed. The applications included in this software review were assessed in terms of how well they allow users to gather, edit, annotate, organize, and save diverse elements from the Web, and track their ongoing work processes. We saw that Netscape and Microsoft's Internet Explorer are both seriously deficient in supporting these critical IA tasks, and while some of the other programs reviewed may contain useful individual features, no applications fully support the tasks of IA in a complete and integrated way. In summary, we cannot expect users to conduct their Web-based IA tasks using a variety of piecemeal tools that fail to form a cohesive package, may not be readily accessible, work inconsistently, and are not designed for their specific needs.

Rather than simply concluding that developers are just inept at creating necessary Web-based software, however, the last major section of this chapter analyzes reasons why developing useful and usable Web-based applications can be such a difficult undertaking. Challenges include dealing with a wide variety of complex Web page components and underlying technologies, handling new security restrictions, designing for a highly diverse user group, and conducting usability studies with a user population that is distributed around the world.

Despite these difficulties, however, it is possible to develop limited solutions to some of the technical challenges highlighted in this chapter. One such solution, a Web-based e-notebook prototype called NetNotes, is presented and described in the next chapter. As we will see, the NetNotes prototype is designed specifically to support the process of IA, and it provides an environment that is used in an experimental evaluation to determine the advantages such software may have over existing software.

CHAPTER IV

NETNOTES: A WEB-BASED E-NOTEBOOK THAT SUPPORTS IA

In the previous chapters, I argued that the process of IA is critical to many Web users and that better tools are needed to support it. Towards that end, I decided to implement my own Web-based e-notebook, called NetNotes, which is dedicated to the demands of IA. At the same time, however, I also recognize that developing Web-based software is very challenging. In fact, due to the significant list of difficulties previously outlined, I remain skeptical that a general Web-based notebook—one that is usable in conjunction with any Web site for all Web users, and that supports all key IA tasks—is possible. Consequently, the implementation of NetNotes is focused on solving only some of the problems highlighted thus far. In particular, the NetNotes prototype:

- works in connection with a specific Web domain (the Zebrafish Information Network or ZFIN),
- provides for a subset of the highest priority IA requirements,
- deals with a limited number of static, dynamic, and linked Web components (no programmed elements),
- is implemented on the client-side,
- requires minor server-side modifications, and
- has been tested by a group of biologists resident at the University of Oregon.

Although the NetNotes prototype represents only a limited solution, it provided me with direct exposure to some of the technical problems associated with implementing Web-based software, it incorporates a number of key IA requirements, and it is robust enough to be used in an experimental evaluation, detailed in Chapter V.

This chapter presents the NetNotes prototype, beginning with a brief introduction to the Zebrafish Information Network (ZFIN) (Sprague, Doerry, Douglas, & Westerfield, 2001) and reasons why this particular Web domain was targeted as the one that NetNotes works in conjunction with. Following the ZFIN description, the IA functional requirements previously identified in Chapter II Table 1 are revisited, but now include indications as to which ones are implemented in the NetNotes prototype. The bulk of the chapter, however, is dedicated to NetNotes implementation details, including descriptions of its system architecture, server-side modifications, client-side modifications, user interface and functionality. The chapter ends with a list of known bugs and limitations to be addressed in the next version of the software.

Preliminary Design

The Zebrafish Information Network

The Zebrafish Information Network Web site and associated relational database (http://zfin.org/ZFIN/), often collectively referred to simply as ZFIN, is a multimedia repository of genetics information related to the zebrafish species. While ZFIN was initially developed by a group of biologists and computer scientists resident at the University of

Oregon, it now supports an international community of researchers interested in isolating and understanding the effects of particular genes on the development of the zebrafish. The ZFIN database includes access to the following types of genetics data: fish, genes, genomics, publications, people, labs, and companies. Unregistered guests are allowed to search and browse the database, while registered users can also update certain information in the database. Figure 9 is a recent screen shot of ZFIN's home page, which gives the reader a high-level view of the types of information and functionality it supports.

There are a number of reasons why ZFIN was chosen as the domain for the NetNotes e-notebook development, including:

- ZFIN is technically complex and a real system,
- The research group to which I belong has control over ZFIN's system architecture, Web site, and database, which is needed for server-side modifications,
- Previous research (i.e., the ethnographic field study described in Chapter II) has indicated that ZFIN's user group might have strong demands for personalized Web-based e-notebooks, and
- The University of Oregon ZFIN biologists are an immediately accessible user group for feedback and testing purposes.

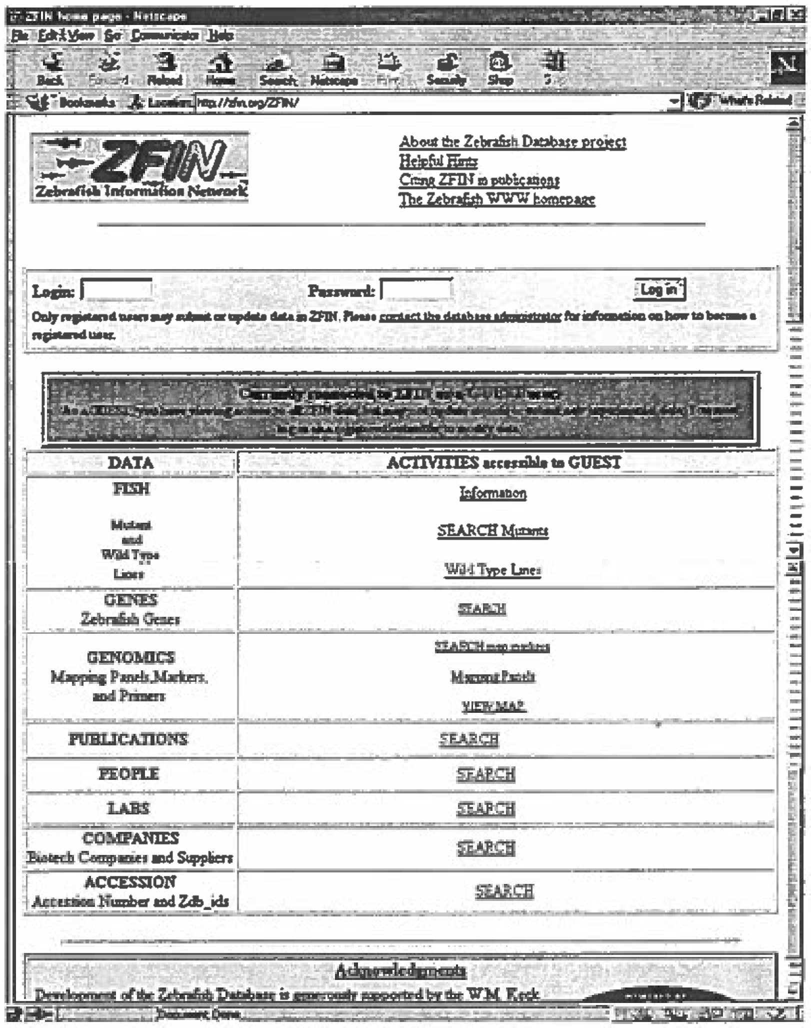


Figure 9. ZFIN Home Page[8].

[8]Netscape Communicator browser window © 2001 Communications Corporation. Used with permission. Netscape Communications has not authorized, sponsored, endorsed, or approved this publication and is not responsible for its content.

A big factor in the decision to focus my prototype implementation on the ZFIN domain is that it is a technically complex Web site. The ZFIN Web pages contain a wide variety of elements to work with—including formatted text, images, lists, tables, and hyperlinks—and these elements are supported by an underlying array of technologies, which include Informix database management, HTML, CGI, and Javascript.

Another critical consideration is that the research group to which I belong has control over the implementation of ZFIN's system architecture, Web site, and Informix database. Because some of my prototype solutions involve making server-side changes to the Web site, it is crucial that I have the necessary access to make these changes. For the development of my prototype, I was able to use a separate testing environment (http://edison.cs.uoregon.edu/ZFIN) that was an exact replica of both the ZFIN production Web site and database. This arrangement ensured that I was free to make any necessary server-side changes without affecting production.

Also contributing to the decision to use ZFIN as my prototype domain is that I had already established a working relationship with a number of the biologists who conduct genetics research at the University of Oregon. This contact was initially established during my ethnographic field study described in Chapter II. Equally important is that these biologists are immediately available for feedback and for participation in my planned experimental study (see Chapter V). As my particular area of research interest is Human-Computer Interaction (HCI) within the broader field of Computer Science, it is critical that I not only thoroughly understand the needs of actual users and base the design and implementation of related software directly on those needs, but also that I use potential future users of the system as the critical testing base.

IA Functional Requirements for NetNotes

In Chapter II Table 1, the functional requirements required for an initial version of IA software are listed. These requirements emerged from my definition of IA, which was informed primarily by my literature review and ethnography, and from an understanding of how notetaking changes in the Web environment. Table 2 shows the same list of IA functional requirements as initially posted in Table 1, but also includes checkmarks in the second column to indicate which of these requirements have been implemented in NetNotes.

As seen in Table 2, a handful of functional requirements have not been included in the initial version of NetNotes. Most of these omitted requirements pertain to the users' ability to organize their e-notes (i.e., move formatted text, images, lists, tables, and hyperlinks around within a notes page), while another has to do with the users' ability to create cross-references within their e-notes. I chose not to implement these particular requirements simply because they were time-consuming and yet not terribly interesting in terms of posing new technical or design challenges. However, these requirements are still considered to be high priority and should be included in any future robust software system designed to support IA.

Table 2. IA Functional Requirements Implemented in NetNotes

Functional Requirements	NetNotes
Gather:	
1. Users should be able to copy and paste text (both plain and formatted) statically from multiple, disparate Web pages into an e-notebook while retaining formatting.	√
2. Users should be able to copy and paste images statically from Web pages into an e-notebook page while retaining formatting.	√[a]
3. Users should be able to copy and paste lists and tables statically from Web pages into an e-notebook while retaining formatting.	√
4. Users should be able to copy and paste hyperlinks from the Web into an e-notebook while retaining formatting and functionality (i.e., hyperlinks should remain "active" in e-notebook).	√
5. Users should be able to archive Web information by having the URL, date, and time of the original source information automatically included in their e-notes. Users should not be able to modify the source or the authentication stamp for such archived information.	√
Edit:	
6. Users should be able to delete any content from their e-notebooks, including original Web elements.	√
7. Users should be able to modify (change text, format text, etc.) any content in their e-notebooks (except images), including original Web elements.	√
Annotate	
8. Users should be able to add text to or delete text from their e-notebooks.	√
9. Users should be able to emphasize or differentiate text in their e-notebooks by choosing between different font styles (e.g., bold, italic, underline) and sizes.	√
10. Users should be able to create automatic cross-references (i.e., links) from one section of their e-notes to another section of their e-notes.	—
11. Users should be able to create automatic cross-references (i.e., links) from their e-notes to any Web page.	√
Organize:	
12. Users should have multiple pages in their e-notebooks and should be able to copy Web information into any page they choose.	√
13. Users should be able to move text (plain and formatted) around in their e-notebooks while retaining formatting.	—
14. Users should be able to move images around in their e-notebooks.	—
15. Users should be able to move lists and tables around in their e-notebooks while retaining formatting.	—

16. Users should be able to move hyperlinks around in their e-notebooks while retaining formatting and functionality.	—
17. Users should be able to create separations between groups of notes.	√
18. Users should be able to name, insert and delete e-notebook pages.	√[b]
Save:	
19. Users should be able to save text (plain and formatted) in their e-notebook while retaining formatting.	√
20. Users should be able to save images in their e-notebook.	√[a]
21. Users should be able to save lists and tables in their e-notebook while retaining formatting.	√
22. Users should be able to save hyperlinks in their e-notebook while retaining formatting and functionality.	√
23. Users should be able to save archived Web information in their e-notebook.	√
Track ongoing work:	
24. Users should be able to track an ongoing Web work process in their e-notebooks so that they can easily remember the work they were doing at a later time.	√
25. Users should be able to track their current progress in an ongoing Web work process (i.e., users should be able to see how much of their initial work goals they have completed, and they should be able to gauge how much work is outstanding).	√
26. Users should be able to annotate an ongoing work process.	√
27. Users should be able to edit an ongoing work process (e.g., delete some portion of it, insert text into it, etc.).	√
28. Users should be able to restart and rejoin an ongoing Web work process from within their e-notebooks with minimal repeated work (i.e., users should not have to relocate Web pages of importance).	√

[a]Images can only be saved dynamically in NetNotes.

[b]Notebook pages can be deleted, but only by system file management applications.

Implementation Details

Prior to the design and implementation of NetNotes, I conducted some early system prototyping and usability testing on a similar system called CAJIN (Computer Assisted Journal and Integrated Notebook). Details of this system can be found in the separate publication entitled "Capturing volatile information: Server-side solutions for a WWW notebook" (Reimer & Douglas, 2001) and will not be re-iterated here. However, during the implementation of CAJIN, a number of technical glitches were uncovered that have subsequently been fixed in the NetNotes implementation. Most noticeably, the CAJIN prototype only allows one person at a time to copy Web elements from ZFIN and paste them into the e-notebook. The NetNotes system architecture has been modified accordingly so that multiple users can copy and paste without interfering with one another. Another problem with CAJIN is that when information is copied and pasted from ZFIN into the e-notebook, some elements might not transfer correctly, and the original formatting and alignment may be lost. This functionality is more robust in NetNotes. Finally, there are a number of other IA functional requirements that are simply not included in the CAJIN implementation that have been incorporated in NetNotes, including the ability for users to save images (dynamically), archive Web pages, and track their ongoing work processes.

NetNotes was implemented in Java on a Dell 8100 PC running the Windows Millennium (Me) operating system. The JDK 1.3 software development environment was used for programming, and its integrated set of Swing classes was used to represent the graphical user interface or GUI.

System Architecture

Perhaps the most important initial design decision I faced when developing NetNotes was determining how its system architecture should be configured. In particular, I had to decide how NetNotes would interact seamlessly with the ZFIN Web site and database. So, a guiding principle that I defined early on is that as many system and programming components should reside on the client machine as possible. This heuristic would ensure minimal changes to the server and to the ZFIN Web site, and thus increase the generality of the prototype solution.

Another important initial decision I made is that the NetNotes application would be kept separate from the Web browser that provides access to the ZFIN site. This software separation increases NetNotes' flexibility by allowing it to work in conjunction with any Web browser (although for this implementation it works only with Netscape), and it also lets users maintain their notebooks even when they do not want to interact with the Web. However, the decision to separate NetNotes from the Web browser also meant that a way for the two applications to communicate with each other had to be devised. This inter-application communication, which was essential for the copy/pasting of ZFIN items into NetNotes and for the tracking of ongoing work processes, posed perhaps the most difficult and interesting technical challenge in the development of NetNotes, and thus is described in more detail throughout this chapter.

A final consideration central to my system architecture design was that the NetNotes application had to support interaction with ZFIN for multiple users simultaneously. This is one example where the earlier CAJIN prototype failed; only one user could use CAJIN/ZFIN at a time, and since this proved to be a serious limitation of the system, I was determined to overcome this if possible in NetNotes. Towards that end, I eliminated a server-side text file in CAJIN's design that contained the URL of ZFIN's current page, and instead programmed ZFIN so that Netscape sends the URL to the client as a cookie. More details of this process follow later in the chapter.

The final system architecture for NetNotes, then, based on all of these considerations, is shown in Figure 10. Both the ZFIN database and its front-end Web system are implemented on the server, while the Netscape browser that loads the ZFIN Web site resides on the client machine along with the NetNotes application. A client-side cookie file and the system clipboard are also displayed in Figure 10 because they are critical to the NetNotes/ZFIN inter-process communication detailed in the next sections.

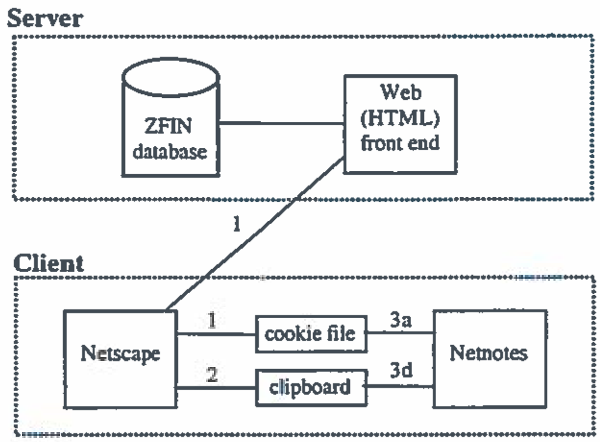


Figure 10. NetNotes and ZFIN System Architecture.

Server-Side Modifications

While the NetNotes implementation involved a number of key server-side modifications to the ZFIN Web site, no changes to the underlying relational database were necessary. All server-side modifications were required for the NetNotes/ZFIN inter-process communication (i.e., when a ZFIN selection is copied and pasted into a NetNotes page, and when a NetNotes user tracks his or her ongoing Web work processes). The following list identifies and describes the implementation details behind each of the necessary server-side modifications.

1. *Javascript functions were added to ZFIN Web pages so that the current Web page URL is sent to the client as a cookie.* Every time select ZFIN Web pages are loaded in Netscape, a set of Javascript functions execute and the current URL is sent to the client machine as a cookie. While I opted to implement this functionality using Javascript, other

programming options are also feasible, such as CGI/Perl scripts. This modification also allows NetNotes to properly handle the common ZFIN situation where the URL in the browser location field stays the same (i.e.,`http://edison.cs.uoregon.edu/ZFIN`) regardless of which page is being viewed instead of reflecting the actual location of the underlying HTML source code. It was only necessary to add the cookie related Javascript functions to one common security file that is executed by many ZFIN pages.

2. *Special HTML breakpoint tags were added to ZFIN pages to delineate copy/paste selections.* To add consistency and accuracy to selections that a user copies from a ZFIN page and pastes into a NetNotes page, special breakpoint tags were added to select ZFIN source code (i.e., HTML) in the form of `<A NAME="NetNotes breakpoint">`. These breakpoint tags are used in the NetNotes copy/paste algorithm to figure out exactly what Web page content should be copied into a NetNotes page. The exact location of the breakpoint tags in the HTML source code, and how frequently they appear, was determined based on the information displayed in the particular Web pages. In general, the more breakpoints there are, the more accurate the copy/paste function will be. Outermost breakpoints should bound the entire HTML page, but comments and Javascript code should be excluded because otherwise they will appear—but likely be undesirable—in the NetNotes page.

It should be noted that there are other more robust ways of handling this issue. For example, the Document Object Model (DOM) could be used to parse the entire HTML document (i.e., ZFIN page) into a tree structure, and the HTML tags related to a selection of text could then be determined. However, my solution is simpler to implement, and it does not detract from the functionality of the NetNotes prototype for purposes of user testing.

3. *BASE tags were added to HTML source code to resolve relative references in copied ZFIN selections.* Because the ZFIN pages are dynamically generated and have no HTML BASE tag in the source code, it was necessary to add my own BASE tag to the HTML in order to properly handle relative references for hyperlinks and images. The BASE tag that I added took the special form of `<A NAME="BASE http://edison.cs.uoregon.edu">` instead of the normal `<BASE href="http://edison.cs.uoregon.edu">` tag simply because of a bug in the JDK 1.3 which seems to completely ignore the normal form of the <BASE> tag. This server-side addition is only necessary when there are relative references in the HTML source code.

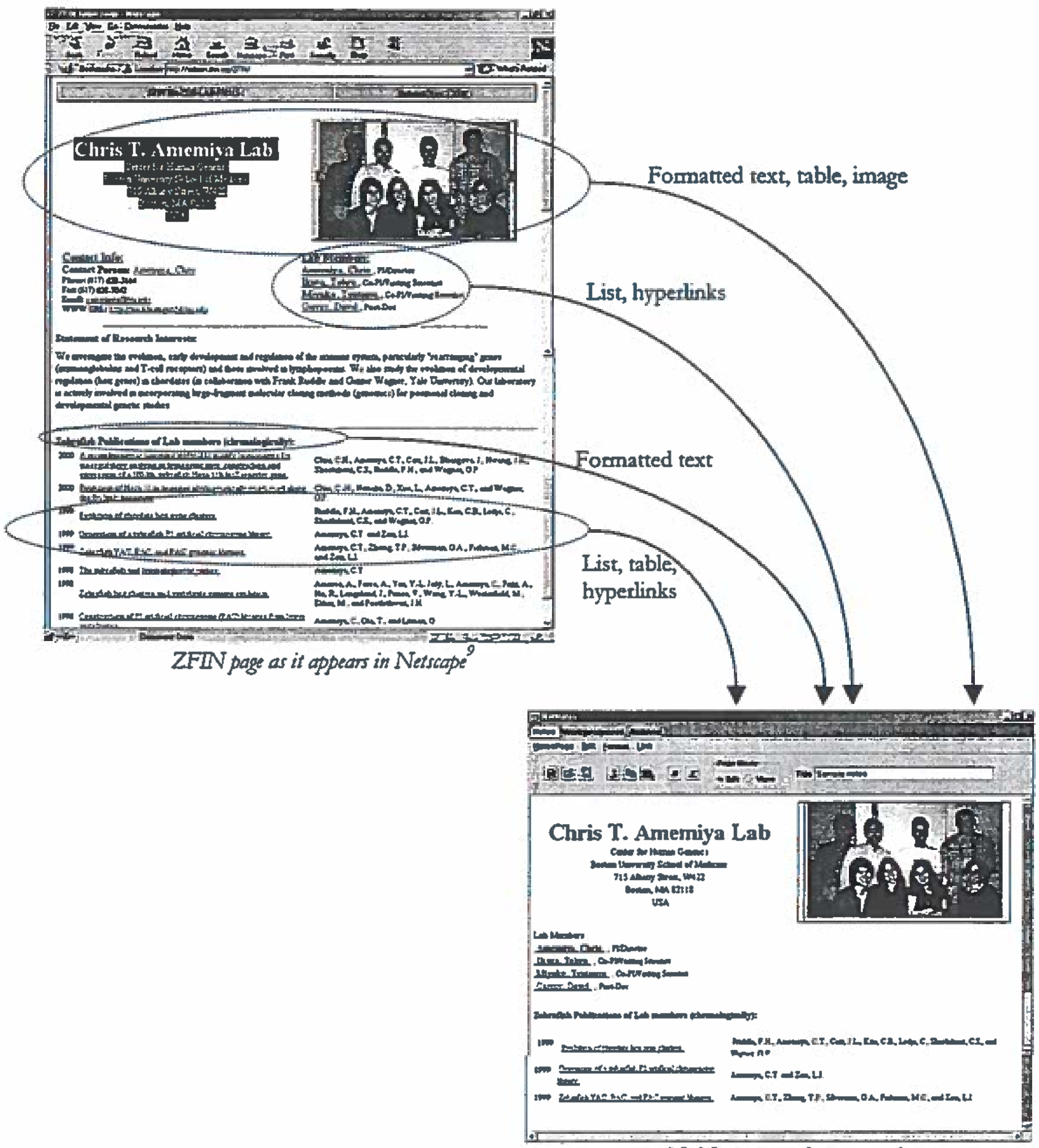
The server-side modifications just described proved to be relatively minor and easy to implement, particularly for Web sites that employ dynamically generated pages, like ZFIN. Since the generation of most of the ZFIN Web pages involves the execution of common script files, by adding my code to only a small number of files I was able to affect a large number of ZFIN Web pages.

NetNotes/ZFIN Interprocess Communication

Perhaps the most interesting technical aspects of the NetNotes implementation have to do with its interaction with ZFIN. As has been discussed repeatedly, one of the motivating factors behind the development of NetNotes was to provide users with the ability to copy and paste information from ZFIN into their notebooks. From a user interface perspective, this process is quite straightforward:

1. Users select the elements in ZFIN they want to copy by clicking and dragging the mouse over the selection;
2. With the selection highlighted, users choose the Netscape *copy* command;
3. With the mouse positioned in the appropriate spot in the notebook, users select the NetNotes *paste* command.

Figure 11 not only provides a first look at the NetNotes user interface, but more importantly, it illustrates an example of this copy and paste interaction. The upper left screen shot in Figure 11 shows a number of non-contiguous ZFIN selections as viewed in Netscape, while the lower right screen shot shows how these selections appear in NetNotes after they have been copied and pasted (each selection is copied and pasted individually). NetNotes successfully handles the copy/pasting of text (plain and formatted), images, lists, tables, and active hyperlinks.



ZFIN page as it appears in Netscape[9]

NetNotes page after copy and paste

Figure 11. Copy and Paste from ZFIN into NetNotes.

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[9]Netscape Communicator browser window © 2001 Communications Corporation. Used with permission. Netscape Communications has not authorized, sponsored, endorsed, or approved this publication and is not responsible for its content.

While the steps that a user must perform to copy and paste elements from ZFIN to NetNotes are quite simple and intuitive, as just described, the underlying program details are considerably more complex. The following algorithm describes these details, and its numbering scheme also coincides with the numbers displayed in the system architecture diagram of Figure 10.

ZFIN to NetNotes Copy/Paste Algorithm

1. When a user loads a ZFIN page in Netscape, Netscape sends a cookie of the page URL to the client machine.
2. The user selects some portion of a ZFIN page, and then chooses the Netscape *copy* command. The text portion of the selection gets sent to the client system clipboard.
3. When the user selects the NetNotes *paste* command, the NetNotes program performs the following steps:
   a.) Reads the cookie file and locates the ZFIN URL of the current Web page.
   b.) Uses the URL to read the HTML source code of the current ZFIN page.
   c.) Strips out all HTML tags and blank spaces from the ZFIN page source code while keeping track of how the stripped source code matches back to the original HTML source code. This is necessary for step 3e below.
   d.) Retrieves the clipboard text from the client system and removes all blank spaces.
   e.) Tries to match the clipboard text with the stripped source code. If match is found

then:

e1)

- The matched string is compared to the original HTML source code.
- The nearest breakpoint tags are located, forming the new HTML copy string.
- Relative references that occur in the newly built HTML copy string are resolved. The original HTML source code is searched for the special BASE tag (see server-side modification 3) and its URL portion is extracted (e.g., `http://edison.cs.uoregon.edu`). All `<A HREF="/` and `<IMG SRC="/` strings are located in the newly built HTML copy string and the relative reference is replaced with an absolute URL. For example,

  `<A HREF="/cgi-bin/webdriver?…">` becomes

  `<A HREF="http://edison.cs.uoregon.edu/cgi-bin/webdriver?…">`

  and

  `<IMG SRC="somepict.jpg">` becomes

  `<IMG SRC="http://edison.cs.uoregon.edu/somepict.jpg">`

The replacement of relative references with absolute references works on only the copied portion of HTML—as opposed to the entire original source page—to improve the efficiency of the algorithm. This algorithm is also particularly good because it correctly handles the situation where different selections from different Web sites are copied and pasted into the same NetNotes page. The alternative approach—inserting one BASE tag in the HEAD section of the underlying HTML code for the NetNotes page—results in conflicting BASE URLs when there is more than one originating Web page.

- The newly built HTML copy string is pasted into the NetNotes page where the HTML is interpreted and correctly displayed.

If a match is not found then:

e2)

- The plain clipboard text is pasted into the NetNotes page.

The other ZFIN to NetNotes interaction that occurs when NetNotes users track an ongoing Web work process is considerably simpler. In this case, the NetNotes program only needs access to the current ZFIN page URL, which it gets from the client-side cookie file.

Client-Side Modifications

In addition to the server-side modifications necessary for the ZFIN to NetNotes interaction, a number of related client-side modifications must also be made. These modifications are as follows:

- The client-side cookie file location must match the location listed in the NetNotes program code. This is critical so that NetNotes will be able to find and read the cookie file, which is necessary for obtaining the URL of the current ZFIN page.

- The client-side command to launch the Netscape program must match the NetNotes program code. This is critical so that when a user selects an active hyperlink in NetNotes, the Netscape browser will start and load the appropriate Web page (i.e., the page referred to by the link).

User Interface and Functionality

The functionality implemented in NetNotes (i.e., those requirements that are checked in Table 2) naturally fell into three different categories: notetaking functionality, functionality to track an ongoing Web work process, and functionality to archive Web pages. To simplify the user interface and keep these three categories of functions separate yet related, the NetNotes interface is designed as having three primary tabs: a Notes tab, a Work Process tab, and an Archive tab. The remainder of this section describes both the functionality and the user interface of NetNotes in terms of each of these three tabs.

Notes Tab

When the NetNotes program is started, the Notes tab is the active tab. The functionality available from this section of the notebook, as well as the appearance of the user interface (see Figure 12), is quite similar to other standard word processing programs (e.g., MS Word), although much simpler. Designing the user interface so that its layout looks like other common word processing programs was done purposefully to facilitate knowledge transfer and to make NetNotes easier to learn. The Notes tab is the section of the notebook where users generate most of their Web-based notes.

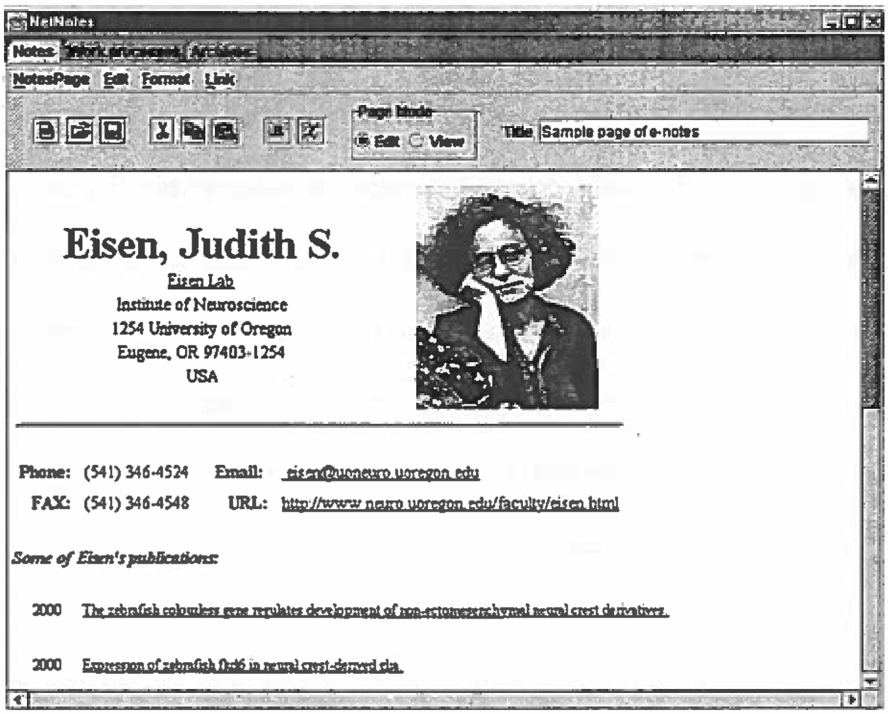


Figure 12. The Notes Section of NetNotes.

The first pull-down menu in the Notes tab, labeled *NotesPage*, allows users to create a *New* page of notes, to *Open* an existing page of notes, and to *Save* a page of notes. These same functions are also represented by small buttons on the toolbar. Both the open and save commands cause a dialog box to appear with a representation of the user's notebook as stored on his or her local system. From this system directory and file listing, the user chooses which page to either open or save. When a user chooses either the new, open, or save command, if the NetNotes program detects that perhaps the user has not yet saved the existing page of notes, a warning message will appear.

The *Edit* pull-down menu contains the standard *Cut*, *Copy*, and *Paste* commands, which are also represented via toolbar buttons. When using these commands within the notebook only (i.e., not interacting with ZFIN), they work as expected with plain text, but unfortunately not with other formatted elements. In other words, if a user selects a portion of his or her notes from within the notes page and then tries to either cut or copy and then paste that portion to a different location in the notes page, only plain text is transferred correctly. On the other hand, as mentioned previously, when users copy selections from the Web and then paste them into their notes page, formatted text, images, lists, tables, and active hyperlinks are all copied correctly.

The *Format* pull-down menu contains commands that allow users to alter the *Size* of their notes (*Regular* or *Heading*), to change the *Style* of their notes (*Italic*, *Bold*, or *Underline*), and to change the *Align*ment of their notes (*Left*, *Center*, or *Right*). While it was not my intention to create another word processing program complete with many of the same standard functions found in software like MS Word, it was important to offer users enough variety in NetNotes so that they could differentiate and highlight their notes as needed (this was an important finding from my earlier ethnographic study as well as from my literature review). The bold and italic functions are also represented by buttons on the toolbar as they are frequently used formatting commands. All formatting commands can be used on all notes regardless of whether the user created them manually (i.e., typed them in) or copied them from ZFIN.

The last available pull-down menu in the Notes section of the notebook, the *Link* menu, contains only one command called *Insert Web Link*. This command is used to insert a hyperlink (i.e., cross-reference) to a Web page in the notes page. When the command is selected, a dialog box like that shown in Figure 13 appears. The first input text field in this dialog box, which is labeled *Link to Web URL*, automatically contains the URL of the current Web (ZFIN) page. Users can either leave this URL as is or change it to something else. In the second input text field labeled *Text of link*, users enter the name they want to give the link in their notes. This name can also be subsequently edited directly in the notes.

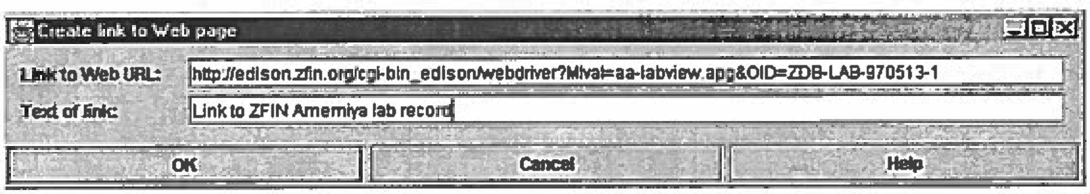


Figure 13. NetNotes Dialog Box to Create a Link to a Web Page.

The Notes toolbar also contains two *Page Mode* radio buttons, *Edit* and *View*. The primary reason for these modes is to correctly handle hyperlinks in a notes page. When the page is in edit mode, users can edit the name of hyperlinks (either links copied from the Web or created directly in the notes). When the page is in view mode, users can click on hyperlinks and the referred to page will automatically open in a new Netscape browser window. In general, when users are creating notes, the page mode should be edit, and when users are viewing or using their notes, the page mode should be view. When users select hyperlinks in a notes page, rather than having the referred to page open up in a new Netscape browser window, another approach is to have the page appear as a new page of notes in the notebook. I think this second design option is more appropriate for the long-term design and development of an e-notebook because it reinforces the notion that the user's tasks are driven from the notebook rather than from the browser.

Work Process Tab

The Work Process tab (see example in Figure 15) represents the part of the notebook designed to help users keep track of an ongoing Web work process. As users browse through various Web pages and come across a particular page that they would like to keep in their work process history list, they can simply choose the *Add work process step* command from either the pull-down menu (under *Tools*) or directly from the toolbar, which causes a dialog box like the one shown in Figure 14 to appear. This dialog box contains four key pieces of work process information, and to reduce the burden of users having to enter this information repeatedly for many different Web pages, the fields automatically contain default information when applicable.

The *Title* text field defaults to the title of the current (ZFIN) Web page, if one exists, but users can also edit this title to whatever they like. The *URL* text field also automatically defaults to the URL of the current (ZFIN) Web page, and again, users can change this if they want. The *Date & Time* text fields automatically contain the system's date and time, but users can change this information too. Lastly, the *Annotation* text area is left blank for users to associate special notes with that particular work process step. Users can also use shortcut keys to copy and paste plain text into any of the input areas.

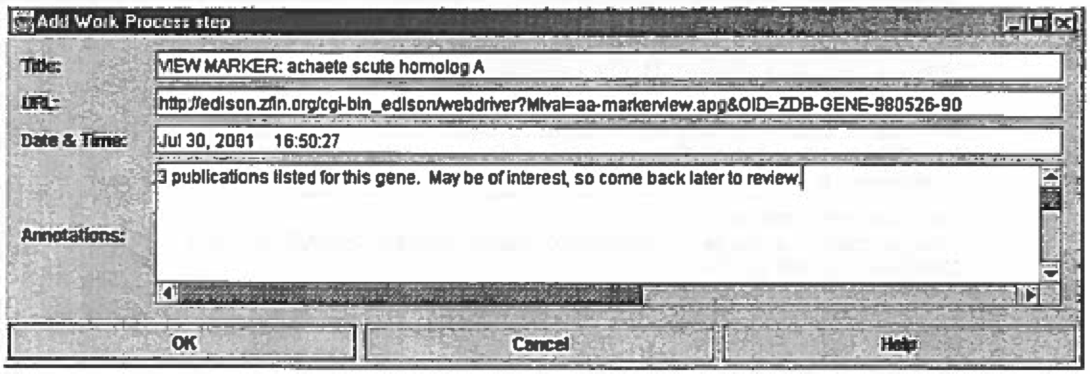


Figure 14. NetNotes Dialog Box to Add a Work Process Step.

After entering/editing the information in the work process step dialog box and selecting the OK button, the work process information is neatly inserted in the work process area of the notebook at the current location of the cursor. Figure 15 shows an example of a user's ongoing work process. In this example, four Web pages have been visited and added to the work process history list. The information that is captured and used to represent a work process in NetNotes allows users to quickly see what Web pages they visited, when they visited them, and why they visited them. Also, the fact that the Web page URLs in the work process list are stored as active hyperlinks means that users can quickly rejoin an existing work process by clicking on a link to bring up the referred to Web page. All work process information can be edited directly in the notepage, and users can insert new steps between existing ones. Users can also use shortcut keys to copy and paste plain text directly in the work process notebook page.

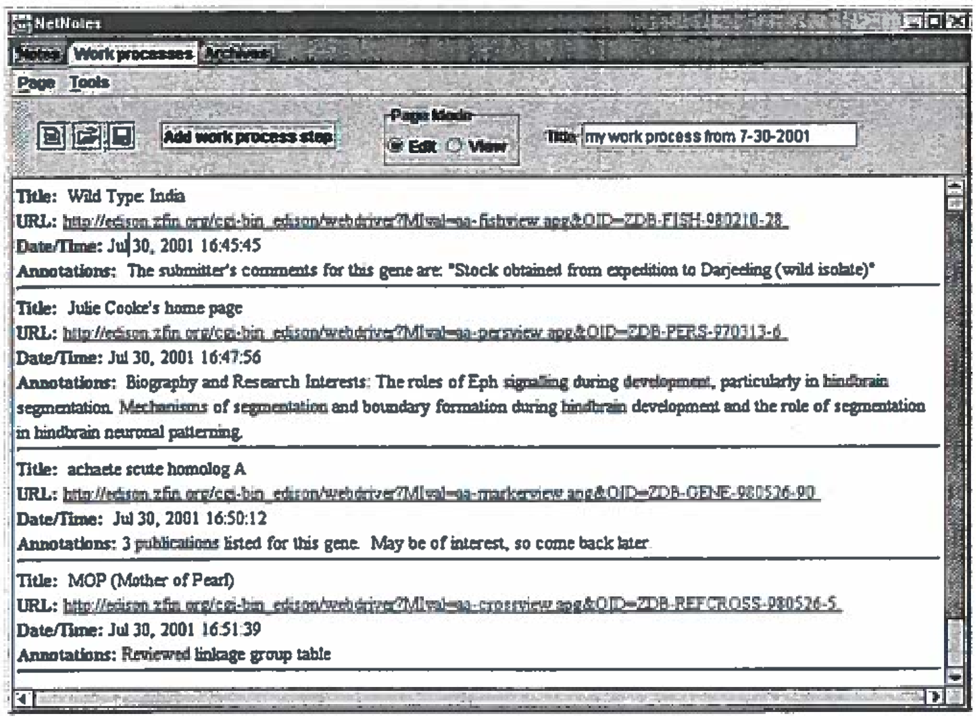


Figure 15. Example of NetNotes Work Process History.

In addition to the primary function of adding work process steps available from the Work Process section of a notebook, users can also create a *New* work process notes page, *Open* an existing work process, or *Save* a work process. Users can also choose a command under the *Tools* pull-down menu to create links to Web pages in exactly the same way as is done in the Notes section of the notebook. Lastly, the page mode functionality also works the same way as in the Notes tab; when a page is in edit mode, users can change any of its information, and when a page is in view mode, users can select hyperlinks to load the referred to page in a new browser window.

When developing the work process portion of NetNotes, I had to decide if every Web page a user visited should automatically be added to the list, or instead if users should decide which pages to add. I opted to allow the user to decide which Web pages to include in his or her work processes rather than have the process totally automated. This provides users with more flexibility and control over their own work processes, and it ensures that a work process will not become unnecessarily cluttered with unwanted information.

Another important work process design decision I faced was how to display the information. Tree structures are often used to represent a user's Web browsing history, such as in MosaicG (Ayers and Stasko, 1995), PadPrints (Hightower, Ring, Helfman, Bederson, & Hollan, 1998), and Webmap (Domel, 1994), and while I briefly considered using a tree instead of a list, I ultimately decided against it for the following reasons:

- Screen real-estate would quickly become a problem, particularly given the amount of information that I felt important to display for all Web pages represented in the work process.
- There would be increased complexity in dealing with issues of how to handle/display unrelated nodes and page re-visitations (i.e., What parent node should join two completely unrelated nodes?). This is especially relevant given my previous design decision to allow users to control what Web pages are added to their work processes, which will likely result in a large number of unrelated pages.
- Edit functionality would be more difficult to provide and might result in the tree becoming disconnected and therefore even more abstract (e.g., What happens to the tree

structure when a node is deleted? What happens if the deleted node has a parent and children, how would the tree be restructured?).

- Some users may not be familiar with interpreting certain tree structure forms.

In addition to showing the Web page title, URL, date and time of visit, and an annotation for each step in a work process, another version of NetNotes also includes thumbnail images of the Web pages. Figure 16 presents the same work process as shown in Figure 15 (taken at a different date and time) but includes thumbnail images. I thought that including these images might provide users with more cues to help them remember a work process more easily; other research corroborates this belief and indicates that thumbnail images might indeed help users recall previously visited Web pages (Robertson et al., 1998). However, the downside of including thumbnail images in a work process is that the images either have to be generated beforehand and installed locally on the client machine (which is how I implemented them in NetNotes), a process that will have to be managed frequently so that the images remain current, or the e-notebook software will have to generate the images dynamically which will increase processing time. A third possibility is the vision that, in the future, Web sites might provide their own thumbnail images of pages which programs like NetNotes could then easily download and use.

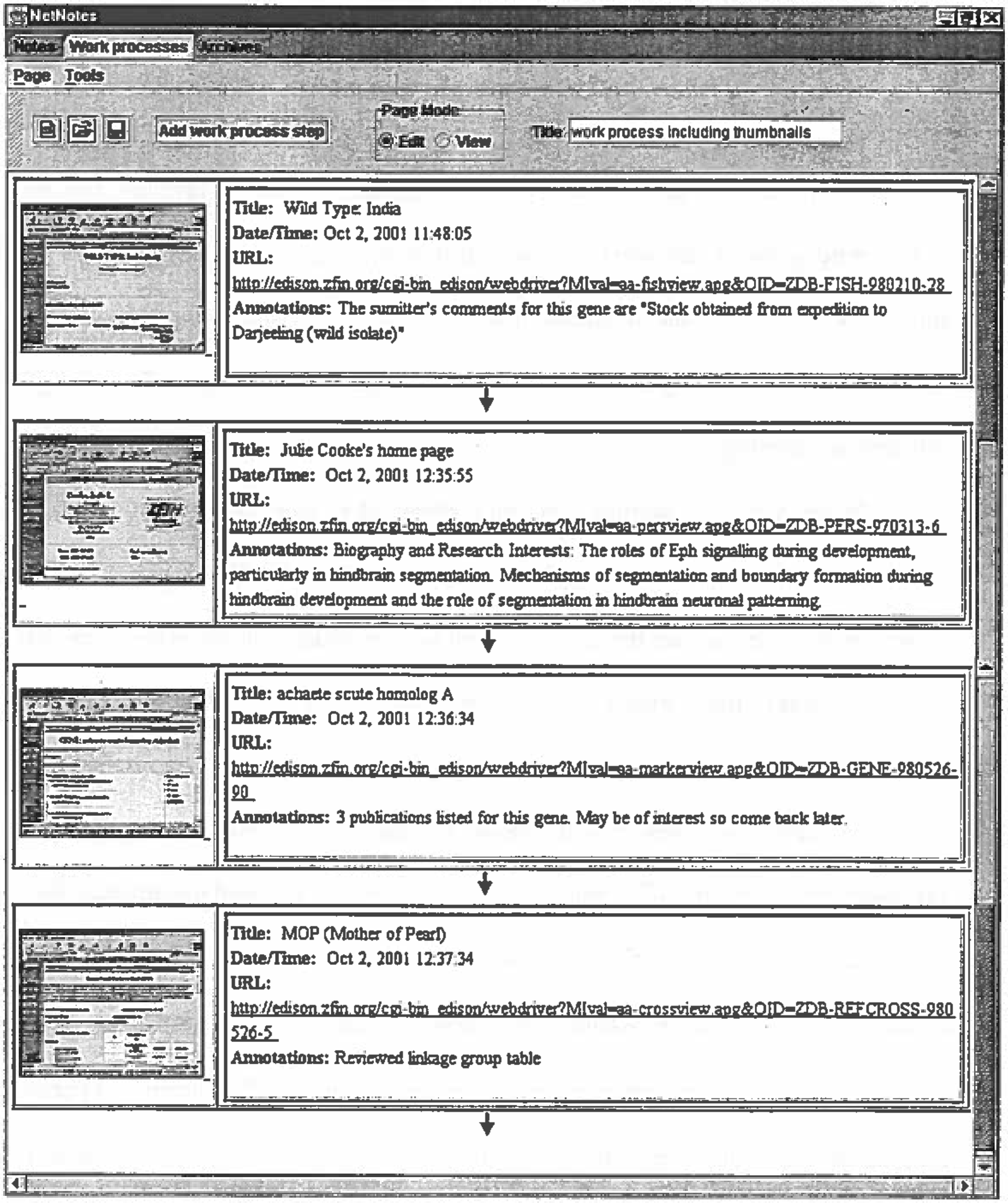


Figure 16. Thumbnail Images Included in a NetNotes Work Process.

Archives Tab

The third major section of a NetNotes notebook is the Archive tab. The Archive section is designed so that users can save entire Web pages in such a way that they can authenticate or validate the information on that page at any later point in time. This functionality is particularly useful in the Web environment since pages often change rapidly and without warning.

In NetNotes, the archive function is designed so that users can save entire Web pages at one time rather than only portions of pages. This provides users with increased context in that they can see the entire original Web page in addition to the piece that is most important to them. Figure 17 shows an example of a ZFIN Web page archived in NetNotes. Users simply have to select the *Get current Web page* button from the toolbar and the current ZFIN Web page is automatically loaded as a notebook archive page. An automatic time, date, and URL stamp is also added to the archived information for authentication purposes. NetNotes archives are not editable in any way, and when they are saved, they are stored in serializable form. This is in contrast to the way that NetNotes notes pages and work process pages are saved—which is in HTML form—to prevent users from being able to alter the archived information using another application. All archives are currently saved in the user's local system directory, but in the long term they should be saved in a special directory where users cannot access them at all except through the NetNotes program.

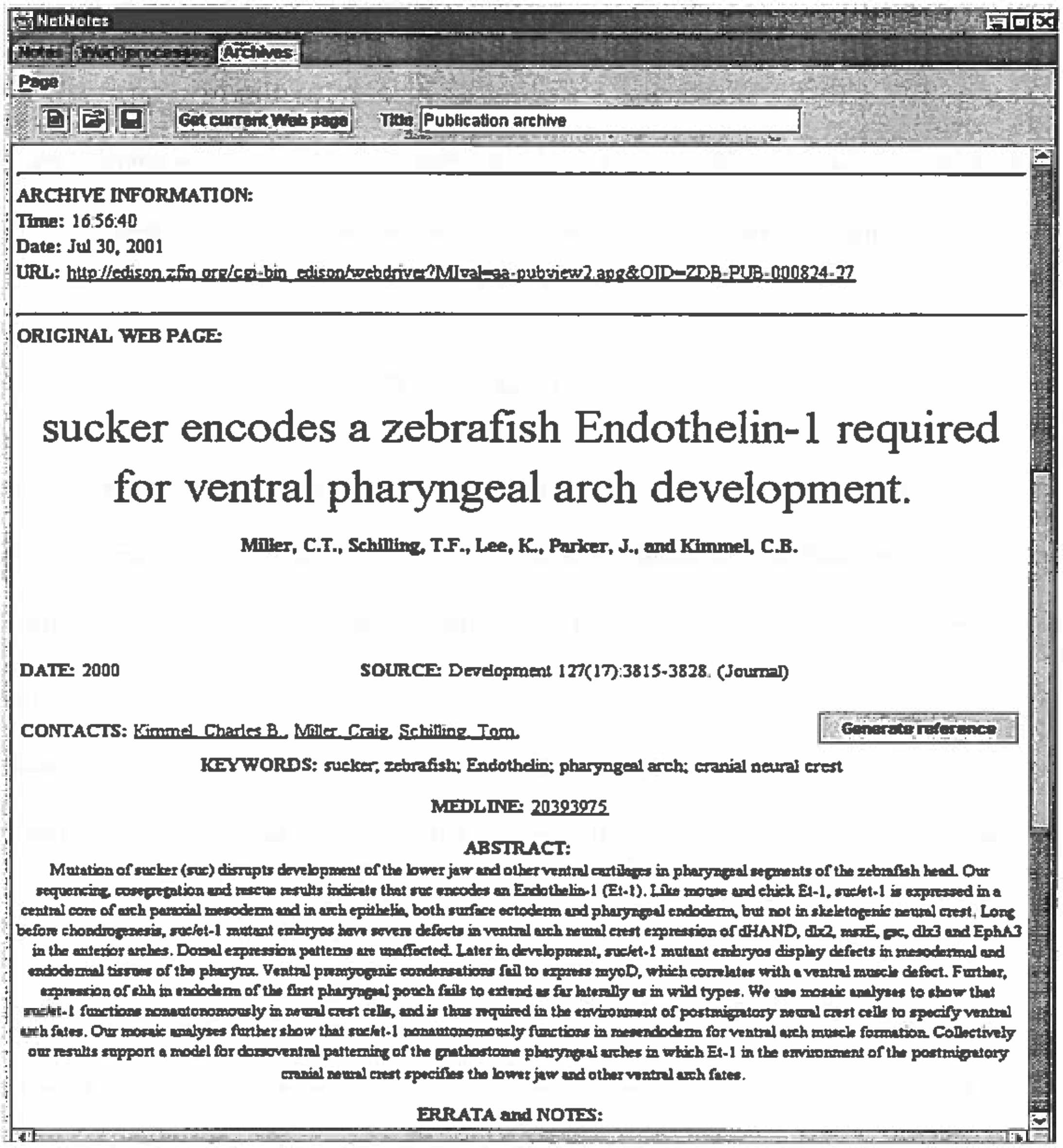


Figure 17. Example of a Web Page Archived in NetNotes.

A long-term design goal for NetNotes is to combine functionality from the three main sections of the notebook together. For example, the copy and paste functionality from the Notes portion of the notebook could complement the Work Process area of the notebook, allowing users to copy and paste formatted elements (like images and hyperlinks) from a Web page into their work process annotations. Or, users may wish to annotate their archived Web pages. Such integration should mostly be trivial since the necessary functionality is already implemented in one section of the notebook.

Known Bugs and Limitations

One of the stated purposes of developing the NetNotes prototype was to explore some of the challenges associated with implementing a Web-based e-notebook. A number of limitations were in fact discovered during the implementation of NetNotes, and they are discussed below. It would be necessary to fix most of these problems before NetNotes ever became publicly available, but for the purposes of this research and the experimental study conducted and described in the next chapter, these limitations were generally surmountable.

1. Changing the layout of information copied from the Web into a NetNotes notes page is problematic. When formatted information—such as lists and tables—is copied from a ZFIN Web page and pasted into NetNotes, the underlying HTML for that information is also transferred over to NetNotes. Because it is invisible to users, this underlying HTML can affect subsequent modifications to the layout of those notes in an undesirable way. This not only confuses users, but it also makes changing the layout of notes very difficult.

2. The ZFIN-to-NetNotes copy/paste procedure does not work correctly when there are special characters in the source Web page. For example, since the '&' (ampersand) symbol is represented in HTML source code as `&`, when a ZFIN copy/paste selection happens to contain an '&', a mismatch occurs between the system clipboard text and the underlying HTML source code that is matched in the NetNotes parsing algorithm. The clipboard text will contain the '&', but the HTML source code contains `&` instead. Possible solutions to this problem include resolving these special chars individually in the NetNotes algorithm or using a DOM-based approach as previously mentioned.
3. Images are only saved dynamically in a NetNotes page and not statically. Whenever a NetNotes page containing an image is saved, only the reference to the image is stored locally and not the actual image itself. When the notes page is re-accessed in NetNotes, the image URL is referenced to display the image. This means that if an image stored in a NetNotes page moves or changes from its originating Web location, there will be a dead link in the notes and no image will appear.
4. The Java Swing classes `editorPane` and `HTMLEditorKit` have difficulty correctly handling font sizes. In a NetNotes notes page, multiple sized fonts are supported in what appears to be an appropriate manner. For example, if a user selects some text and changes its font size to 18 point, the change seems appropriately reflected in the notes page. However, when that text is subsequently saved (as HTML), the stored HTML code becomes `<FONT SIZE="18">`. The next time this page is loaded in NetNotes, the font size of that text is huge (much bigger than normal font size 18). So, to get around this

problem, whenever a notes page is saved, I translate all font sizes as follows:

```
<FONT SIZE="10">    becomes    <FONT SIZE="-1">
<FONT SIZE="12">    becomes    <FONT SIZE="+0">
<FONT SIZE="18">    becomes    <FONT SIZE="+1">
<FONT SIZE="24">    becomes    <FONT SIZE="+2">
```

This temporary fix seems to work, and when saved pages are re-accessed in NetNotes, the font sizes appear normal.

Conclusion

This chapter presents NetNotes, a Web-based e-notebook prototype system designed to support the process of Information Assimilation (IA). The purpose of developing NetNotes was twofold: 1) I wanted to explore some of the programming and design challenging associated with implementing Web-based software, particularly software that addresses many critical IA requirements, and 2) I wanted to develop a prototype system robust enough to be used in an experimental evaluation. Both of these goals were met.

Perhaps the most interesting technical challenge I faced in the NetNotes implementation was dealing with the interaction between Netscape (i.e., ZFIN) and NetNotes. Ultimately, this interaction was made possible by a few, relatively minor server-side modifications, and its benefits include allowing users to copy and paste various Web elements into their e-notes and to track their ongoing work processes. Notable design challenges I confronted while developing NetNotes included figuring out a way to allow users to both edit their notes and to view hyperlinks in their notes (i.e., how would the program know when a user wished to edit a hyperlink versus view the hyperlink?). This was resolved by the introduction of two page modes, edit mode and view mode. Another design challenge was deciding how to display work process representations. The next chapter presents an experimental study I conducted using the NetNotes prototype to determine how software designed specifically to support IA compares to other existing software.

CHAPTER V

EXPERIMENTAL STUDY

The purpose of the experimental evaluation described in this chapter is to determine the extent to which a software application designed specifically to support the process of IA (i.e., NetNotes) affects a user's ability to generate and use a set of Web-based notes. In particular, this experiment is designed to evaluate whether scientists currently have adequate support for their Web-based notetaking tasks, and whether a software application designed specifically to support such tasks will be an improvement over existing systems by increasing user productivity, decreasing cognitive effort, and increasing user satisfaction. As a reminder, the high-level definition of IA includes the users' ability to:

- Gather text (plain and formatted), images, lists, tables and hyperlinks from the Web into an e-notebook while retaining original formatting and functionality,
- Edit original elements as stored in the notebook,
- Annotate notebook contents,
- Organize notebook contents,
- Save notebook contents, and
- Track and save ongoing Web work processes.

To observe scientists' Web-based notetaking practices and to achieve the goals just mentioned, I designed a between-subjects experiment using 20 biologists from the Institute of Neuroscience at the University of Oregon. Half of the biologists in this study represented the experimental or NetNotes group, and they were asked to complete a set of ZFIN-related IA tasks using the NetNotes prototype. The remaining participants represented the control group, and they were asked to complete the same set of IA tasks using their normal software applications. Dependent variables for the experiment included task completion percentages, time to complete the tasks, the effectiveness of the notes created, number of software transitions, perceived effort, and user satisfaction.

This experiment was designed as a between-subjects experiment—as opposed to using a within-subjects design—for two primary reasons: 1) to avoid the effects of learning, which can be a confounding factor that skews the results if not handled properly, and 2) there were many IA tasks that I wanted to include in the experiment that would have to be removed for a within-subjects design; otherwise, it would simply take too long for each subject to participate. However, as noted in the discussion section of this chapter and in the conclusion, a carefully designed within-subjects experiment is also feasible, and may in fact produce more significant results for some of the dependent variables.

The results of this experiment are complex and rather mixed. Task completion measurements show that NetNotes users were significantly more productive with certain tasks than participants who used their normal software (i.e., the control group). Furthermore, NetNotes users expended significantly less cognitive effort than the control group to complete certain tasks as evidenced by higher degrees of user satisfaction with effort required. Nevertheless, no significant differences were discovered between the NetNotes group and the control group in terms of how satisfied participants were completing the tasks with the available software; additionally, for other tasks, differences in productivity and cognitive effort also were not significant.

The experimental study presented in this chapter is considered to be an initial success, particularly given its overall complexity and the organizational challenges that had to be overcome. It represents a crucial first step in building a foundation for further research in the area of Web-based notetaking, and the lessons learned from its novel design can be applied towards new experimental studies.

Hypotheses and Dependent Measures

This experiment is designed based on the belief that the NetNotes system, which was developed specifically to support the process of IA, would be an improvement over existing software. The primary hypothesis of this experiment is as follows:

NetNotes will support the completion of certain Web-based IA tasks better than current software tools by increasing user productivity, decreasing user cognitive effort, and increasing user satisfaction.

I attempt to demonstrate this main hypothesis using the following sub-hypotheses and dependent measures (shown in italics). The results section of this chapter describes in more detail what the dependent measures are and how they were assessed.

Increased productivity

1. The NetNotes group will have higher *task completion percentages* than the control group.
2. The NetNotes group will be able to complete the tasks in less *time* than the control group.
3. The NetNotes group will be able to create a more *effective* set of notes than the control group.

Decreased cognitive effort

4. The NetNotes group will require fewer *transitions* between software applications when completing the tasks.
5. The NetNotes group will report less *effort* (i.e., more satisfaction with effort required) required to complete the tasks with the available software than the control group.

Increased user satisfaction

6. The NetNotes group will report a higher degree of *user satisfaction* completing the tasks with the available software than the control group.

Participants

Because the NetNotes prototype works in conjunction with the ZFIN Web site and relational database, and since my previous ethnographic study focused on how biologists engage in scientific notetaking, a total of 20 biologists were recruited to participate in this experiment. This group consisted of 6 post-doctoral researchers, 4 graduate students, and 10 research staff, and together they represented the four primary labs from the Institute of Neuroscience at the University of Oregon. The only necessary criteria for participation in this experiment was an affiliation with the Institute of Neuroscience at the University of Oregon and a familiarity with browsing the Web using Netscape. Individual emails were sent to each of the 41 possible candidates asking for volunteers. Each email provided candidates with a high-level overview of the experiment and the time commitment necessary, and assured recruits that their participation was completely voluntary. Approximately 28-30 recruits responded to the emails, of which 20 agreed to participate in the experiment. A full application to conduct this experiment was submitted and approved by the Human Subjects Compliance Office at the University of Oregon.

Responses from one of the experimental questionnaires used (questionnaires are listed in their entirety in Appendix A) indicate that the participants are extremely computer literate. As Table 3 shows, most respondents use a variety of different software applications on a regular basis, including sophisticated applications like Adobe

Photoshop. We also see that most participants browse the Web daily for general purposes, have had considerable exposure to the ZFIN Web site, and rate their Netscape expertise at average or above. Furthermore, all participants report a frequent desire to record notes based on information they find on the Web.

Table 3. Participant Software Use and Expertise

Code #	**Apps most frequently used**	**General purpose Web browsing (frequency)**	**ZFIN Web site usage (frequency)**	**Netscape expertise (none)1–7(expert)**	**Want to record Web notes (frequency)**
10051NN	Netscape, IE, Word, Photoshop	Daily	Weekly	4	Daily
10052NN	Netscape, IE, Word, NIH Image	Daily	Yearly	4	Monthly
16051NN	{*left blank*}	Daily	Yearly	4	Monthly
17052NN	Word, Excel, Filemaker Pro	Daily	Monthly	4	Monthly
17053NN	Stickies, Word, Wordperfect, SimpleText	Daily	Monthly	5	Weekly
18052NN	Netscape	Daily	Monthly	6	Weekly
22051NN	{*left blank*}	Daily	{*left blank*}	4	Weekly
24051NN	Netscape, IE, Acrobat Reader	Daily	Monthly	4	Weekly
24052NN	Netscape, Word, Photoshop	Daily	Daily	5	Daily
24053NN	Word, SimpleText	Daily	Weekly	5	Daily
11051C	Word, Photoshop, PowerPoint, Excel, Canvas	Daily	between Weekly & Monthly	4	Monthly

11052C	Word, Telnet, Netscape, Photoshop	Daily	Monthly	6	Daily
15051C	Photoshop, IE, Eudora, Word	Daily	Yearly	5	Weekly
15052C	Photoshop, MS Office, Eudora, IE, Netscape	Daily	Monthly	6	Daily
17051C	Filemaker Pro, Netscape, Word, Eudora, Photoshop, Excel, Visual Page	Daily	Monthly	5	Weekly
18051C	Word, Netscape, Photoshop, Canvas, PowerPoint, Acrobat Reader, Eudora, Excel	Weekly	Monthly	3	Monthly
18053C	Word, Photoshop, End Note, Eudora, Netscape, PowerPoint	Daily	Every few months	3	Weekly
25051C	Mac Stickies, Notepad, Word, bookmarks	Daily	3 times a year	5	Weekly
25052C	{*left blank*}	Daily	Weekly	3	Monthly
25053C	BBedit, SimpleText, Word, Canvas, Photoshop, DNAstrider	Daily	Weekly	5	Daily

Procedure

The 20 participants were randomly divided into two groups of 10. The first group—the experimental or NetNotes group—was asked to complete a set of Web-based (i.e., ZFIN) IA tasks using the NetNotes prototype. The second group—the control group—was asked to complete the same tasks using their normal software applications. No restrictions were placed on which applications the control group could use during the experiment, but all participants were told that their final notes must be in electronic form.

The experiment consisted of two separate sessions held approximately 2-4 weeks apart. The main purpose of the first session was to observe how participants were able to create a set of IA notes, and the purpose of the second session was to test how effective or useful those notes were. For the NetNotes group, both sessions of the experiment took place in the Human-Computer Interaction Video Lab in the Department of Computer and Information Science at the University of Oregon; for control group participants, both experimental sessions took place at the machine where they normally access the Web while at work. The decision to have the control group participate in the experiment at their everyday work area was difficult to organize and to execute, and yet it was necessary for observing how scientists complete the tasks using their normal software tools. On the other hand, it was not practical (or necessary) to have the NetNotes subjects participate in the experiment at their normal work areas since this would have meant installing and re-configuring the NetNotes application on each user's personal machine. It is arguable that the difference in experimental locations might introduce a confounding factor and skew the results; however, any such bias would primarily favor the control group since they are already familiar with their own work environments and software applications while the experimental group was asked to use an unfamiliar machine and a new program (NetNotes).

All NetNotes participants completed the experiment using a Dell PC running the Windows Millennium (Me) operating system at a speed of 1.1 GHz. The only software applications used by NetNotes participants during the experiment were the NetNotes prototype and Netscape 4.7. Since the control group participated in the experiment at their normal work Web machine, their resources were varied, as shown in Table 4. While the NetNotes participants using the Dell PC had access to a very fast machine with a recent version of the Netscape Web browser, Table 4 shows that the control group's resources were also quite current. Any potential differences between the two groups in terms of the speed at which they were able to complete the tasks that might be attributed to hardware or software resources are deemed minimal in this experiment.

Table 4. Hardware and Software Resources Used by Control Group Participants

Code #	Hardware	Software applications used during experiment
11051C	Mac PowerPC G3, 400 MHz	Mac OS 8.5.1, Netscape 6.0, Netscape 4.0, Word 98, Canvas 6, Photoshop 5.0
11052C	Power Macintosh G3, 266 MHz	Mac OS 9.0.4, Netscape 4.7, Word 98
15051C	PC, Pentium III 750 MHz	Windows 98 OS, Netscape 4.77, Word 2000, Photoshop 5.5, Internet Explorer 5.5
15052C	Mac Powerbook G3, 333 MHz	Mac OS 9, Netscape 4.6, Word 2001, Internet Explorer 4.5
17051C	Mac PowerPC G3, 350 MHz	Mac OS 9, Netscape 4.7, Word 2001, Notepad 9.0, Photoshop 3.0
18051C	Mac Powerbook G3, 400 MHz	Mac OS 8.6, Netscape 4.5, Word 98, Photoshop 5.0
18053C	Mac PowerPC G4, 450 MHz	Mac OS 9.0.4, Netscape 4.73, Word 2001
25051C	Power Macintosh G3, 266 MHz	Mac OS 9.0.4, Netscape 4.7, Word 98, Internet Explorer 5
25052C	Power Macintosh G3, 266 MHz	Mac OS 9.0.4, Netscape 4.7, Eudora Light 3.1
25053C	Mac Powerbook G3, 400 MHz	Mac OS 9, BBedit Lite 4.6, Netscape 4.08, Word 2001, SimpleText 1.4

All participants were video and audio taped as they worked through the given tasks on an individual basis. To record the control group participants, a portable 8mm camcorder with built-in microphone was used. This camcorder was set-up on a tripod in the normal workspace of each participant, and its lens was focused on the computer screen. After each experimental session was over, the 8mm video/audio tape of that session was re-recorded onto a VHS tape to facilitate later analysis.

Each participant in the NetNotes group was videotaped using 2 separate cameras: 1 camera situated to the back right of the participant and focused on the computer screen, the other camera situated to the left of the participant and focused on the participant's entire body, the desk, and the computer. Each NetNotes participant also wore a microphone. Both camera feeds were passed through a Picture-in-Picture (P-I-P) device, and the output from the P-I-P player was fed together with the audio feed into a VCR, where a VHS recording was made. The main picture recorded for NetNotes participants was the view of the computer screen, and the sub-picture (i.e., the P-I-P inset) contained the side view of the participant, desk, and computer.

Experimental Session 1

The first experimental session took between 60-120 minutes per participant. When participants first arrived (or, in the case of the control group, after I arrived at the participants' workspace and finished setting up the camera), they were welcomed and asked to read and sign two forms giving their consent to participate in all aspects of the experiment, including being video and audio taped (consent forms are shown in their entirety in Appendix A). Participants were then presented with an overview of session 1 (see Appendix A), and together we reviewed each point on the list.

All subjects were told that once the experiment started, they would be given two ZFIN related research scenarios to complete, and that their goal was to create a set of electronic notes to support their research tasks. Participants in the control group were asked to employ their typical notetaking practices and software tools to complete the tasks, and they were told that there were no constraints as to which applications they could use, or how many. NetNotes participants were instructed to use only the NetNotes prototype and the Netscape Web browser to complete the tasks. All participants were told that the notes they created had to be in electronic form and could not include printouts or handwritten notes.

Participants were told that as they worked through the research scenarios, if they came across a task that they did not completely understand, they should simply try to figure it out to the best of their ability by keeping in mind the overall goal of the experiment (i.e., to generate a set of electronic notes that best supports the research tasks). In the case where participants are unable to complete a task as requested, they were asked first to spend a reasonable amount of time trying, and then to move on to the next task. All participants were encouraged to think aloud as they completed the experiment, but only if doing so was not distracting to them. Participants were also instructed to complete the tasks in the order they were given and not to skip around. For both scenarios 1 and 2, tasks were located on separate pages to facilitate the recording of time per task.

Each NetNotes participant received approximately 5-10 minutes of general training on the NetNotes prototype prior to the commencement of the experiment. These participants were not trained on specific tasks, but instead were given a verbal description of all the available functions in the prototype. The NetNotes participants were then encouraged to spend a few minutes getting comfortable with the prototype and to try using as many functions as they liked. All questions that the NetNotes users had pertaining to the prototype's functionality were answered in a direct and straightforward manner.

Before NetNotes participants began working on the experimental tasks, the Netscape history and cache memory were cleared (this operation was only critical for the NetNotes group since all participants used the same machine), and Netscape was made the active application on the desktop while NetNotes ran in the background. For the control group, participants were encouraged to launch any and all software applications they thought they might want to use to generate their notes, and after doing so, Netscape was also made the active application.

Once participants were ready to begin the tasks and had no other questions, the video and audio recording was started. During each session, I remained in the same room as the participants in order to monitor time and the video cameras. However, participants were reminded that once the experiment began, I would not be able to answer any questions or help them in any way until they finished both scenarios.

After finishing each of the two research scenarios, participants were asked to fill out a brief After-Scenario Questionnaire or ASQ (Lewis, 1995). These ASQs were designed to assess the degree of satisfaction users felt completing the tasks with the available tools, how satisfied participants were with the amount of effort they needed to expend to complete the tasks, and the purported need for Web-based notetaking tools. As seen in Appendix A, where the ASQs are listed in their entireties, most of the questions are based on a 7-point scale where 1 represents strong disagreement (or dissatisfaction) and 7 represents strong agreement (or satisfaction).

Upon completion of all the tasks in both research scenarios, along with the two questionnaires, each participant was asked to comment informally about his or her Web-based notetaking practices and about the tasks they just completed. Lastly, each participant was asked to save his or her notes in a secure location and to refrain from discussing the experiment with other biologists.

Tasks

Two research scenarios were given to each participant during session 1. These research scenarios, which are based entirely on the ZFIN Web site for reasons previously discussed, are presented in their entirety in Appendix A. The first research scenario is comprised of 5 tasks and focuses on the creation of a set of Web-based notes. In general, participants were asked to locate specific information in ZFIN, and then to record and edit that information in their electronic notes. Scenario 1 was designed to encompass as many IA tasks as realistically possible, as illustrated in Table 5. For example, task 1 asks participants to locate the Amemiya lab page in ZFIN, and then to record in their notes the lab name, address, members, and what the members look like. From an IA perspective, this task tests how well participants were able to gather and save text (plain and formatted) and a stand-alone image from the Web in their notes. The last column in Table 5 cross-references the primary IA goals for each task with the IA functional requirement numbers previously listed in Chapter IV Table

2, and shows that many original IA requirements are covered by one task or another.

Table 5. Scenario 1 (Notes Generation) Tasks

Task	Description	Primary IA goals	Table 2 Req #
1	• Locate Amemiya lab page in ZFIN • Record lab name and address in notes • Record who lab members are in notes • Record what lab members look like • Save your notes	• Gather text (plain & formatted) • Gather a stand-alone image • Save text (plain & formatted) • Save image	1, 2[a], 19, 20[a], 18
2	• Locate Amemiya lab publications • Record only 1999 publications in notes including the year, hyperlink title, and authors • Enter a heading for these publications in your notes • Save your notes	• Gather active hyperlinks • Gather list • Add text • Format text • Save active hyperlinks • Save list	4, 3, 8, 9, 22, 21
3	• Change the hyperlink title of the publication *Evolution of chordate hox gene clusters* in your notes to *chordate hox*. • Save your notes	• Edit a hyperlink	7
4	• Find the page for the mutant fish with Allele b104 • Record the full name and the development table for this fish in your notes • Save your notes	• Gather table of images • Gather table of text • Save table of images • Save table of text	3, 2[a], 21, 20[a]
5	• Find primary publication page for the Mutant Spadetail fish • Create a link to this page in your notes • Name the link Mutant Spadetail and surround it with meaningful text • Save your notes	• Create a cross-reference (link) to a Web page from within notes • Annotate link	11, 8

[a]Images are gathered and saved dynamically in NetNotes, not statically.

Research scenario 2 was comprised of 4 tasks and focused on tracking an ongoing Web work process. Participants were asked to locate 4 different ZFIN pages, and then to record and save the following work process information about each page: the page title, URL, date and time of visit, and an annotation. These tasks encompass IA functional requirement numbers 24, 26, and 27, as listed in Table 2.

Experimental Session 2

Approximately 2-4 weeks after the first session, each participant reconvened for the second experimental session, which took between 30-45 minutes. The goal of session 2 was to determine the effectiveness of the notes that participants created during session 1, which was done by observing how many related test questions participants could answer correctly using only their notes.

Like session 1, when participants arrived for the second session, they were welcomed, asked to read and sign another consent form (see Appendix B), and then together we discussed an overview of the second experimental session (see Appendix B). All participants were told that they would be given a set of test questions relating to the information they gathered during the first experimental session, and that their goal was to try and answer as many of the questions correctly as possible by deferring first to the notes they created during session 1. If they were unable to access the answer from their notes, participants were told that they should then re-locate the answer on the ZFIN Web site. Participants were also told that if they had hyperlinks in their notes, they should feel free to use them to load Web pages that might contain the answer to a question.

Each NetNotes participant received a brief refresher on the NetNotes functionality, particularly how to view any hyperlinks that might be contained within their notes. For the NetNotes group, the Netscape history and cache memory were cleared, the notes that the participant created during session 1 were opened, and NetNotes was made the active application while Netscape ran in the background. The control group participants opened the notes they created during session 1 and kept those notes as the active application while Netscape ran in the background.

Once a participant was ready to begin the tests and had no other questions, the cameras were started. The video and audio taping was set-up exactly the same way as in session 1. As during session 1, I remained in the same room as the participants in order to monitor time and the video cameras. Participants were again reminded that once the testing started, I would not be able to answer any questions or to help them in any way until they were done. Upon completion of both tests, each participant was thanked and asked to refrain from discussing the experiment with other biologists.

<u>Tasks</u>

During the second experimental session, participants were given two sets of test questions to answer. The first test contained a total of four questions relating to research scenario 1 (i.e., notes generation tasks) from session 1, and the second set contained three questions relating to research scenario 2 (i.e., work process tracking tasks) from session 1. Appendix B shows both tests in their entirety.

Each test question was designed to focus on one (or more) of the IA tasks from the first session study, and on the IA functionality implemented in NetNotes and shown in Chapter IV Table 2. For example, the first task in session 1 scenario 1 was to gather information about a particular ZFIN lab—information that included the lab's name and address, who the lab members are, and what the lab members look like. The associated question on session 2 test 1, which asked *What kind of shirt is the man in the back row, right hand side wearing (in the Amemiya lab group photo)?*, was intended to target whether or not participants were able to successfully copy the picture of lab members into their notes. Participants who were successful would only have to refer to their notes to answer the question, while those not successful would presumably have to re-access the lab page and the picture in the ZFIN Web site. Table 6 lists all of the questions on both tests, along with reasons why the questions were included and the Table 2 requirements that they tested.

The format of the test questions included multiple choice, short answer, and matching. Participants were not expected to know answers to any of the questions without using either their notes or ZFIN, and in fact I selected rather obscure questions in an attempt to avoid this possibility. However, just to be sure, each test question was followed with a secondary question that asked, *Could you have answered this question with certainty without referring to either your notes or to ZFIN?* If participants answered yes to any of these secondary questions, that test question was excluded from the data analysis. Since the answers to all questions were readily available from either a participant's set of notes or from ZFIN, all wrong answers were also excluded from the data analysis. All test questions were located on separate pages to facilitate the recording of time.

Table 6. Session 2 Test Questions

Test / Question #	Question	Point of question *Were participants successful…*
1/1	What kind of shirt is the man in the back row, right hand side wearing (in the Amemiya lab group photo)?	…copying and saving a stand-alone image in their notes? (Table 2, reqs: 2, 20)
1/2	What is the SOURCE listed on the ZFIN publication abstract page for the primary publication of the Mutant Spadetail?	…creating, annotating, and saving an active hyperlink in their notes? (Table 2, reqs: 11, 8, 22, 19)
1/3	What is the MEDLINE number listed on the ZFIN abstract page for the 1999 Amemiya paper entitled "Zebrafish YAC, BAC, and PAC genomic libraries"?	…copying and saving active publication hyperlinks in their notes? (Table 2, reqs: 4, 22)
1/4	Match each of the Mutant Spadetail's development images with the correct Development Stage.	…copying and saving a table of embedded images and text in their notes? (Table 2, reqs: 3, 2, 1, 21, 20, 19)
2/1	List the titles for all the ZFIN pages you kept track of during your scenario 2 work process, in the order that you visited them from first to last.	…recording what Web pages they visited and when? (Table 2, req: 24)
2/2	Why did you visit the asha gene page last time during your scenario 2 work process?	…recording annotations for Web pages they visited? (Table 2, req: 26)
2/3	What is Julie Cooke's FAX number?	…recording URLs that help them re-access previously visited Web pages easily and quickly? (Table 2, req: 28)

Pilot Studies

Prior to conducting the actual experimental sessions with the University of Oregon biologists, 4 pilot studies were executed. Two computer science graduate students, 1 computer science visiting assistant professor, and 1 ZFIN developer were recruited for these pilot studies. The goal of the pilot studies was to help troubleshoot and refine my experimental testing instruments and procedures (i.e., questionnaires, task instructions, etc.), and to find existing usability and technical bugs in the NetNotes program. Of the 4 pilot participants, 3 were assigned to the NetNotes group, and 1 to the control group. This uneven assignment was purposeful as I was most concerned with uncovering potential problems with the NetNotes prototype. Two of the pilot sessions were video and audio taped (1 for a NetNotes participant, 1 for a control group participant), and only one study session per participant was conducted (as opposed to two sessions 2-4 weeks apart for the actual experiment). The test that was to normally take place during session 2 of the actual experiment was instead administered at the end of the single pilot study session for each participant.

The pilot sessions proved very useful and, based on their results, a number of significant changes were made to both the testing instruments and to the NetNotes program. The user satisfaction questionnaires were re-formatted to be shorter and less verbose; confusing task instructions were clarified; and a few additions were made to the experimental procedure scripts (e.g., a note was added to make sure that the control group used the ZFIN test Web site as opposed to the production Web site which they might already have a bookmark set for). A number of NetNotes program bugs were also discovered and fixed as a result of the pilot studies, including: having existing filenames automatically appear in the save dialog box instead of forcing the user to select it from a directory list each time; having a hyperlink replace any text that was selected immediately before the *Add link* function was activated; and adding strategic spacing after hyperlinks so that users could insert plain text annotations more easily.

Analysis of Dependent Measures

The quantitative dependent measurements of this experiment described in this section were analyzed using the experimental videotapes, the notes and work process representations that participants generated, the session 1 ASQs, and the session 2 tests.

Task Completion

Two task completion results, which are measurements for hypothesis 1, were assessed based on users' session 1 notes. First, task completion scores were calculated for each of the session 1 tasks by participant. These scores were determined based on how thoroughly participants were able to complete the tasks. For example, the scenario 1 task 1 instructions read as follows:

Suppose you want to collect information about the ZFIN lab named the Amemiya lab. Your first task is to locate the detailed ZFIN page for this lab, and then to record the following information in your notes:

- *The name and address of the lab*
- *Who the lab members are*
- *What the lab members look like*

When you are done recording this information, save your notes in the default directory.

Based on the instructions given, the key components of this task that should be recorded in a participant's notes are:

1. the name of Amemiya lab
2. the address of Amemiya lab
3. a list of lab members
4. a group lab picture or 1 or more individual lab member pictures
5. an integrated set of notes for this task (i.e., not separate documents or files)

For each of these line items, a participant's notes were awarded 1 point if they satisfied the criteria, and 0 points if they did not. Scores were added up and percentages calculated by task. Continuing with our task 1 example, if a participant's notes contained 4 of the 5 criteria listed above, then they received a score of 4/5 or 80% for that task.

Table 7 shows the scoring criteria used for all tasks in both scenarios 1 and 2. Because I was the only person to develop the task completion scoring criteria, I tried to avoid subjective interpretation—and thus the need for multiple people to be involved in the scoring—by doing a direct translation between the task instructions given to participants (see Appendix A for full task instructions) and the scoring criteria. The example of scenario 1 task 1 just presented illustrates the type of direct translation performed. It should also be noted that the participants' notes were not evaluated in terms of how they were formatted since this was not explicit in the instructions, and thus would have introduced an element of subjective interpretation given that there was only one evaluator.

In addition to task completion scores, the number of participants per group who were totally successful completing each task was calculated. In other words, when a participant's notes received the maximum number of available points per task (e.g., 5 out of 5 for task 1 in Table 1, 9 out of 9 for task 2, etc.), or 100%, then he or she was counted as totally successful.

Table 7. Criteria for Evaluating Task Completion

SCENARIO 1 Notes Generation Tasks	Score (0 or 1)
Task 1	
1. Name of Amemiya lab	
2. Address of Amemiya lab	
3. List of lab members	
4. Group lab picture or 1 or more individual lab member pictures copied purposefully	
5. Task 1 notes integrated (one document)	
Task 2	
1. Amemiya lab 1999 pubs	
2. Amemiya lab 1999 pubs only	
3. Amemiya 1999 pubs year	
4. Amemiya 1999 pubs title	
5. Amemiya 1999 pubs titles are hyperlinks	
6. All hyperlink titles work correctly (i.e., point to correct Web page)	
7. Amemiya 1999 pubs authors	
8. Heading for Amemiya 1999 pubs	
9. Task 2 notes integrated	
Task 3	
1. Changed Amemiya pub name to chordate hox	
2. Chordate hox title is hyperlink	
3. Chordate hox hyperlink title works correctly	
4. Task 3 notes integrated	
Task 4	
1. Full name of Allele b104	
2. Development table for Allele b104 -- text	
3. Development table for Allele b104 -- images	
4. Task 4 notes integrated	
Task 5	
1. Hyperlink created to mutant spadetail primary publication	
2. Text of hyperlink is "mutant spadetail" or close	
3. Link points to correct Web page	
4. Meaningful text surrounds link	
TOTAL (Max 26)	

SCENARIO 2 Work Process Tracking Tasks	Score (0 or 1)
Task 1	
1. Page title (Wild Type: India)	
2. Correct URL	
3. Date	
4. Time	
5. Submitter's comments annotation	
Task 2	
1. Page title (Julie Cooke's home page)	
2. Correct URL	
3. Date	
4. Time	
5. Julie's biography and research interests annotation	
Task 3	
1. Page title (achaete scute homolog A)	
2. Correct URL	
3. Date	
4. Time	
5. Total # pubs annotation	
Task 4	
1. Page title (MOP)	
2. Correct URL	
3. Date	
4. Time	
5. Later review linkage table annotation	
TOTAL (Max 20)	

TOTAL for both scenarios (MAX 46): ____________

Time

The amount of time needed per participant to complete the session 1 tasks, which is a dependent measure for hypothesis 2, was recorded. Since the research scenarios were formatted such that each task was located on a separate page, during the experiment I was able to record exactly when participants started and ended tasks based on when pages were flipped. In a few instances, the time recorded for a particular task was later adjusted to account for minor interruptions (in one instance, a control group participant was interrupted by other lab members; in another case, I interrupted a control group participant to clarify a situation). These time adjustments were made based on subsequent analysis of the videotapes to determine exactly how much time to deduct. Time adjustments were also made in those instances where users failed to save their notes for a particular task (10 seconds were added to the overall task time). Since participants were instructed not to skip around when completing tasks, in one case task time was adjusted when a participant did a task 3 save while officially working on task 4. In another case, a control group participant (code # 17051C) successfully completed scenario 1 task 1, but exceeded expected requirements by such a large degree that a time adjustment was deemed appropriate. More specifically, this participant captured and labeled six individual pictures when only one was necessary, and because this process took such a long time, I felt it would be more accurate to report only the time needed to capture one picture (in this case, time was reported for the first picture capture only).

Effectiveness

To determine the effectiveness of a set of notes, which is a dependent measure for hypothesis 3, the number of session 2 test questions that participants answered correctly using only their notes (as opposed to using the ZFIN Web site) was calculated. Each test question was initially marked as having been answered either correctly or incorrectly, and all incorrect answers were omitted. Questions that participants reported already knowing the answer to without having to consult either their notes or ZFIN were also omitted from the data analysis. For the remaining questions, the videotapes were analyzed to determine when users answered a question using only their notes, and when they had to rely on ZFIN to find the answer.

There were three distinct instances I counted as a participant using his or her notes to answer a question: 1) if the answer is derived directly from the notes, 2) if the participant clicks on a hyperlink in his or her notes causing the page with the answer to appear in Netscape, and 3) if a participant copies a URL from his or her notes and pastes it into Netscape causing the page with the answer to appear. Even though the second and third instances involve Netscape displaying ZFIN pages, I consider that the information encoded in the notes is critical to the direct access of an answer. The instances that I counted as a participant requiring ZFIN to answer a question include: 1) when a participant re-locates the answer to a question using ZFIN, 2) when a participant clicks on a hyperlink in his or her notes, and then selects another hyperlink from the Web page that appears to find the answer (this was considered using ZFIN because the hyperlink in the notes did not lead directly to a page with the answer), and 3) when a participant uses a Netscape bookmark to access the answer.

Transitions

The number of software transitions that each participant needed to complete the session 1 tasks, which is a dependent measure for hypothesis 4, was determined per task based on analysis of the experimental videotapes. A software transition is defined as that moment when an application different than the current application comes into focus or becomes the active application on the computer. For example, if Netscape is the current application and then a participant starts Microsoft Word, the minute Word becomes the active application, a transition is counted. Note that the total number of application transitions per task includes *any* change in application focus, regardless of whether or not a participant actually uses the newly focused application. For example, if an application transition between Netscape and Word occurs but the user doesn't appear to use Word in any way before switching back to Netscape, that action still counts as 2 transitions (1 for the Netscape to Word transition, 1 for the Word to Netscape transition). Intra-application transitions—such as a transfer between the Netscape browser and Netscape email—are not counted as transitions as they would blur the line between what should actually be considered a transition (e.g., would Word editing versus Word spell-check be considered a transition or not?).

All application transitions were counted by analyzing the experimental videotapes.

As with the time adjustments that were made, the number of transitions were also adjusted in those instances where participants forgot to do a task save (2 transitions were added), and in the special case of participant #17051C described previously.

User Satisfaction and Perceived Effort

The degree of user satisfaction that that users felt completing the session 1 tasks with the available software, which is a dependent measure for hypothesis 6, was assessed based on user responses to eight statements from ASQ1 (related to scenario 1 tasks) and six statements from ASQ2 (related to scenario 2 tasks). Participants were asked to rate their agreement with each statement using a 7-point scale where 1 represents the least satisfaction and 7 the most satisfaction. For example, a typical statement is *I am satisfied with the ease of gathering images from the Web.* Mean scores and standard deviations were calculated for each group of participants.

To determine perceived effort, which is a dependent measure for hypothesis 5, participants were asked to rate their degree of satisfaction with the amount of time, the amount of effort, and the number of software applications needed to complete the session 1 tasks. The same 7-point scale was used, and again, mean scores and standard deviations were calculated per group. Higher degrees of user satisfaction with effort required were interpreted to mean that less cognitive effort was necessary.

Results

Task Completion

As described in the previous section, two task completion results were assessed for session 1: task completion scores, and the number of participants per group who were totally successful completing each task. Once each set of session 1 notes was awarded points based on the criteria listed in Table 7, task completion percentages were calculated by scenario (i.e., for all tasks), and by individual task. These calculations were made simply by dividing the number of points awarded by the maximum number of available points, and then multiplying by 100. Table 8 shows the task completion mean scores (in percentage format) and standard deviations for both the NetNotes group and the control group, as well as statistically significant *p* values based on the nonparametric one-tailed Mann-Whitney *U* Test for n_2 between 9 and 20 (Siegel, 1956, pp.119-121). The *U* Test was used to evaluate levels of significance rather than a stronger parametric test such as the *t*-test for uncorrelated measures (Martin, 2000, p. 321) because the normality assumptions of the *t*-test were not met. Figures 18 and 19 also provide a graphical view of the mean task completion scores (percentages) for scenarios 1 and 2 respectively.

Table 8. Task Completion Means, Standard Deviations, and p Values

		NetNotes		Control group		
		Mean	SD	Mean	SD	$p <$
Scenario 1	ALL TASKS	91%	8.9%	62%	9.4%	.001
	Task 1	88%	10.3%	76%	22.7%	
	Task 2	98%	7.0%	77%	6.3%	.001
	Task 3	78%	32.2%	33%	12.1%	.01
	Task 4	98%	7.9%	50%	39.1%	.01
	Task 5	85%	21.1%	50%	28.9%	.01
Scenario 2	ALL TASKS	97%	8.2%	91%	10.7%	
	Task 1	98%	6.3%	94%	9.7%	
	Task 2	98%	6.3%	94%	9.7%	
	Task 3	90%	31.6%	94%	9.7%	
	Task 4	100%	0.0%	82%	19.9%	.025

Note. $n_1 = n_2 = 10$.

One of the strongest results of the experiment is the significant difference found in task completion scores between the two groups for the accumulation of all scenario 1 (notes generation) tasks. As seen in Table 8 and Figure 18, the mean task completion score for ALL TASKS was 91% for NetNotes participants and 62% for control group participants, with $p < .001$ ($U = 2$, $n_1 = 10$, $n_2 = 10$). Table 8 and Figure 18 also show that NetNotes participants completed each individual scenario 1 task more successfully than the control group participants, and for all but task 1, these differences were found to be statistically significant using the U test (task 2: $U = 4.5$, $n_1 = 10$, $n_2 = 10$, $p < .001$; task 3: $U = 14.5$, $n_1 = 10$, $n_2 = 10$, $p < .01$; task 4: $U = 12$, $n_1 = 10$, $n_2 = 10$, $p <$

.01; task 5: $U = 17$, $n_1 = 10$, $n_2 = 10$, $p < .01$). It should be noted that these results support hypothesis 1, as will be discussed later in the chapter.

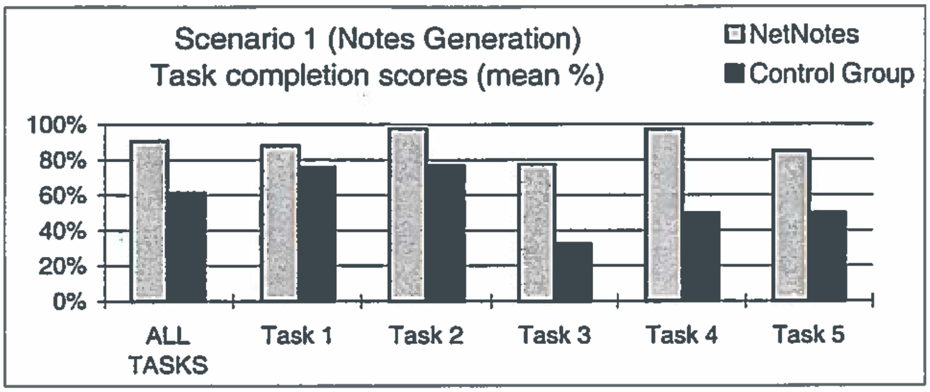


Figure 18. Scenario 1 (Notes Generation) Task Completion Scores.

For scenario 2 (work process tracking tasks), as shown in Table 8 and Figure 19, the NetNotes participants completed each task except the third one, including the aggregation of all tasks, more successfully than control group participants. However, only in the case of task 4 was the difference significant ($U = 20$, $n_1 = 10$, $n_2 = 10$, $p < .025$). Unfortunately, the scenario 2 results do not provide strong support for hypothesis 1 like scenario 1 does, which will be further discussed later in the chapter.

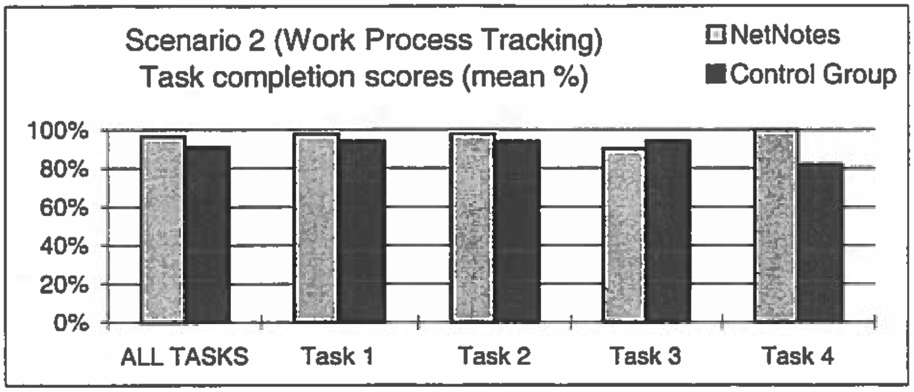


Figure 19. Scenario 2 (Work Process Tracking) Task Completion Scores.

The number of NetNotes participants who were totally successful completing the session 1 scenario 1 tasks (i.e., those participants whose notes received the maximum number of available points per task based on the criteria listed in Table 7) was also quite a bit higher than the number of totally successful control group participants, as seen in Table 9. Some of these differences are rather stark, such as 9 out of 10 NetNotes participants being totally successful with task 2 as compared to 0 control group participants, and 9 of 10 NetNotes participants being totally successful with task 4 compared to 2 of 10 control group participants.

As seen in Table 10, more NetNotes participants were also totally successful completing the scenario 2 (work process tracking) tasks than control group participants, but these differences are not as obvious as they are for scenario 1 (notes generation) tasks. In general, though, the overall task success rates provide more support for hypothesis 1, indicating that NetNotes users were more productive completing the session 1 tasks than control group users, particularly for scenario 1.

Table 9. Number of Individuals Who Completed Each Scenario 1 (Notes Generation) Task Totally Successfully

Group	Task 1	Task 2	Task 3	Task 4	Task 5
NetNotes	4	9	6	9	6
Control group	2	0	0	2	1

Note. *n* = 10 per group.

Table 10. Number of Individuals Who Completed Each Scenario 2 (Work Process Tracking) Task Totally Successfully

Group	Task 1	Task 2	Task 3	Task 4
NetNotes	9	9	9	10
Control group	7	7	7	4

Note. *n* = 10 per group.

Time and Transitions

The amount of time and the number of software transitions needed for participants to complete the session 1 tasks did not turn out to be effective dependent measures for a number of reasons. Because participants had such a wide range of task completion scores, it would not be appropriate to simply compare time and transitions for all participants. For example, a participant who only completed 67% of a task would likely take less time and fewer transitions than a participant who completed 100% of that task. A more accurate comparison would consider only those participants who completed the session 1 tasks with total success (i.e., 100% task completion). However, as seen in Table 9, since so few control group participants were completely successful with the scenario 1 tasks, these comparisons also seem inappropriate.

For scenario 2, since more control group participants were totally successful completing the tasks (see Table 10), time and transition comparisons were made between the two groups for each task. This detailed analysis, which can be found in its entirety in Appendix C, shows mixed results between the two groups, and thus largely fails to provide conclusive evidence for hypotheses 2 and 4.

Effectiveness

Table 11 shows a summary of how all participants in each group answered the 7 test questions during session 2 (i.e., whether they used only their notes to answer the question, or whether they had to rely on ZFIN). Questions 1-4 were related to the scenario 1 (notes generation) research tasks, while questions 5-7 were related to the scenario 2 (work process tracking) research tasks. Some of the group totals do not add up to 10 for certain questions (even though $n = 10$ per group) because a participant either answered the question incorrectly or knew the answer beforehand. For example, Table 11 indicates that 3 people in the control group used their notes to answer question 2, and 5 people used ZFIN. This means that this particular question was omitted from the data analysis for 2 people in the control group.

Table 11. How Participants Answered Session 2 Test Questions

Group	Q1	Q2	Q3	Q4	Q5	Q6	Q7
NetNotes	9 Notes 1 ZFIN	6 Notes 2 ZFIN	9 Notes 1 ZFIN	5 Notes 1 ZFIN	7 Notes 0 ZFIN	8 Notes 0 ZFIN	10 Notes 0 ZFIN
Control group	4 Notes 6 ZFIN	3 Notes 5 ZFIN	1 Notes 8 ZFIN	1 Notes 2 ZFIN	8 Notes 0 ZFIN	9 Notes 0 ZFIN	7 Notes 3 ZFIN

The data presented in Table 11 was translated into the percentage of participants per group who were able to answer each question using only their notes, and is shown as a bar chart in Figure 20. We can see that more NetNotes participants were able to answer each of the first four questions (which are related to scenario 1 notes generation tasks) by accessing their notes than control group participants. For questions 1 and 3, the Fisher-Yates test of significance in 2 x 2 contingency tables shows that these differences are significant (Question 1: $A + B = 10$, $C + D = 10$, $A = 9$, $C = 4$, $p \leq .05$; Question 3: $A + B = 10$, $C + D = 9$, $A = 9$, $C = 1$, $p \leq .005$). For questions 5-7 (which are related to scenario 2 work process tracking tasks), all participants were able to answer questions 5 and 6 using just their notes, and more NetNotes participants were able to answer question 7 using only their notes than control group participants, although this difference was not significant. As will be discussed later in the chapter, the effectiveness results partially support hypothesis 3.

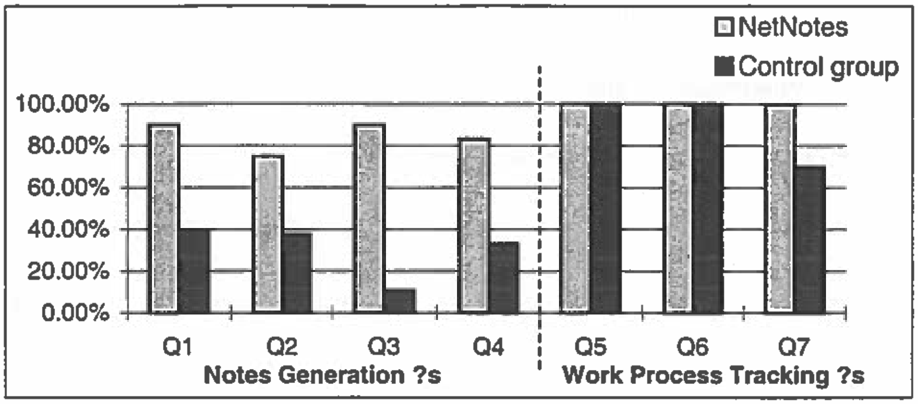


Figure 20. Percentage of Participants Who Correctly Answered Session 2 Test Questions Using Only Their Notes.

User Satisfaction and Perceived Effort

During session one of the experiment, after completing each of the two research scenarios, participants were asked to fill out questionnaires (see Appendix A). Among other things, these questionnaires were designed to assess levels of user satisfaction at completing the given tasks with the available software, and to determine the amount of effort that participants felt they had to expend to complete the given tasks. The results of these questionnaires are presented by scenario throughout the remainder of this section.

Scenario 1 (Notes Generation)

Table 12, which presents the results of ASQ1 (After Scenario Questionnaire 1), lists an abbreviated version of each test question along with the mean scores and standard deviations for both NetNotes participants and control group participants. As described earlier in the chapter, each question was based on a 7-point scale where 1 represents the least satisfaction and 7 the most satisfaction.

The first 8 questions (1.1-1.8) are grouped together under the heading "EASE OF USE", and they all relate to how satisfied participants were completing specific scenario 1 tasks. The second block of 3 questions (2.1-2.3)—with the heading "EFFORT"—pertain to the amount of effort participants felt they had to expend to complete the tasks. The third block of questions (3.1-3.8)—"STATUS QUO"—only appeared on the NetNotes group questionnaire as they have to do with how satisfied participants felt doing tasks *like* those in presented scenario 1 using the software that they normally have access to (control group participants *did* use their normal software during the experiment, so these questions were not applicable to them). Note that questions 3.1-3.8 are basically the same as 1.1-1.8, the only difference being that 1.1-1.8 refer to the NetNotes prototype software while 3.1-3.8 refer to participants' normal software. Lastly, the "WISH LIST" block of questions (4.1-5.4) attempts to identify those IA tasks that users wish they had better software support for.

Table 12. ASQ1 (After Scenario 1 Questionnaire) Results

	NetNotes Mean	NetNotes SD	Control group Mean	Control group SD
EASE OF USE				
1. I am satisfied with the ease of…				
1.1 completing the tasks overall	5.40	1.43	4.90	1.91
1.2 gathering formatted text from the Web	5.80	1.23	5.11	1.83
1.3 gathering images from the Web	5.10	2.13	3.70	1.83
1.4 gathering hyperlinks from the Web	5.10	2.47	3.90	1.91
1.5 editing information from the Web	4.80	2.30	4.89	1.83
1.6 annotating information from the Web	5.70	1.95	5.40	1.78
1.7 creating hyperlinks to Web pages	4.90	2.73	3.20	2.30
1.8 saving information from the Web	6.30	0.82	5.40	1.84
EFFORT				
2. Overall, I am satisfied with the…				
2.1 amount of time	6.00	1.15	5.20	1.55
2.2 amount of effort	5.90	1.29	4.60	1.96
2.3 number of applications	6.40	0.97	5.30	1.89
STATUS QUO				
3. Normally, I am satisfied with the software tools that I typically have access to for…				
3.1 completing similar tasks overall	3.33	1.58		
3.2 gathering formatted text from the Web	3.50	1.65		
3.3 gathering images from the Web	2.89	1.54		
3.4 gathering hyperlinks from the Web	3.00	1.58		
3.5 editing information from the Web	3.90	2.33		
3.6 annotating information from the Web	4.30	2.16		
3.7 creating hyperlinks to Web pages	2.71	1.60		
3.8 saving information from the Web	5.40	1.71		
WISH LIST				
4. I wish I had better software tools to help me…				
4.1 gather formatted text from the Web	5.20	1.32	5.20	1.75
4.2 gather images from the Web	5.70	1.06	5.70	1.89
4.3 gather hyperlinks from the Web	6.40	0.84	5.30	1.34
4.4 gather lists and tables from the Web	6.40	0.97	5.20	1.55
4.5 edit information from the Web	5.50	1.18	4.70	1.77
4.6 annotate information from the Web	5.20	1.23	4.20	1.87
4.7 create hyperlinks to Web pages	6.20	1.03	4.90	1.73
4.8 save information from the Web	5.60	1.58	5.10	1.45
5. I wish I had …				
5.1 one integrated software tool	6.50	0.71	6.60	0.70
5.2 a better way to integrate Web information with other notes	6.20	0.79	6.00	1.25
5.3 a better way to organize Web information	6.20	0.79	5.70	1.34
5.4 a software tool to archive Web pages	6.10	1.20	5.80	1.40

Perhaps the best interpretation of the ASQ1 results is to compare how NetNotes participants answered questions 1.1-1.8 with how control group participants answered them, and to look at the differences between how NetNotes users answered questions 1.1-1.8 versus questions 3.1-3.8. To help visualize these results, Figure 21 shows a bar chart of the mean scores for how satisfied NetNotes participants were completing the tasks using the NetNotes prototype (questions 1.1-1.8 for NetNotes participants), the mean scores for how satisfied NetNotes participants are completing the same tasks using their normal software (questions 3.1-3.8 for NetNotes participants), and how satisfied the control group participants were completing the tasks using their normal software (questions 1.1-1.8 for control group participants). As we can see, NetNotes participants were more satisfied completing the scenario 1 (notes generation) tasks than the control group participants with the exception of question 1.5 (editing information copied from the Web), but none of these differences were found to be statistically significant using the Mann-Whitney *U* Test.

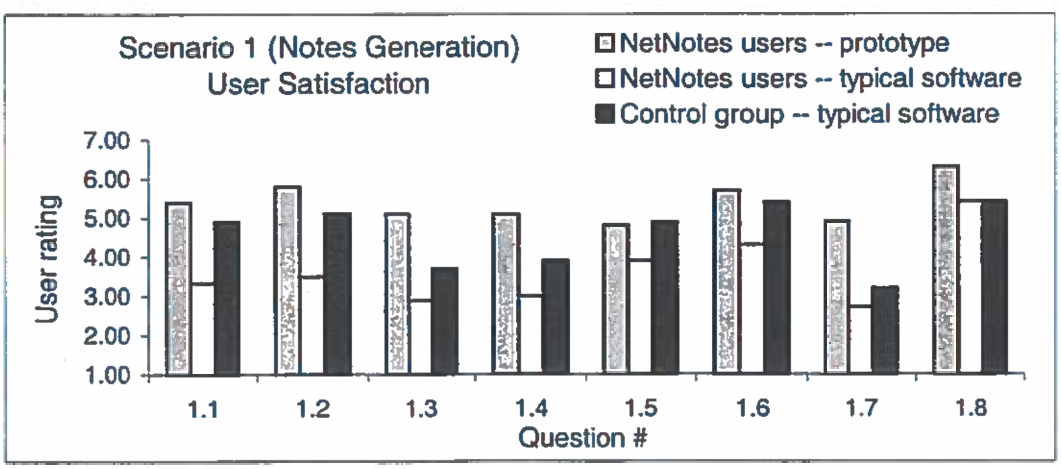


Figure 21. Scenario 1 (Notes Generation) User Satisfaction.

Figure 21 also shows that the lowest scores for each question, with the exception of 1.8, belong to NetNotes participants reporting how satisfied they are using their normal software to complete tasks like those in scenario 1. It is interesting to note that these scores are quite a bit lower than the satisfaction levels reported by NetNotes participants in using the NetNotes prototype to complete the tasks (comparison of questions 3.1-3.8 and 1.1-1.8 for NetNotes participants in Table 12). A one-tailed Wilcoxon matched-pairs signed-ranks test performed for all NetNotes participants who answered both matched questions on ASQ1 (i.e., 1.1 & 3.1, 1.2 & 3.2, etc.) shows significant differences for a number of these pairs. For matched questions 1.1 & 3.1, $p < .025$ ($T = 3.5$, $n = 9$); for questions 1.2 & 3.2, $p \leq .01$ ($T = 5$, $n = 10$); for 1.3 & 3.3, $p < .05$ ($T = 7$, $n = 9$); for 1.4 & 3.4, $p < .025$ ($T = 4.5$, $n = 9$); and for 1.6 & 3.6, $p < .05$ ($T = 9.5$, $n = 10$). Although these significant results were not explicitly predicted by a hypothesis, I will argue later in the discussion section of this chapter that they actually support hypothesis 6.

Again to help visualize more ASQ1 results, Figure 22 shows a bar chart of the mean scores for how satisfied the NetNotes participants were with the amount of effort (i.e., time, effort, number of software applications) they needed to expend to complete the given tasks versus how satisfied the control group participants were. The NetNotes participants scored higher on each question than the control group (i.e., the NetNotes participants were more satisfied), but the Mann-Whitney *U* Test showed that these differences are not statistically significant.

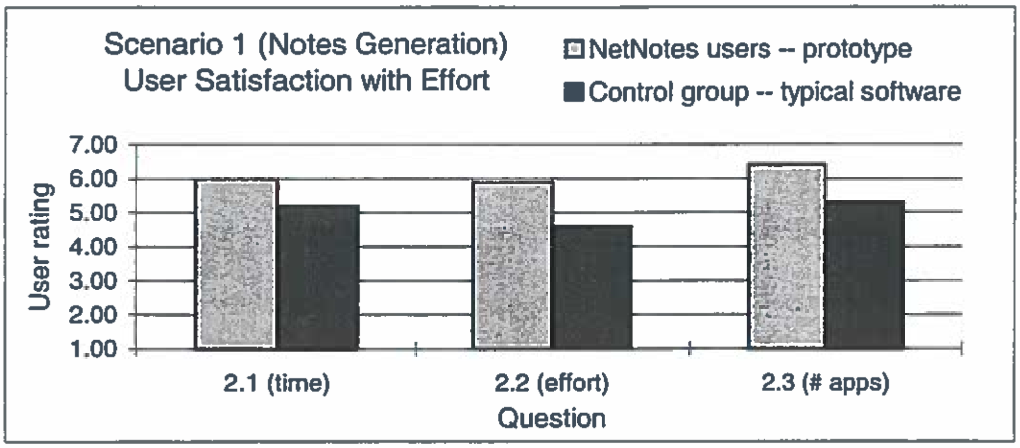


Figure 22. Scenario 1 (Notes Generation) User Satisfaction With Effort Required.

To evaluate the results of the scores given to the Wish list questions on ASQ1, I calculated the means and rankings of questions 4.1-4.8 for the NetNotes participants and control group participants combined. The higher the mean score, the more desire users had for that particular function. In this case, it does not make sense to compare the two sets of numbers against one another (i.e., NetNotes vs. control group) since these numbers simply represent each experimental participant's desire for certain IA-related functionality; instead, it is more suitable to look at the accumulation of all scores. Rankings were then assigned in order from the highest mean score to the lowest (i.e., the #1 ranked function is the most desired function, the #8 function is the least desired), as seen in Table 13. Note that questions 5.1-5.4 were not included in the ranking since they are more general than the other questions and, therefore, not immediately comparable.

Table 13. Means and Ranks of ASQ1 Wish List Questions

Question #	Function *I wish I had better software tools to help me…*	Mean	Rank
4.1	Gather formatted text from the Web	5.20	6
4.2	Gather images from the Web	5.70	3
4.3	Gather hyperlinks from the Web	5.85	1
4.4	Gather lists and tables from the Web	5.80	2
4.5	Edit information from the Web	5.10	7
4.6	Annotate information from the Web	4.70	8
4.7	Create hyperlinks to Web pages	5.55	4
4.8	Save Web information	5.35	5

What becomes clear upon reviewing Table 13 is that participants feel the most desire to have a tool that helps them to gather hyperlinks, lists and tables, and images from the Web, and they seem to have the least need for a tool that allows them to annotate or edit Web information once they have gathered it.

Scenario 2 (Work Process Tracking)

Just as Table 12 shows the ASQ1 results, Table 14 presents the results of ASQ2 (After Scenario Questionnaire 2). Once again, an abbreviated version of each 7-point question is displayed, along with the mean scores and standard deviations per question for both NetNotes participants and control group participants. As with ASQ1, the questions are grouped together into four blocks, and the STATUS QUO block contains only scores for NetNotes participants as these questions were omitted from the control group questionnaires (since for control group participants, they are the exact same questions as 1.1-1.6).

Table 14. ASQ2 (After Scenario 2 Questionnaire) Results

	NetNotes Mean	NetNotes SD	Control group Mean	Control group SD
EASE OF USE				
1. I am satisfied with the ease of …				
1.1 completing the tasks overall	6.50	0.53	6.00	0.67
1.2 noting the title of Web pages I visit	6.00	1.25	6.00	0.67
1.3 noting the URL of Web pages I visit	6.80	0.42	6.10	0.99
1.4 noting when I visit certain Web pages	6.80	0.42	5.60	1.35
1.5 creating annotations for Web pages	6.10	1.52	5.40	1.35
1.6 saving my ongoing work processes	6.50	0.97	5.40	1.26
EFFORT				
2. Overall, I am satisfied with the …				
2.1 amount of time	6.60	0.52	5.60	1.17
2.2 amount of effort	6.60	0.52	5.60	1.17
2.3 number of software applications	6.60	0.52	5.70	1.25
STATUS QUO				
3. Normally, I am satisfied with the software tools that I typically have access to for …				
3.1 keeping track of my ongoing Web work processes	2.20	1.03		
3.2 noting the title of Web pages I visit	2.70	1.25		
3.3 noting the URL of Web pages I visit	2.40	1.26		
3.4 noting when I visit certain Web pages	2.10	1.20		
3.5 creating annotations for Web pages	2.70	1.42		
3.6 saving my ongoing work processes	4.67	2.52		
WISH LIST				
4. I wish I had better software tools to help me …				
4.1 keep track of my ongoing Web work processes	6.30	0.67	5.80	1.32
4.2 note the title of Web pages I visit	6.00	0.94	4.40	1.58
4.3 note the URL of Web pages I visit	6.20	0.79	4.60	1.65
4.4 note when I visit certain Web pages	6.10	1.10	5.10	1.37
4.5 capture thumbnail images of Web pages I visit	5.50	1.58	5.90	0.99
4.6 create annotations for Web pages	5.90	0.99	5.00	1.49
4.7 save my ongoing work processes	6.00	1.15	5.40	1.26
4.8 rejoin a previous work process quickly/easily	6.30	0.95	5.70	1.25

An analysis of the ASQ2 results as seen in Table 14 yields interesting comparisons between how NetNotes participants answered questions 1.1-1.6, how NetNotes participants answered questions 3.1-3.6, and how control group participants answered questions 1.1-1.6. Figure 23 displays these results (mean scores) in bar chart format and shows first that NetNotes participants were more satisfied with completing the scenario 2 (work process tracking) tasks than control group participants, with the exception of question 1.2 (noting the titles of visited Web pages). For two of these questions, the *U* Test shows statistically significant differences (Question 1.4: $U = 21$, $n_1 = 10$, $n_2 = 10$, $p < .025$; Question 1.6: $U = 22.5$, $n_1 = 10$, $n_2 = 10$, $p < .025$).

Figure 23 also shows that the lowest mean scores for each question are registered by NetNotes participants responding to how satisfied they are using their normal software to complete tasks like those given in scenario 2 (NetNotes mean scores, questions 3.1-3.6 in Table 14). It is interesting to note that these scores are quite a bit lower than the satisfaction levels reported by NetNotes participants in using the NetNotes prototype to complete the scenario 2 tasks (NetNotes mean scores, questions 1.1-1.6 in Table 14). A one-tailed Wilcoxon matched-pairs signed-ranks test for all NetNotes participants who answered both matched questions on ASQ2 (i.e., questions 1.1 & 3.1, 1.2 & 3.2, etc.) shows significant differences ($p < .005$, $T = 0$, $n = 10$) for all questions except the last pair (1.6 & 3.6); for the last pair, since only 3 participants answered both questions, the Wilcoxon test could not be used since $n < 5$. Once again, these significant results were not explicitly predicted prior to the experiment by a hypothesis, but in the discussion section of this chapter, I argue that they provide more supporting evidence for hypothesis 6.

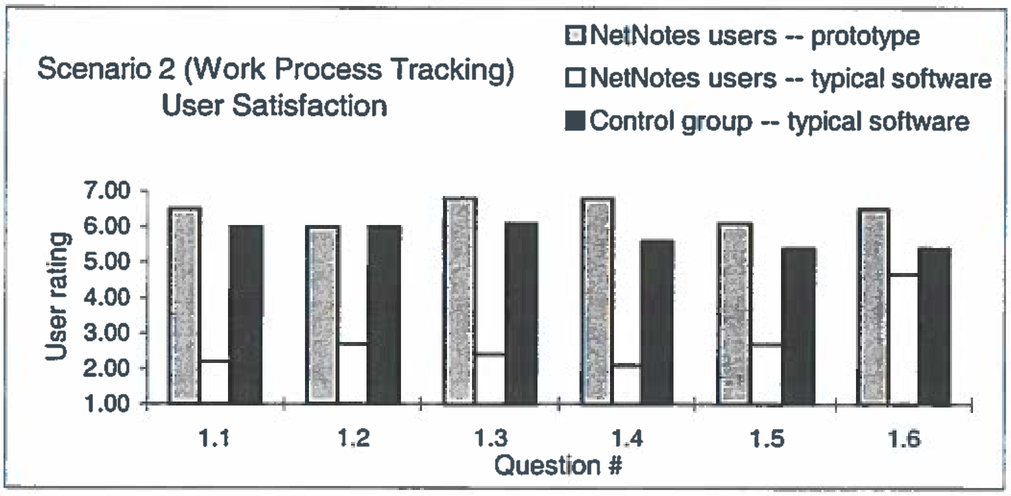


Figure 23. Scenario 2 (Work Process Tracking) User Satisfaction.

Figure 24 displays a bar chart comparing the mean scores of how satisfied NetNotes participants were with the amount of effort (i.e., time, effort, and number of software applications) they needed to expend in order to complete the scenario 2 tasks using the software provided during the experiment (i.e., the NetNotes prototype) with how satisfied the control group participants were using their normal software. The NetNotes participants scored higher on each question than the control group (i.e., the NetNotes participants were more satisfied), and a one-tailed Mann-Whitney *U* Test shows all of these differences to be statistically significant (Question 2.1: $U = 22$, $n_1 = 10$, $n_2 = 10$, $p < .025$; Question 2.2: $U = 22$, $n_1 = 10$, $n_2 = 10$, $p < .025$; Question 2.3: $U = 26$, $n_1 = 10$, $n_2 = 10$, $p < .05$). These results provide supporting evidence for hypothesis 5.

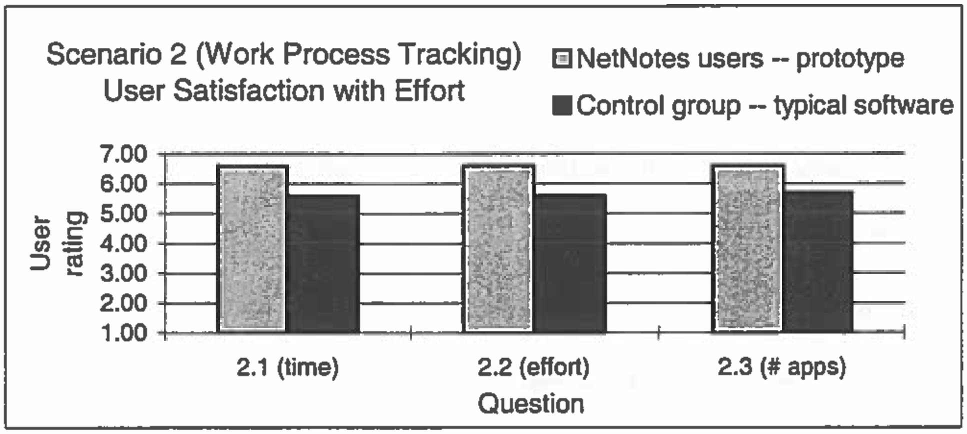


Figure 24. Scenario 2 (Work Process Tracking) User Satisfaction With Effort Required.

Lastly, it is not as appropriate to calculate the means and rankings for the wish list block of questions (4.1-4.8) from ASQ2 as was done with ASQ1 since general questions are mixed in with more specific functionality questions. For example, question 4.1 asks participants about keeping track of an ongoing Web work process (general), while question 4.3 asks about noting the URL of visited Web pages (specific). However, the relatively high means reported in Table 14 for these questions do indicate that participants are quite interested in having access to software that allows them to keep better track of their ongoing work processes overall.

Summary of Results

Because the experiment described in this chapter produced so much data and so many different results to analyze, this section summarizes the key experimental results. This summary is organized around the main dependent measures of the experiment: task completion, time and application transitions, effectiveness, and user satisfaction and perceived effort.

Task Completion

Scenario 1 (Notes Generation)

- NetNotes participants had higher task completion scores for the accumulation of ALL TASKS as well as for each individual task. For all but task 1, these differences were significant.
- More NetNotes participants were totally successful completing each of the tasks than control group participants, and for some tasks the differences were quite strong.

Scenario 2 (Work Process Tracking)

- NetNotes participants had higher task completion scores for all but one task, including the aggregation of ALL TASKS. Only in the case of task 4 was this difference significant.
- More NetNotes participants were totally successful completing each of the tasks than control group participants.

Time and Transitions

Scenario 1 (Notes Generation)

- Since so few control group participants were totally successful completing the tasks, time and software transition comparisons were inappropriate.

Scenario 2 (Work Process Tracking)

- The results were mixed and inconclusive in terms of both time and number of application transitions.

Effectiveness

Scenario 1 (Notes Generation)

- More NetNotes participants were able to answer each of the test questions using only their notes than control group participants, and for half of the questions these differences were significant.

Scenario 2 (Work Process Tracking)

- Out of 3 questions, both groups were able to answer two of the questions using only their notes; while more NetNotes participants were able to answer the third question using only their notes than control group participants, this difference was not significant.

User satisfaction and Perceived Effort

After Scenario 1 Questionnaire (ASQ1)

- NetNotes participants were more satisfied completing the tasks with the available tools than the control group, with one exception (question 1.5), but these differences were not significant.
- NetNotes participants were more satisfied with the amount of effort they had to expend to complete the tasks than control group participants, but these results were not significant.
- NetNotes participants were more satisfied with completing the tasks using the NetNotes prototype than they would be using their normal software. Significant differences were found for 5 out of 8 matched-pair questions.

After Scenario 2 Questionnaire (ASQ2)

- NetNotes participants were more satisfied completing the tasks with the available tools than the control group, with one exception (question 1.2). For 2 of the remaining 5 questions, these differences were significant.
- NetNotes participants were more satisfied with the amount of effort they had to expend to complete the tasks than control group participants, and all of these differences were found to be significant.
- NetNotes participants were more satisfied with completing the tasks using the NetNotes prototype than they would be using their normal software, and significant differences were found for 5 out of 6 matched-pair questions.

To further help understand the experimental results, Table 15 shows the significance of all experimental results according to the hypothesis/dependent measure and scenario they relate to.

Table 15. Significance of Experimental Results

Hypothesis / Dependent Measure	Scenario 1 Notes Generation Tasks	Scenario 2 Work Process Tracking Tasks
Higher Productivity		
• Task Completion	**Significant** positive results	Positive results, but not significant
• Time	NA	Mixed results, not significant
• Effectiveness	Strong positive results, **partially significant**	Mixed results, not significant
Less Cognitive Effort		
• Software Transitions	NA	Mixed results, not significant
• User Satisfaction with Effort	Positive results, but not significant	**Significant** positive results
Higher User Satisfaction		
• User Satisfaction	Positive results, but not significant	Positive results, but not significant

Discussion

This discussion section is organized based around the experimental hypotheses previously stated at the beginning of the chapter.

Increased Productivity Hypotheses

Hypothesis 1: The NetNotes group will have higher task completion percentages than the control group.

The results of this experiment largely support hypothesis 1 for scenario 1 (i.e., notes generation) tasks, but not for scenario 2 (i.e., work process tracking) tasks. For scenario 1, NetNotes participants had higher task completion scores for all tasks (including the aggregation of ALL TASKS), and for all but one of these tasks, these results were shown to be statistically significant. For scenario 2, even though NetNotes participants had a higher percentage of task completion for all but one task, including the aggregate of ALL TASKS, only in the case of task 4 was this difference significant. The task completion scoring system detailed earlier in the chapter, along with an analysis of the notes that participants generated and observations made during the experiment, clearly illustrate common problems that each group encountered while completing the session 1 tasks. These problems are discussed throughout the remainder of this section, starting with each of the five scenario 1 tasks followed by the scenario 2 tasks.

Scenario 1, task 1

Task 1 is the only scenario 1 task where the differences in task completion percentages between the control group and the NetNotes group are not significant. The common problem encountered by members of both groups in completing this task was copying a stand-alone image from the Web and storing it in their notes (only 3 of 10 control group participants and 4 of 10 NetNotes participants were successful at copying an image during this task). Gathering images from the Web is one of the key Information Assimilation (IA) tasks discussed earlier in Chapter II, and while prior to the experiment I strongly believed that this task would be problematic for control group participants, I also suspected that it might be difficult for NetNotes participants as well.

The difficulty that NetNotes participants encountered while completing task 1 was selecting the image to be copied. Because participants were not asked to copy anything immediately surrounding the image, the only way for NetNotes participants to select the image was to highlight it using the mouse, which included panning over dots to the left and right of the image. Many NetNotes participants successfully highlighted the first (left) dot, but then failed to highlight the second (right) dot before releasing the mouse button. The reason why these dots surrounding the image had to be highlighted at all is because of the way the NetNotes prototype is implemented; text copied from Netscape and stored on the system clipboard is parsed and matched to the HTML of the source page when a NetNotes paste occurs. If the dots are omitted, nothing is stored on the system clipboard and the program does not know which image, if any, to insert into the notes. Even though so many

NetNotes participants ultimately failed in task 1 to get the image copied from the Web and pasted into their notes, I still believe that the prototype design represents the best approach to this problem because it is simple and because it uses the same copy-and-paste technique that users are already familiar with from other applications. If NetNotes users are taught how to use the system ahead of time, which they were not for this experiment, then they should understand how this function operates, and they will be prepared in the future to effortlessly copy and paste stand-alone images from the Web into their notes.

The fact that so few control group participants were able to copy and paste an image from the Web into their notes is hardly surprising given the current state of Web-based software. Of the 3 successful control group participants, only one was able to use a straightforward and intuitive process by dragging and dropping the image from Netscape into Macintosh Word 2001. The second successful control group participant had to drag and drop images to the desktop, rename them, open them using Adobe Photoshop, and then copy and paste them into Word. The third successful control group participant saved the image in its own separate file, which is useful only to a limited degree since then the image is not integrated with its other related notes. The other 7 control group participants were not successful in storing the requested image in their notes.

Scenario 1, task 2

Scenario 1 task 2—which involved copying a list of publication hyperlinks from the Web into a set of notes—illustrates one of the starkest differences between functionality contained within the NetNotes prototype and that available in other software applications used by control group participants. While 9 of 10 NetNotes users were totally successful at completing task 2, no control group participants were.

For NetNotes participants, retaining the list of publication hyperlinks requested in task 2 was as simple as selecting the list by highlighting it with the mouse, and then copying and pasting it into NetNotes. All hyperlinks in the list remained active once they were pasted into the page of notes, which meant that participants could still select them from within their notes, and Netscape would automatically load the appropriate page. For control group participants following this same procedure, however, all of the Web hyperlinks were lost once the list was pasted into a page of notes. Most control group participants used Microsoft Word to create their notes, and unfortunately, when the list of publication hyperlinks was pasted into this application, all of the hyperlinks were automatically formatted as plain text, causing them to lose their functionality.

Scenario 1, task 3

This task involved editing (i.e., changing the name of) one of the publication hyperlinks copied from the Web into a set of notes as part of task 2. Since no control group participants were totally successful completing task 2, it is not surprising that none of them were entirely successful with task 3 either. A number of control group participants were able to change the name of the appropriate publication, but since this publication was not a hyperlink, they were ultimately unsuccessful with the task.

Fewer NetNotes participants were as successful completing task 3 as were completing task 2 (only 6 of 10 total successes for task 3). Observations made during the experiment indicate that the reason for this drop-off had to do with some small usability problems that were uncovered in the NetNotes prototype. In particular, when editing hyperlinks in NetNotes, it was difficult for users to manipulate when they were editing the hyperlink versus when they were editing plain text. For example, while trying to change the name of a hyperlink in NetNotes, some users first deleted the original hyperlink name; this had the unfortunate effect of causing the new text that they typed to be treated as plain text rather than still as a hyperlink. These problems should be easily fixed in the next version of the prototype.

Scenario 1, task 4

The primary goal of task 4 was for participants to copy a table of images and text from the Web into their notes. Once again, the total success rates between NetNotes participants (9 of 10) and control group participants (2 of 10) are dramatically different. Given the previous discussion of task 1, which also involved gathering a Web image, it is not surprising that so few control group participants were ultimately successful at completing task 4. However, one can also see that quite a few more NetNotes participants were successful with task 4 than with task 1. This is because the images requested in task 4 were not stand-alone images (as in task 1), but instead were embedded within a table containing other text. In this case, NetNotes participants did not have the same difficulty selecting individual images; typically, NetNotes participants clicked and dragged the mouse over the entire table, thus highlighting and selecting all images and text included within it. Since text was then stored on the system clipboard after the participant executed the copy command, the NetNotes program could easily determine which pictures embedded within the text should be pasted into the page of notes.

Scenario 1, task 5

Six of 10 NetNotes participants were able to complete task 5 in its entirety as opposed to only 1 of 10 control group participants. Task 5 involved creating a hyperlink to a Web page from within a page of notes, and while a number of control group participants were successful at doing this by copying a URL from Netscape and pasting it into Word—where it is automatically recognized as a link—they were unable to finish the task by editing the link name properly. Furthermore, in many instances, the link did not end up pointing to the correct Web page. The unsuccessful NetNotes participants mostly failed to name the hyperlink properly in their notes; once again, I fully believe that this problem was exacerbated by a lack of familiarity with the NetNotes prototype. With more training and exposure to the prototype's functionality and user interface, I think problems like this would largely cease to exist.

Scenario 2, tasks 1-4

For scenario 2 (work process tracking tasks), there were not significant differences in task completion percentages between NetNotes participants and control group participants for any of the tasks. This result is really not surprising given that all four of the scenario 2 tasks, in addition to being very similar to one another, did not necessarily involve new functionality that was present in NetNotes yet missing from other typical software applications. One of the primary reasons why scenario 2 tasks were included in this experiment was to expose the repetition and tedium of gathering certain information over and over again. As a reminder, all of the scenario 2 tasks ask users to record the following work process information in their notes about different ZFIN Web pages: the page title, the URL, the date and time of visit, and an annotation. Again, it is quite simple for control group participants to gather this information (thus no significant differences in task completion percentages), but recording the URL and the date & time of visit, prove to be particularly redundant and tiresome for the users. Since this information is automatically recorded for NetNotes users, along with appropriate labels, the NetNotes participants found the scenario 2 tasks less cumbersome and to require less effort—a result that is evident in the user satisfaction responses and post-experiment interview comments.

Hypothesis 2: The NetNotes group will be able to complete the tasks in less time than the control group.

Hypothesis 2 has not been demonstrated by this experiment. However, an analysis of the data shows that part of the reason for this, at least in the case of scenario 1 (notes generation), is that so few control group participants were able to fully complete the tasks. The lack of sufficient control group data rendered statistical comparisons between the time needed by participants in both groups to create the notes in scenario 1 not possible in some cases, and not meaningful in others.

For scenario 2 (work process tracking) tasks, the time differences between the two groups were quite mixed and not significant. This result is somewhat surprising, perhaps, given the earlier discussion (under Hypothesis 1) regarding the repetition and tedium of certain aspects of the scenario 2 tasks for control group participants—aspects that were automated for NetNotes participants. However, one possible explanation why significant time differences for scenario 2 tasks are non-existent, despite their repetition, is that these tasks were too short for significance to be distinguished. If the scenario 2 tasks were more complex and longer, in addition to being manually repetitive for control group participants and automated for NetNotes participants, then significant time differences between the two groups might become more apparent.

Finally, it bears mentioning in this section that as this experiment was being conducted, a number of reasons why strict measurements of time and the number of software transitions are problematic evaluation benchmarks for an experiment such as this became apparent. These reasons, which are listed below, indicate that for an experiment such as this, where the tasks are so complex and the set-up rather unique, only large differences in time and transitions between the experimental groups should be accepted as evidence; this can be done by setting significance levels lower than normal. It should be noted that in this experiment, when many of the examples that follow occurred, time and software transition adjustments were made accordingly.

- It is not possible to control the control group conditions as tightly as the laboratory setting. For example, some control group participants were unavoidably interrupted during the experiment.
- The ways in which different users accomplish the same task are so varied that time and transitions might be meaningless. For example, in this experiment, scenario 1 task 1 asks users to record what the Amemiya lab members look like. Some users tried to copy the single group lab picture, while others visited the Web pages of individual lab members and attempted to capture each person's picture separately (which obviously takes a lot more time and transitional states).
- Some users skip small steps, such as forgetting to save their notes when instructed.
- Some users fail to complete tasks as asked without seeming concerned, while others make a special effort and double-check that they complete each task correctly.
- Some users make a lot more effort with things like formatting (lining things up, making pictures smaller, etc.) than others.
- System crashes during an experiment are inevitable.
- It is difficult to uncouple Netscape/ZFIN from the other applications. For example, it

may take users more time to complete a task because of ZFIN usability problems, such as navigation difficulties. In at least one case (participant code #10052C, scenario 2, task 4), a participant was unable to complete a task because he/she could not locate the correct ZFIN page.

- NetNotes participants might be at a disadvantage because they completed the experiment using a PC/Windows machine when they are generally used to Macintoshs. For example, some NetNotes participants were unsure how to access shortcut keys on a PC (i.e., they looked for the PC equivalent to the Macintosh apple key). In some of these instances, I mentioned the shortcut key equivalency on the PC, but in other cases, I did not. This discrepancy allowed some NetNotes participants access to shortcut keys during the experiment while others did not have such access.

Hypothesis 3: The NetNotes group will be able to create a more effective set of notes than the control group.

This hypothesis, which was measured by the number of session 2 test questions that users could answer correctly using only their notes from session 1, was partially demonstrated for scenario 1 (notes generation) test questions but not for scenario 2 (work process tracking) test questions. For the 4 scenario 1 test questions, more NetNotes participants were able to answer each of the questions correctly using only their notes than control group participants, and for 2 of these questions, the differences were significant. This result, along with the results supporting hypothesis 1, provide strong evidence that NetNotes users were able to generate a more complete set of notes than the control group for scenario 1, and that their notes were of higher quality. Since one of the primary reasons why people create notes is to help them recall important information, the fact that more NetNotes participants were able to use only their notes to answer questions—which is a form of recalling information—than control group participants indicates that the NetNotes prototype contained critical notetaking functionality that was easy to learn and use, and that may not be available in other widely used notetaking software.

That no significant results were discovered between how the two groups answered scenario 2 test questions is not surprising given that control group participants were able to record all of the necessary scenario 2 task information in their notes, just as NetNotes participants were. Again, the scenario 2 tasks were not necessarily included in this experiment to expose functionality contained in the NetNotes prototype but missing in other software, but instead to illustrate the repetition and tedium involved with manually recording certain key work process information over and over again in a set of notes. So, in terms of completeness and quality, the scenario 2 notes that control group participants were able to create are not markedly different than those of NetNotes participants.

Decreased Cognitive Effort Hypotheses

Hypothesis 4: The NetNotes group will require fewer transitions between software applications when completing the tasks.

For the same reasons discussed in hypothesis 2, hypothesis 4 was not statistically demonstrated in this experiment. In other words, because it only makes sense to compare the number of transitions for tasks that participants were totally successful at completing, and since so few control group participants were completely successful with the scenario 1 (notes generation) tasks overall, analyzing the number of software transitions per task was ultimately not that meaningful. As for the number of application transitions required per participant for scenario 2 (work process tracking) tasks, these results were too mixed between the NetNotes group and the control group to draw any inferences from.

Hypothesis 5: The NetNotes group will report less effort (i.e., more satisfaction with effort required) required to complete the tasks with the available software than the control group.

Statistically, hypothesis 5 was demonstrated in this experiment for scenario 2 (work process tracking) tasks, but not for scenario 1 (notes generation) tasks. On both ASQ1 and ASQ2, NetNotes participants reported feeling more satisfied with the amount of effort they needed to expend to complete the tasks than control group participants, but only in the case of scenario 2 tasks were these differences significant.

These results are not surprising for scenario 2 tasks given the previous discussions detailing the manual repetitive nature involved with completing these tasks for control group participants that was automated for NetNotes participants. Additionally, post-experiment comments indicate that many NetNotes participants were quite pleased and excited by the work process tracking functionality found in the prototype system, particularly with the automatic capture of Web page URLs and the date and time of Web page visits. Furthermore, many NetNotes participants stated that such a tool would be very useful in helping them manage their day-to-day Web tasks. For example, one NetNotes participant mentioned that she recently used the Web to research Bed and Breakfasts in New England for an upcoming trip. She noted that during this research, she visited quite a few different Web pages that she wanted to keep track of. Rather than using bookmarks to mark the pages, which she avoided since she worked on a common laboratory machine and did not want this information to be publicly available to others, this user had to write down each of the URLs on a piece of paper which she found quite tedious. This participant commented that a tool like NetNotes would be very helpful in allowing her to easily keep track of these Web pages in a private way for later review.

In addition to the ASQ responses, the techniques that some control group participants employed for scenario 2 suggest that they found the tasks to be quite tedious. For example, after understanding that it would be necessary to record the same information repeatedly for multiple Web pages, a number of control group participants created a template page in their notes ahead of time to facilitate this process. After generating the first set of information (i.e., the title, URL, date and time, and annotation for the first Web page), these participants made a copy of this information and re-pasted it multiple times in their notes, thus effectively creating a template. This template allowed participants to avoid re-labeling the information and adding the current date in every time, although they still had to change the title, URL, time, and annotation for each additional Web page they visited.

Even though no significant differences were reported in how satisfied participants were with the amount of effort they had to expend for scenario 1 (notes generation) tasks, I firmly believe that part of the reason for this is that control group participants did not have the NetNotes prototype to compare against. While I observed control group participants completing the scenario 1 tasks, it appeared to me on a number of occasions that participants would not be able to complete a task correctly, and yet did not seem particularly bothered by this and simply moved on to the next task. These participants, perhaps simply unaware that they had not completed the task correctly, were more likely to report inflated satisfaction levels on the ASQs. On the other hand, if they had the NetNotes prototype to compare against, I think these same participants would not only recognize that they were unable to complete the task as requested using their normal software, but also that NetNotes allows them to complete the same tasks correctly and with relatively little effort. Therefore, I think a more appropriate gauge of user satisfaction would ultimately come from a within-subjects experiment where each participant completes the same (or similar) tasks using both the NetNotes prototype as well as their normal software.

Increased User Satisfaction Hypothesis

Hypothesis 6: The NetNotes group will report a higher degree of user satisfaction completing the tasks with the available software than the control group.

Based on the results of ASQ1 and ASQ2, this hypothesis was not demonstrated with statistical significance for either scenario 1 or 2. However, for both scenarios, NetNotes participants reported feeling more satisfied completing the tasks with the available tools than control group participants with two exceptions (scenario 1 question 1.5, and scenario 2 question 1.2). Furthermore, for two questions related to scenario 2 (questions 1.4 and 1.6), NetNotes participants were significantly more satisfied completing the tasks than control group participants.

As discussed for hypothesis 5, I believe that more significant user satisfaction results would have been evident between the two groups if a within-subjects experimental design was used where all participants completed the same tasks using both the NetNotes prototype and their typical software. In fact, in addition to the suggestions that were made in the hypothesis 5 discussion section, more evidence for this supposition is found in the within-subjects comparison from this experiment between how satisfied NetNotes users were completing the tasks using the NetNotes prototype versus how satisfied they are completing the same tasks using their normal software. For scenario 1, these differences were significant for 5 of 8 matched-pair questions, and for scenario 2, they were significant for 5 of 6 matched-pair questions (i.e., NetNotes users reported being more satisfied with NetNotes that they thought they would be using their typical software). Although these results do not represent a true comparison between the NetNotes prototype and participants' normal software—since these participants only actually used NetNotes and were asked to imagine doing the same tasks using their normal software—it does give a good indication of the results we might expect to see from a within-subjects experiment.

Lastly, perhaps the user satisfaction ratings would have been even higher for NetNotes participants (and thus maybe more significant) if they had more familiarity with the prototype prior to the experiment. With little to no previous exposure, NetNotes participants were effectively learning the software functionality and the user interface as they completed the experimental tasks.

Conclusion

This chapter presents the research objectives, methodology, and results of a between-subjects experiment designed to examine how biologists perform certain Web-based IA tasks using the NetNotes prototype versus using their normal software. Although not all of the hypotheses stated prior to the execution of the experiment were demonstrated statistically, a number of significant results were produced and some new insights were formed. It should be noted that this experiment might also be effectively conducted using a within-subjects design—as commented on in the discussion section—but special attention would then have to be given to minimize the effects of learning. Furthermore, for a within-subjects design, the number of experimental tasks given to the users might have to be significantly reduced in order to make the length of the experiment shorter and thus more manageable for each participant.

Among the most notable results, this experiment demonstrated that NetNotes participants were more productive completing the notes generation portion of the experiment (i.e., scenario 1 tasks) than those participants who only had access to their normal, everyday software. This was evidenced by significant task completion differences between the two groups, and by the effectiveness of the notes created. Unfortunately, no significant productivity differences were noticeable for the scenario 2 (work process tracking) tasks. The experiment also revealed that, based on the After-Scenario Questionnaires (ASQs) that were administered, the NetNotes group expended significantly less cognitive effort (i.e., felt more satisfied with effort required) when keeping track of their ongoing work processes (scenario 2 tasks) than the control group. However, no discernable cognitive effort differences were evident for the notes generation (scenario 1) tasks. Lastly, NetNotes users reported feeling generally more satisfied completing the tasks with the software they had available to them than the control group, but these differences were not significant.

Finally, the wish list portion of the ASQs filled out by both groups indicates that participants do have the desire for some sort of integrated Web-based notetaking software. Participants reported primarily wanting a tool to help them gather hyperlinks, lists and tables, and images from the Web, while annotating or editing Web information once it has been gathered seems to be less necessary. This result warrants further research in that it implies that perhaps users will have the most use for a tool that simply allows them to gather formatted information from the Web without necessarily letting them modify that information further.

CHAPTER VI

CONCLUSIONS AND FUTURE WORK

The work in this dissertation revolves around my definition of the term *Information Assimilation (IA)*. As we continue the transformation of many aspects of our lives to the digital world of the World Wide Web, we must also continue to assess how our tasks change and what tools we need to better support our evolving needs. The definition of IA that I propose is relatively straightforward and much like the process of traditional notetaking that most of us are already quite familiar with. At a high level, IA encompasses a Web user's need to gather and save information from the Web, to personalize that information by editing, annotating, and organizing it, and to keep track of longer term, ongoing Web work processes to allow for the suspension and later rejoining of Web-based tasks.

The basis for my definition of IA, and the evidence that I use to argue that it is a critical process for many Web users, comes from a number of significant background research efforts. Recognizing the similarities between IA and notetaking, I began my research by conducting an extensive literature review of the process of traditional notetaking. From this review, I discovered common reasons why people take notes, what those notes typically consist of, how notes are organized and used, and what "good" notes are. These factors, when translated from a traditional paper-based system to the electronic medium of the Web, helped in the development of a consistent, high-level definition of IA. In order to define IA more specifically, however, I also incorporated my findings from an ethnographic field study of how scientists take notes. During this ethnographic study, where I observed how four biologists engaged in the process of notetaking as part of their everyday work activities, evidence emerged that supported the literature review findings, and a number of new requirements unique to the scientific community were also discovered. The ethnographic study results were then used to define IA at a more detailed, functional requirements level. This list of low-level IA requirements was finalized based on a preliminary analysis of how traditional notetaking changes in the electronic Web environment.

Armed with a definition of IA—both at a high level and at a detailed functional requirements level—I then sought to determine how well existing software supports this process. I conducted a heuristic evaluation of a number of related Web-based applications, including Web browsers, and discovered a significant gap between the process of IA and software that adequately supports it. In an effort to begin bridging this gap and to explore the challenges associated with developing Web-based applications, I implemented a Web-based e-notebook prototype system called NetNotes. NetNotes was designed specifically to support the process of IA, and during its development, I discovered firsthand why creating Web-based software can be so difficult. However, by making a few minor server-side modifications to the Web site that NetNotes was designed to work in conjunction with, I was able to create a functional application that does indeed support many critical IA tasks.

The final phase of my dissertation research involved using NetNotes in an experimental evaluation to determine its impact on usability. In particular, I was interested in testing out my belief that an application designed specifically to support the process of IA, such as NetNotes, would allow users to complete certain Web-based tasks more productively, with less cognitive effort, and with a higher degree of user satisfaction when compared to participants using their normal software applications. This experiment, which was complex in terms of both its design and in the types of tasks that it encompassed, showed that NetNotes users were in fact able to complete some tasks more productively than the control group, as evidenced by task completion and effectiveness measurements. Furthermore, NetNotes users were also able to complete another set of tasks with less cognitive effort than the control group, as evidenced by higher levels of satisfaction with effort required. Unfortunately, there were no significant differences between the two groups in terms of how satisfied users were completing the tasks with the available tools; additionally, for other tasks, there were no evident differences in productivity or cognitive effort.

Future Work

In many respects, the work I have completed thus far is just a beginning. My research into Web-based notetaking tasks, the development of NetNotes, and the design and execution of the experimental evaluation described in this dissertation were all necessary first steps that have opened up a number of continuing and new research avenues to follow. Some of these possible research directions are discussed throughout the remainder of this chapter.

New Experimental Designs

Although a number of my hypotheses were not demonstrated with significant results by my experimental evaluation, I still strongly believe that they are valid and important, and that perhaps what is needed is a slightly different set of experimental designs. For example, although the two groups of participants (i.e., NetNotes and the control group) did not report significant differences in how satisfied they were completing the given tasks with the software they had available to them, changing the experiment from a between-subjects design to a within-subjects design might successfully produce the anticipated results. A within-subjects experiment would allow each participant to compare using the two software environments—NetNotes versus other applications like word processing programs, graphics editors, etc.—and I believe, would result in stronger feelings that NetNotes was better for the tasks given. These results might be even more pronounced if participants were given more training time on the NetNotes prototype prior to the experiment rather than having to learn the user interface and functionality as they went along. Lastly, I would also consider increasing the scale used on the After Scenario Questionnaires (which were used to report user satisfaction and effort) to more than 7-points, which may make clusters of user responses more evident.

I am also very interested in continuing research on the work process tracking functionality implemented in NetNotes from both an experimental perspective and from a user interface design perspective. Although the scenario 2 work process tracking tasks produced some of the least significant results in my experiment, the extremely positive comments made by NetNotes participants about this aspect of the prototype—along with my own convictions—lead me to believe that this particular area still has a lot of potential. While the work process part of my experiment represents a good start, some changes to the experimental design might result in more significant results.

Although more thought is still required, my initial feeling is that a separate experiment dedicated to tracking ongoing work processes should be designed (i.e., one that does not include other Web notetaking tasks), and that this new experiment should include a more involved work process than my initial experiment did. Because the experiment described in this dissertation was so complex from a task perspective, it was necessary to keep the work process portion relatively short (only four Web pages were involved). I believe this had the unintended consequence of minimizing some of the effects. On the other hand, a stand-alone work process experiment could involve significantly more tasks to keep track of, which should better highlight the advantages of a semi-automated prototype like NetNotes over existing systems. Furthermore, such an experiment could also focus more on the recall and rejoining of a previous work process. Other research experiments similar to the one I envision here can also be used as models. For example, Robertson et al. (1998) conducted an experiment comparing how users stored and retrieved 100 Web pages using Internet Explorer's favorites mechanism versus a 3D document management system called Data Mountain. In part, this experiment indicates that Data Mountain users are able to take advantage of having personal control over the spatial layout of storing and retrieving their Web pages. A close examination of this experimental design, as well as of the dependent measures used, might help in the design of a similar experiment dealing with tracking ongoing work processes using NetNotes.

Work Process Tracking

In addition to developing some new experimental designs that might do a better job of teasing out the advantages of having automated work process tracking functionality in an e-notebook, there is also more research to be done on the user interface design aspects of this function. In the NetNotes prototype, I made a number of fundamental user interface design decisions that should be re-examined with the users' help. For example, in NetNotes, a step (i.e., Web page to track) is added to an existing work process only when the user explicitly chooses. Should this be changed so that all Web pages visited are automatically added to a work process? As another example, work process steps in NetNotes currently include the title, URL, system date and time, and annotation for visited Web pages. Does this satisfy users' needs or is there information that should be added to or omitted from these work process steps? Lastly, NetNotes uses a sequential list to represent work process steps. Are there more effective ways to display this information? As with any good user-centered design, these questions should be posed to potential users of the system along with prototypes illustrating the various options, and the feedback gathered should be incorporated into future iterations of the software.

Along with incorporating user feedback into the design, experimental evaluations might also be used to determine the information that is essential for tracking a work process. For example, one version of NetNotes also included thumbnail images of visited Web pages in a work process step; perhaps an experiment can test whether these images actually help users recall and rejoin previous work processes, or if instead they are superfluous and perhaps even distracting. The previous study by Robertson et al. (1998) can once again be used as a model for such an experiment. In their experiment, some of the cueing conditions used for page retrieval included a thumbnail image of the Web page while other conditions did not provide this information. Results from their experiment suggest that thumbnail images did help users recognize and retrieve Web pages, but more research still has to be done. This same type of experiment might test the usefulness of various kinds of work process information, including thumbnail images, titles, URLs, and annotations of previously visited Web pages.

Differences Between Traditional Notetaking and IA

One of the more interesting avenues of new research stemming from this work is determining the differences between traditional paper-based notetaking and IA on the Web. In this dissertation, I argued that there are indeed significant differences between these two processes, and I even identified a number of them. However, I believe that more abstract differences still exist that have yet to be investigated. For example, one outstanding research question I have is, *Do we take notes from the Web for fundamentally different reasons than* *we do traditionally?* In Chapter II, I summarized from my literature review that people engage in traditional notetaking for the following reasons: to remember things, to think, to organize information, to process information, and to document events. Are these reasons still accurate when we move to the Web environment? I think that further research might uncover some significant changes in the reasons why we take notes from the Web, and these changes are critical to understand if we are to continue developing the most effective support tools for Web-based notetaking possible.

I suspect that another key difference between traditional notetaking and IA has to do with the amount of information we gather. In the traditional process of notetaking, especially if the notes are being transcribed by hand, the notetaker is more likely to read a source carefully, process the information, and summarize the most relevant parts before writing it down. Conversely, because it is relatively easy to capture (i.e., copy/paste or print) large selections of unformatted information from the Web, and because there is so much information readily available, we may become less discriminatory as notetakers and gather more data from the Web than we need. One result of this would be that we may have to go back and re-analyze (and possibly trim) our notes more frequently. Subsequently, how well our electronic notes are organized, how accessible they are, how easy it is to edit and re-structure them, the retrieval methods we have, etc., all become even more critical aspects of our IA process.

Looking Forward

I feel particularly buoyed by my work so far in the area of Web-based notetaking. I strongly believe that the process of IA is critical to many Web users—as I have argued throughout this research—and that more and more evidence supporting this claim will become apparent in the future as our use of the Web continues to grow and as new tools become available. The conception and design of the NetNotes prototype is based on a foundation of strong empirical and ethnographic evidence, and without underestimating the many challenges associated with developing applications for the Web, I think that it is within our realm to create applications like NetNotes that will work in conjunction with a number of general Web sites. These Web-based e-notebook applications, which in the future should support the seamless transfer of an increasing number of Web elements, will empower users to make more effective use of the World Wide Web as never before. In an even longer-term outlook, we may see e-notebooks help users decentralize Web usage by allowing them to browse the Web or launch new Web processes from within a notebook application itself. I am proud to think that the work presented as part of this dissertation might someday play a role in future realizations of such visions.

APPENDIX A

EXPERIMENTAL SESSION 1

Consent Forms

Consent 1 for Control Group

Code # ______

You are invited to participate in a research study conducted by Yolanda Reimer, from the University of Oregon, Department of Computer Science. The Zebrafish database, which is also commonly referred to as ZFIN, is a web accessible multimedia data repository housing genetic information relating to the zebrafish species. Up to the minute information about genes, mutations, map markers, genetic researchers, labs, and publications can all be found within ZFIN. The purpose of this study is to analyze how biologists capture and record ZFIN notes, and how biologists track their ongoing ZFIN/Web work processes.

If you decide to participate in this observational study, you will be asked to meet with Yolanda for a total of two sessions. During the first session, you will be presented with a series of tasks that involve locating information in ZFIN, and you will be asked to record notes pertaining to specific information that you find. How you record these notes is completely up to you, but should reflect your typical Web-based notetaking practices (i.e., how you normally record notes when you use the Web for research purposes). One constraint in this study is that the final notes that you produce must be in electronic form (no printouts or hand-written notes). After completing these tasks, you will be requested to complete questionnaires. During the second study session, you will be asked to answer questions relating to the first notetaking session. I am estimating that the first study session will take between 85-120 minutes, and the second session will take between 40-50 minutes. Both sessions will take place at the place where you normally access the Web (i.e., desk or office).

It is important that you realize that during these studies, I am solely interested in observing your typical Web-based notetaking practices; I am not evaluating your ability to locate information in ZFIN or your notetaking skills. There is no time limit imposed, and it is not critical for you to finish any of the tasks. In many places, the instructions are purposefully abstract—I simply ask that you try to complete each task as best as you can. If you get really stuck on any particular task, and it appears that you are unable to continue, I will let you know when it's okay to move on. Please remember that it's okay if you get stuck—this is all part of what I'm trying to observe, and it may indicate that my study design needs more work!

To record your notetaking practices for later analysis, I will be videotaping (including audio) your computer screen during both study sessions. It's possible that parts of the back of your head, your arms, and/or your hands may be visible on the tapes; this is necessary because of the camera angle needed to best capture the computer screen. I will also be monitoring time during this study.

The risks associated with participating in this study are deemed to be minimal. That is, you will not be subjected to any pain or stress beyond that normally encountered in everyday life. Any information that is obtained in connection with this study that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Subject identities will be kept confidential by assigning each subject a code number. All data will be marked and identified using this code number. No personal information for any participant will be attached to the data. All videotapes will be kept in a secure location at all times during and after the study. Only members of the Human-Interaction Group and other researchers associated with the project will be allowed to view the videotape data. In no case will the data be made generally available without your additional prior consent.

Your participation is voluntary. Your decision whether or not to participate will not affect your relationship with the University of Oregon in any way. If you decide to participate, you are free to withdraw your consent and discontinue participation at any time without penalty.

If you have any questions, please feel free to contact Yolanda Reimer (346-4425) or her faculty advisor, Sarah Douglas (346-3974) in the Computer Science Department at any time. If you have questions regarding your rights as a research subject, contact the Research Compliance Office, University of Oregon, Eugene, OR 97403, (503) 346-2510. You will be offered a copy of this form to keep.

Your signature indicates that you have read and understand the information provided above, that you willingly agree to participate, that you may withdraw your consent at any time and discontinue participation without penalty, that you will receive a copy of this form, and that you are not waiving any legal claims, rights or remedies.

Signature ______________________________________ Date______________

Addendum: Express Consent for Videotaping

I have received an adequate description of the purpose and procedures for videotaping sessions during the course of the proposed research study. I give my consent to allow myself to be videotaped and audiotaped during my participation in both sessions of this study, and for those videotapes to be viewed by persons involved in the study, as well as for other professional purposes as described to me. I understand that all information will be kept confidential and will be reported in an anonymous fashion. I understand that the videotapes will be kept on file, in order to be available for further analysis in the future, for several years. I further understand that I may withdraw my consent at any time.

Signature ______________________________________Date_____________

Consent 1 for NetNotes Group

Code # _______

You are invited to participate in a research study conducted by Yolanda Reimer, from the University of Oregon, Department of Computer Science. The Zebrafish database, which is also commonly referred to as ZFIN, is a web accessible multimedia data repository housing genetic information relating to the zebrafish species. Up to the minute information about genes, mutations, map markers, genetic researchers, labs, and publications can all be found within ZFIN. NetNotes is an electronic notebook prototype system designed to help researchers capture and record notes from ZFIN. The purpose of this study is to analyze how well NetNotes supports a researcher's notetaking tasks, and to identify any flaws in the NetNotes design.

If you decide to participate in this observational study, you will be asked to meet with Yolanda at the Human-Computer Interaction Video Lab located in room 337 of Deschutes building for a total of two sessions. During the first session, you will be presented with a series of tasks that involve locating information in ZFIN, and you will be asked to record notes pertaining to that information using the NetNotes application. After completing these tasks, you will be requested to complete a questionnaire. During the second study session, you will be asked to answer questions relating to the first notetaking session. I am estimating that the first study session will take between 90-120 minutes, and the second session will take between 40-50 minutes.

It is important that you realize that during these studies, *it is the design of NetNotes that is being tested, not your data manipulation skills.* There is no time limit imposed, and it is not critical for you to finish any of the tasks. In many places, the instructions are purposefully abstract because our goal is to design intuitive interfaces that don't require complex training or manuals to operate. We just ask that you try to complete each task as best as you can. If you get really stuck on any particular task, and it appears that you are unable to continue, I will let you know when it's okay to move on. Please remember that it's okay if you get stuck – this just means that our interface needs more work!

To record your interaction with ZFIN and NetNotes for later analysis, videotapes (including audio) of the computer screen and of you will be made during both study sessions. Your whole upper body will be visible on the tapes; this is necessary because the analysis I will do must account for your gestures, facial expressions, and progress through the given tasks.

The risks associated with participating in this study are deemed to be minimal. That is, you will not be subjected to any pain or stress beyond that normally encountered in everyday life. Any information that is obtained in connection with this study that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Subject identities will be kept confidential by assigning each subject a code number. All data will be marked and identified using this code number. No personal information for any participant will be attached to the data. All videotapes will be kept in a secure location at all times during and after the study. Only members of the Human-Interaction Group and other researchers associated with the project will be allowed to view the videotape data. In no case will the data be made generally available without your additional prior consent.

Your participation is voluntary. Your decision whether or not to participate will not affect your relationship with the University of Oregon in any way. If you decide to participate, you are free to withdraw your consent and discontinue participation at any time without penalty.

If you have any questions, please feel free to contact Yolanda Reimer (346-4425) or her faculty advisor, Sarah Douglas (346-3974) in the Computer Science Department at any time. If you have questions regarding your rights as a research subject, contact the Research Compliance Office, University of Oregon, Eugene, OR 97403, (503) 346-2510. You will be offered a copy of this form to keep.

Your signature indicates that you have read and understand the information provided above, that you willingly agree to participate, that you may withdraw your consent at any time and discontinue participation without penalty, that you will receive a copy of this form, and that you are not waiving any legal claims, rights or remedies.

Signature ______________________________________Date_____________

Addendum: Express Consent for Videotaping

I have received an adequate description of the purpose and procedures for videotaping sessions during the course of the proposed research study. I give my consent to allow myself to be videotaped and audiotaped during my participation in both sessions of this study, and for those videotapes to be viewed by persons involved in the study, as well as for other professional purposes as described to me. I understand that all information will be kept confidential and will be reported in an anonymous fashion. I understand that the videotapes will be kept on file, in order to be available for further analysis in the future, for several years. I further understand that I may withdraw my consent at any time.

Signature ____Date______________

Consent 2 for Both Groups

Code # _______

I appreciate your assistance with this research project on Web-based notetaking. I plan to use the results of this study in my dissertation thesis. This research will help me understand the ways in which biologists currently take notes from the Web, and ways in which this process might be better supported with appropriate software tools.

As part of this study, you will be asked to complete two questionnaires. Each questionnaire should take approximately 7-10 minutes to complete. If you do not wish to participate, simply discard the questionnaire. Responses will be completely anonymous; your name will not appear anywhere on the survey. Completing and returning the questionnaires constitutes your consent to participate.

At the end of this session, I will wrap-up with some informal, open-ended questions. This should take approximately 5-10 minutes. Responses will be completely anonymous; your name will not appear anywhere on the question responses. If for any reason you do not wish to participate in this informal interview, that is fine. When we get to this part of the study, please indicate to me verbally your willingness to participate.

Keep this letter for your records. If you have any questions, please feel free to contact Yolanda Reimer (346-4425) or her faculty advisor, Sarah Douglas (346-3974) in the Computer Science Department at any time. If you have questions regarding your rights as a research subject, contact the Research Compliance Office, University of Oregon, Eugene, OR 97403, (503) 346-2510. Thank you again for your help.

Overviews

Overview for Control Group

Please read the following overview carefully and feel free to ask any questions you may have before the session begins.

1. In a moment, you will be presented with two research scenarios. These scenarios are intended to be similar to actual research you might conduct using the ZFIN Web site. For the purposes of this study, your overall goal is to create a set of notes that best supports your research tasks and that contains ZFIN information you find. Specifics about the notes that you are to create are described in more detail in each scenario.
2. To browse the ZFIN Web site, use the Netscape Web browser. To create your notes, use whatever software tools you normally use when you do Web-based research. You may use any software application (or combination of applications) that you wish to create your notes. However, one restriction is that your notes must be in electronic form (i.e., no printouts or hand-written notes allowed).
3. In some instances, the instructions are left purposefully vague—my overall intention is to witness your typical Web-based notetaking practices without being too specific. In cases where you are unsure of what is being asked of you, simply solve the problem as best you can. If you get really stuck on a task and it appears as though you can't continue, I will let you know when it's okay to move on.
4. As you work through each scenario, you will be periodically prompted to save your notes. You will be given two code #s to use (one for each scenario). Use the appropriate code # for the file name and the default directory when saving your notes.
5. During both sessions of this study, with your permission, you will be video and audio taped. Feel free to talk aloud during any part of the study and to express questions or difficulties. When the study session begins, I will begin the video/audio tape.
6. I will be monitoring time and the video camera as you complete the tasks, and I will not be able to answer any questions you may have until the study is over.
7. After you complete research scenario 1, you will be asked to fill out a brief questionnaire before continuing on with research scenario 2. After you have completed research scenario 2, you will be asked to complete another questionnaire.

8. Your participation in this study is greatly appreciated, but is voluntary. If for any reason during the study you wish to stop, please just do so. You are under no obligation to complete the study.
9. Above all, please remember that the point of this study is to observe typical Web-based notetaking practices, not your data manipulation skills.

Please feel free to ask any questions at this point.

Overview for NetNotes Group

Please read the following overview carefully and feel free to ask any questions you may have before the session begins.

1. In a moment, you will be presented with two research scenarios. These scenarios are intended to be similar to actual research you might conduct using the ZFIN Web site. For the purposes of this study, your overall goal is to create a set of notes that best supports your research tasks and that contains ZFIN information you find. Specifics about the notes that you are to create are described in more detail in each scenario.
2. To create your notes, please use only the following two software applications: Netscape to browse the ZFIN Web site, and NetNotes to create and store your notes. The notes you generate must be in electronic form (i.e., no printouts or hand-written notes allowed).
3. In some instances, the instructions are left purposefully vague—my overall intention is to observe your interaction with the software without being too specific. In cases where you are unsure of what is being asked of you, simply solve the problem as best you can. If you get really stuck on a task and it appears as though you can't continue, I will let you know when it's okay to move on.
4. As you work through each scenario, you will be periodically prompted to save your notes. You will be given two code #s to use (one for each scenario). Use the appropriate code # for the file name and the default directory when saving your notes.
5. During both sessions of this study, with your permission, you will be video and audio taped. Feel free to talk aloud during any part of the study and to express questions or difficulties. When the study session begins, I will begin the video/audio tape.

6. I will be monitoring time and the video camera as you complete the tasks, and I will not be able to answer any questions you may have until the study is over.
7. After you complete research scenario 1, you will be asked to fill out a brief questionnaire before continuing on with research scenario 2. After you have completed research scenario 2, you will be asked to complete another questionnaire.
8. Your participation in this study is greatly appreciated, but is voluntary. If for any reason during the study you wish to stop, please just do so. You are under no obligation to complete the study.
9. Above all, please remember that the point of this study is to test the software tools that you are using, not your data manipulation skills.

Please feel free to ask any questions at this point.

<u>Research Scenarios</u>

Scenario 1

Remember, your overall goal is to create a set of electronic notes containing the information described below. There are 5 tasks in this research scenario, each described on a separate page. Please finish each task to the best of your ability before moving on to the next one. Once you have moved on to another task, please do not revisit any of the tasks you have already completed. Please complete the tasks in the order in which they are presented.

At this time, make sure you have your scenario 1 code # for saving purposes.

Do you have any questions before we begin?

———————— *page break* ————————

Task 1

Suppose you want to collect certain information about the ZFIN lab named the **Amemiya** lab. Your first task is to locate the detailed ZFIN page for this lab, and then to record the following information in your notes.

- The name and address of the lab
- Who the lab members are
- What the lab members look like

When you are done recording this information, save your notes in the default directory. Use your scenario 1 code # as the file name.

Continue on to the next page

——————————— ***page break*** ———————————

Task 2

From the **Amemiya** lab ZFIN page, record all publications produced by members of that lab in the year **1999** only. Include the publication **year**, the **hyperlink title**, and the **authors**.

Give the publications you just copied a suitable heading (e.g., **1999 pubs from Amemiya lab**).

Re-save your notes (use same directory and file name).

Continue on the next page

——————————— ***page break*** ———————————

Task 3

One of the 1999 publications from the Amemiya lab that you recorded in your notes is entitled, "**Evolution of chordate hox gene clusters**", but you've always known and referred to this article simply as "chordate hox". Change the hyperlink title of this publication in your notes to reflect your personal name for it (i.e., **chordate hox**).

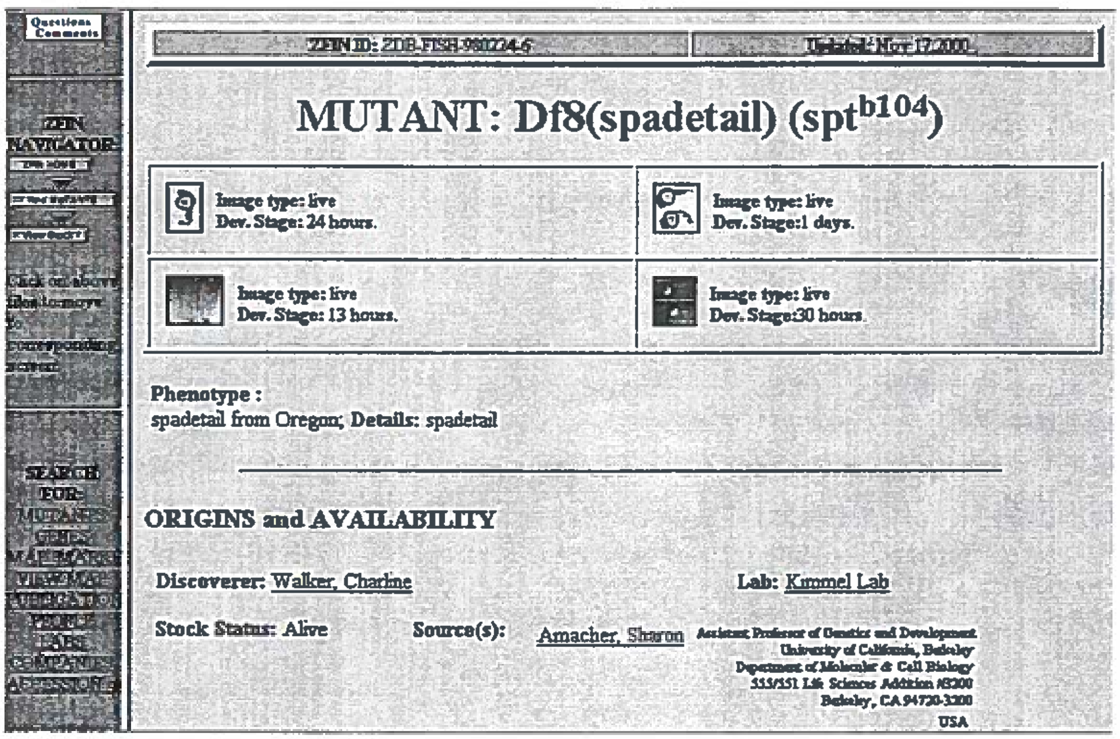
Re-save your notes (use same directory and file name).

Continue on to the next page

——————————— ***page break*** ———————————

Task 4

Now you wish to move on and research some mutant fish. Search the ZFIN database for all **Mutant Fish with Allele b104** (you can leave all search fields blank or to their default as long as you enter Allele b104 in the appropriate search field). Only one record should be returned from the search. Click on the hyperlink for allele **b104** to bring up the detailed ZFIN page as shown below:



Once you have located this ZFIN page, record in your notes the full name and the development table for this fish.

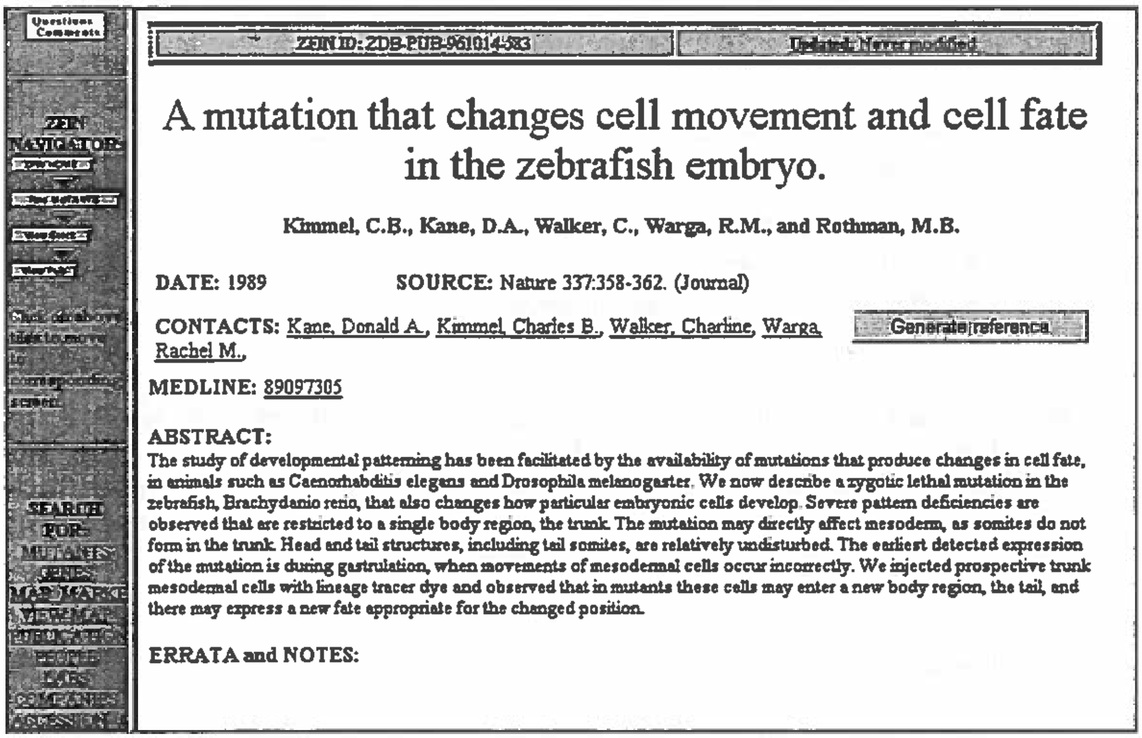
Re-save your notes (use same directory and file name).

Continue on to the next page

page break

Task 5

Still on the same ZFIN page for the Mutant Fish with **Allele b104** (full name **Df8(spadetail)(spt^{b104})**, find and select the primary publication listed for this fish. The page you are seeking is shown below:


ZFIN ID: ZDB-PUB-961014-583 | Updated: Never modified

A mutation that changes cell movement and cell fate in the zebrafish embryo.

Kimmel, C.B., Kane, D.A., Walker, C., Warga, R.M., and Rothman, M.B.

DATE: 1989 SOURCE: Nature 337:358-362. (Journal)

CONTACTS: Kane, Donald A., Kimmel, Charles B., Walker, Charline, Warga, Rachel M., [Generate reference]

MEDLINE: 89097305

ABSTRACT:
The study of developmental patterning has been facilitated by the availability of mutations that produce changes in cell fate, in animals such as Caenorhabditis elegans and Drosophila melanogaster. We now describe a zygotic lethal mutation in the zebrafish, Brachydanio rerio, that also changes how particular embryonic cells develop. Severe pattern deficiencies are observed that are restricted to a single body region, the trunk. The mutation may directly affect mesoderm, as somites do not form in the trunk. Head and tail structures, including tail somites, are relatively undisturbed. The earliest detected expression of the mutation is during gastrulation, when movements of mesodermal cells occur incorrectly. We injected prospective trunk mesodermal cells with lineage tracer dye and observed that in mutants these cells may enter a new body region, the tail, and there may express a new fate appropriate for the changed position.

ERRATA and NOTES:

Knowing that you want to return to this ZFIN publication page later, store a link to it in your notes. Name the text of the link "**Mutant spadetail**". Surround this link by meaningful text so that you know what it leads to. For example, in your notes, you might create a line similar to the following, where Mutant spadetail is a link to the ZFIN publication page for that article:

Primary publication for Mutant spadetail (1989) -- check out later when have more time.

Re-save your notes (use same directory and file name).

Continue on to the next page

page break

You have now completed Scenario 1. At this point, you will be asked to complete a questionnaire relating to the tasks you just completed.

Scenario 2

In this scenario, you are asked to locate a number of different ZFIN pages, and your overall task is to keep track of your work process. In other words, you want to keep notes about which ZFIN/Web pages you visited, when you visited them, and why you visited them. The idea is that at some later date, you should be able to recall and rejoin your previous work process easily.

For each Web page that you are asked to locate, you want (and will be prompted) to keep track of the following information in any order you wish.

- What the page was (title or other meaningful description)
- URL of the page
- When you visited the page (date, time)
- Annotations about the page

There are 4 tasks (i.e., ZFIN pages to locate and make notes about) in this research scenario. As with scenario 1, each task is described on a separate page. To help you identify the correct ZFIN page to locate, snapshots of the screens are also provided. Please finish each task to the best of your ability before moving on to the next one. Once you have moved on to another task, please do not revisit any of the tasks you have already completed. Please complete the tasks in the order in which they are presented.

We will now review a sample task.

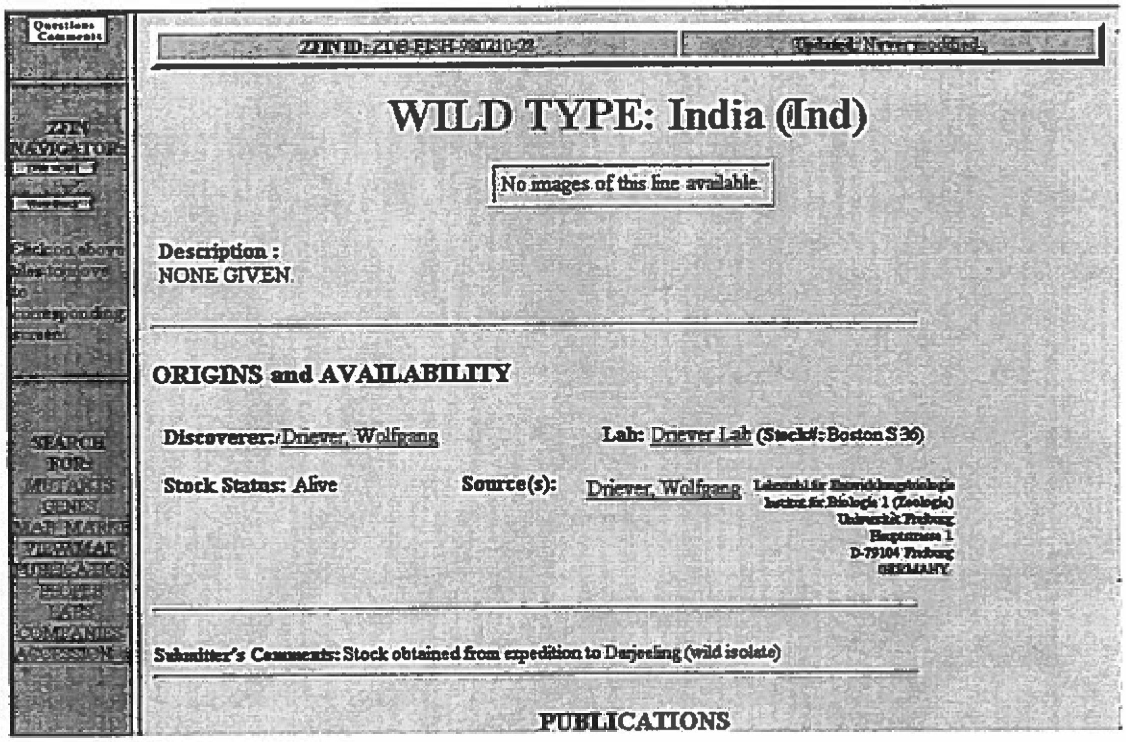
At this time, make sure you have your scenario 2 code # for saving purposes.

Do you have any questions before we begin?

——————————— *page break* ———————————

Task 1

ZFIN page to locate → Wild Type Fish, detailed record for Strain "India"



Information to record in your notes about the page:

- *Page title* → use "Wild Type: India"
- *URL* → http://edison.cs.uoregon.edu/cgi-bin_edison/webdriver?MIval=aa-fishview.apg&OID=ZDB-FISH-980210-28
- *Date & Time* → (insert applicable info)
- *Annotation* → (note the Submitter's comments for this fish)

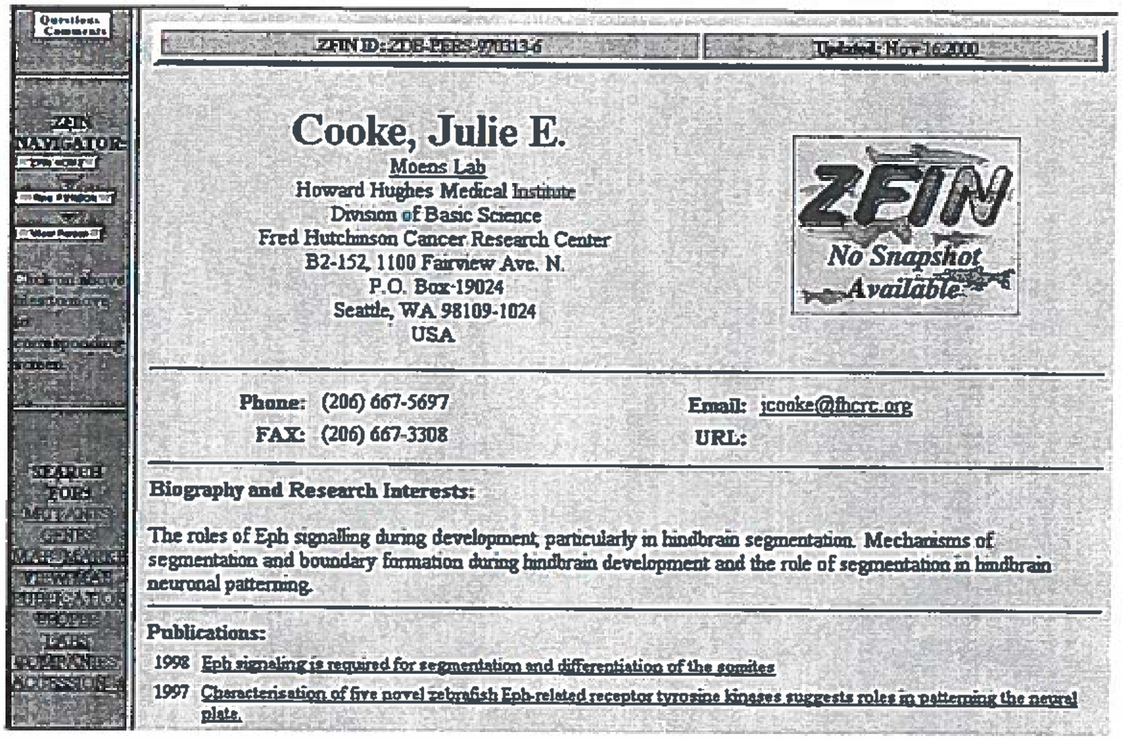
Save your notes in the default directory. Use your scenario 2 code # as the file name.

Continue on to the next page

——————————— *page break* ———————————

Task 2

ZFIN page to locate→ Julie Cooke's ZFIN home page



Information to record in your notes about the page:

- ***Page title→*** use "Julie Cooke's home page"
- ***URL→*** http://edison.cs.uoregon.edu/cgi-bin_edison/webdriver?MIval=aa-persview.apg&OID=ZDB-PERS-970313-6
- ***Date & Time→*** (insert applicable info)
- ***Annotation →*** (note Julie's Biography and Research Interests)

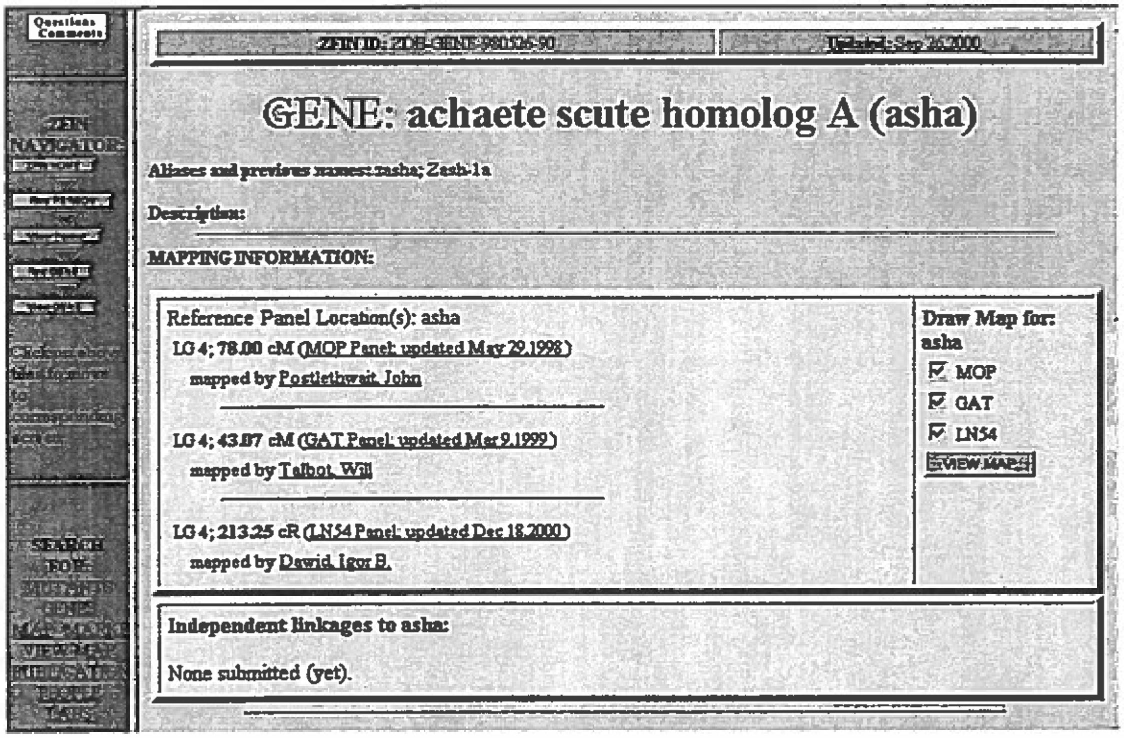
Re-save your notes (use same directory and file name).

Continue on to the next page

page break

Task 3

ZFIN page to locate→ Detailed record for Gene named "asha"



Information to record in your notes about the page:

- *Page title→* use "achaete scute homolog A"
- *URL→* http://edison.cs.uoregon.edu/cgi-bin_edison/webdriver?MIval=aa-markerview.apg&OID=ZDB-GENE-980526-90
- *Date & Time→* (insert applicable info)
- *Annotation →* (note the total number of publications listed for this gene)

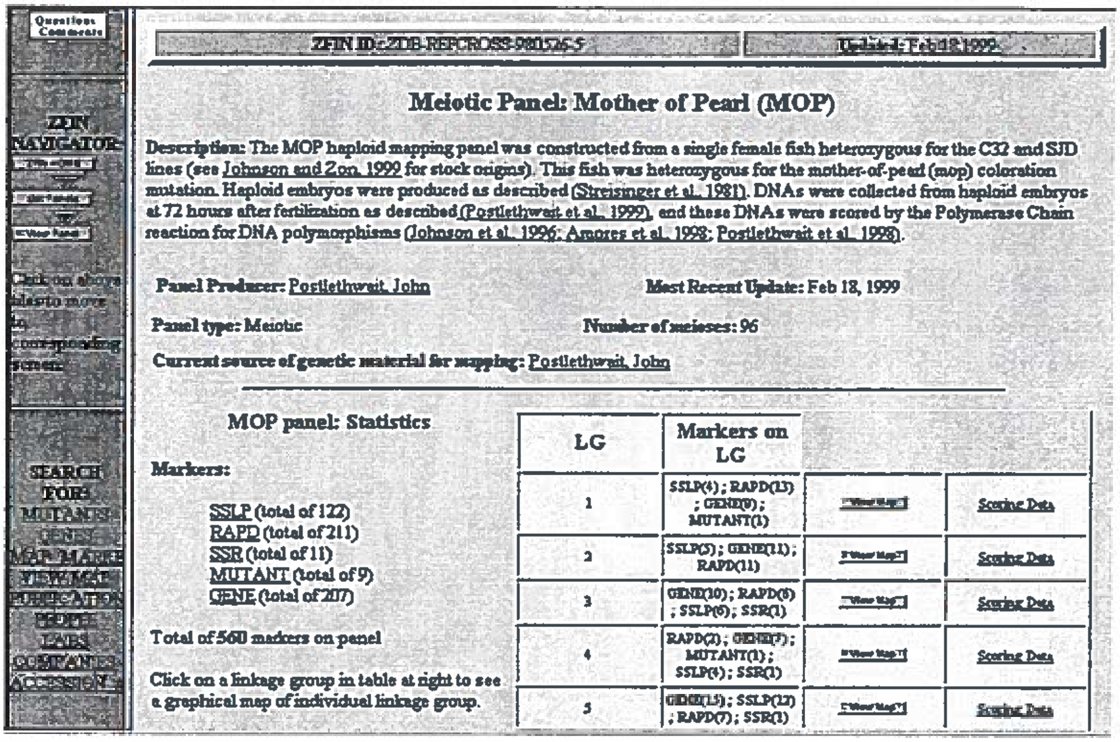
Re-save your notes (use same directory and file name).

Continue on to the next page

——————————— *page break* ———————————

Task 4

ZFIN page to locate→ Mother of Pearl (MOP) mapping panel



Information to record in your notes about the page:

- ***Page title→*** use "MOP"
- ***URL→*** http://edison.cs.uoregon.edu/cgi-bin_edison/webdriver?MIval=aa-crossview.apg&OID=ZDB-REFCROSS-980526-5
- ***Date & Time→*** (insert applicable info)
- ***Annotation →*** (note that later you want to come back and review linkage group table)

Re-save your notes (use same directory and file name).

Continue on to the next page

——————————— *page break* ———————————

You have now completed Scenario 2. At this point, you will be asked to complete a questionnaire relating to the tasks you just completed.

After Scenario Questionnaires (ASQs)

ASQ1 for Control Group

Code# ______

Please mark the oval of the number that most represents your response to the following statements, where 1 represents strong disagreement and 7 represents strong agreement (leave the answer blank if the statement is not applicable). **These statements all relate to the Scenario 1 tasks you just completed.**

EASE OF USE

1. I am satisfied with the ease of ...	*strongly disagree*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*strongly agree*
completing the scenario 1 tasks overall.		O	O	O	O	O	O	O	
gathering formatted text (headings, bold text, etc.) from the Web.		O	O	O	O	O	O	O	
gathering images from the Web.		O	O	O	O	O	O	O	
gathering hyperlinks from the Web.		O	O	O	O	O	O	O	
editing (changing) information that I copied from the Web.		O	O	O	O	O	O	O	
annotating (adding to) my Web notes.		O	O	O	O	O	O	O	
creating a hyperlink to a Web page from my notes.		O	O	O	O	O	O	O	
saving my Web notes.		O	O	O	O	O	O	O	

EFFORT

2. Overall, I am satisfied with the ...	*strongly disagree*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*strongly agree*
amount of time it took to complete the tasks.		O	O	O	O	O	O	O	
amount of effort it took to complete the tasks.		O	O	O	O	O	O	O	
number of software applications I had to use to complete the tasks.		O	O	O	O	O	O	O	

WISH LIST

3. I wish I had better software tools to help me …

	strongly disagree 1	2	3	4	5	6	7 *strongly agree*
gather formatted text (headings, bold text, etc.) from the Web.	O	O	O	O	O	O	O
gather images from the Web.	O	O	O	O	O	O	O
gather hyperlinks from the Web.	O	O	O	O	O	O	O
gather lists and tables from the Web.	O	O	O	O	O	O	O
edit (change) information from the Web.	O	O	O	O	O	O	O
annotate (add to) information from the Web.	O	O	O	O	O	O	O
create hyperlinks to Web pages.	O	O	O	O	O	O	O
save Web information.	O	O	O	O	O	O	O

4. I wish I had …

	strongly disagree 1	2	3	4	5	6	7 *strongly agree*
one integrated software tool to help me copy and save formatted text, images, lists, tables, and hyperlinks from the Web.	O	O	O	O	O	O	O
a better way to integrate Web information with other notes I keep.	O	O	O	O	O	O	O
a better way to organize information I copy and save from the Web.	O	O	O	O	O	O	O
a software tool that archived Web pages so that I could validate that page's information when needed.	O	O	O	O	O	O	O

5. Please list the software applications that you most frequently use:

6. How often do you use the Web for general purposes?
Daily ____ Weekly ____ Monthly ____ Yearly ____ Never____

7. How often do you use the ZFIN Web site?
Daily ____ Weekly ____ Monthly ____ Yearly ____ Never____

8. On the following scale of 1 to 7, please rate your expertise (check 1 number) with the Netscape Web browsing application, where 1 is no experience and 7 is expert:

no experience … *expert*
1 ___ 2 ___ 3 ___ 4 ___ 5 ___ 6 ___ 7 ___

9. How often do you have the need or desire to record notes based on information you find on the Web?

Daily ____ Weekly ____ Monthly ____ Yearly ____ Never____

ASQ1 for NetNotes Group

Code# ______

Please mark the oval of the number that most represents your response to the following statements, where 1 represents strong disagreement and 7 represents strong agreement (leave the answer blank if the statement is not applicable). **These statements all relate to the Scenario 1 tasks you just completed.**

EASE OF USE

1. I am satisfied with the ease of …	*strongly disagree*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*strongly agree*
completing the scenario 1 tasks overall.		O	O	O	O	O	O	O	
gathering formatted text (headings, bold text, etc.) from the Web.		O	O	O	O	O	O	O	
gathering images from the Web.		O	O	O	O	O	O	O	
gathering hyperlinks from the Web.		O	O	O	O	O	O	O	
editing (changing) information that I copied from the Web.		O	O	O	O	O	O	O	
annotating (adding to) my Web notes.		O	O	O	O	O	O	O	
creating a hyperlink to a Web page from my notes.		O	O	O	O	O	O	O	
saving my Web notes.		O	O	O	O	O	O	O	

EFFORT

2. Overall, I am satisfied with the …	*strongly disagree*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*strongly agree*
amount of time it took to complete the tasks.		O	O	O	O	O	O	O	
amount of effort it took to complete the tasks.		O	O	O	O	O	O	O	
number of software applications I had to use to complete the tasks.		O	O	O	O	O	O	O	

STATUS QUO

3. **Normally, I am satisfied with the software tools that I *typically* have access to for …**	*strongly disagree* 1	2	3	4	5	6	7 *strongly agree*
creating Web-based notes such as those in scenario 1.	O	O	O	O	O	O	O
gathering formatted text (headings, bold text, etc.) from the Web.	O	O	O	O	O	O	O
gathering images from the Web.	O	O	O	O	O	O	O
gathering hyperlinks from the Web.	O	O	O	O	O	O	O
editing (changing) information from the Web.	O	O	O	O	O	O	O
annotating (adding to) information from the Web.	O	O	O	O	O	O	O
creating hyperlinks to Web pages.	O	O	O	O	O	O	O
saving information from the Web.	O	O	O	O	O	O	O

WISH LIST

4. **I wish I had better software tools to help me …**	*strongly disagree* 1	2	3	4	5	6	7 *strongly agree*
gather formatted text (headings, bold text, etc.) from the Web.	O	O	O	O	O	O	O
gather images from the Web.	O	O	O	O	O	O	O
gather hyperlinks from the Web.	O	O	O	O	O	O	O
gather lists and tables from the Web.	O	O	O	O	O	O	O
edit (change) information from the Web.	O	O	O	O	O	O	O
annotate (add to) information from the Web.	O	O	O	O	O	O	O
create hyperlinks to Web pages.	O	O	O	O	O	O	O
save Web information.	O	O	O	O	O	O	O

5. **I wish I had …**	*strongly disagree* 1	2	3	4	5	6	7 *strongly agree*
one integrated software tool to help me copy and save formatted text, images, lists, tables, and hyperlinks from the Web.	O	O	O	O	O	O	O
a better way to integrate Web information with other notes I keep.	O	O	O	O	O	O	O
a better way to organize information I copy and save from the Web.	O	O	O	O	O	O	O
a software tool that archived Web pages so that I could validate that page's information when needed.	O	O	O	O	O	O	O

6. Please list the software applications that you most frequently use:

7. How often do you use the Web for general purposes?
   Daily ____ Weekly ____ Monthly ____ Yearly ____ Never____

8. How often do you use the ZFIN Web site?
   Daily ____ Weekly ____ Monthly ____ Yearly ____ Never____

9. On the following scale of 1 to 7, please rate your expertise (check 1 number) with the Netscape Web browsing application, where 1 is no experience and 7 is expert:

   no experience *expert*
   1 ___ 2 ___ 3 ___ 4 ___ 5 ___ 6 ___ 7 ___

10. How often do you have the need or desire to record notes based on information you find on the Web?
    Daily ____ Weekly ____ Monthly ____ Yearly ____ Never____

ASQ2 for Control Group

Code# ______

Please mark the oval of the number that most represents your response to the following statements, where 1 represents strong disagreement and 7 represents strong agreement (leave the answer blank if the statement is not applicable). **These statements all relate to the Scenario 2 tasks you just completed.**

EASE OF USE

1. I am satisfied with the ease of ...	***strongly disagree***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***strongly agree***
completing the scenario 2 tasks overall.		O	O	O	O	O	O	O	
noting the *title* of Web pages I visited.		O	O	O	O	O	O	O	
noting the *URL* of Web pages I visited.		O	O	O	O	O	O	O	
noting when (*date/time*) I visited certain Web pages.		O	O	O	O	O	O	O	
creating annotations for Web pages I visited.		O	O	O	O	O	O	O	
saving my ongoing Web work processes.		O	O	O	O	O	O	O	

EFFORT

2. Overall, I am satisfied with the ...	***strongly disagree***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***strongly agree***
amount of time it took to complete the tasks.		O	O	O	O	O	O	O	
amount of effort it took to complete the tasks.		O	O	O	O	O	O	O	
number of software applications I had to use to complete the tasks.		O	O	O	O	O	O	O	

WISH LIST

3. I wish I had better software tools to help me ...	***strongly disagree***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***strongly agree***
keep track of my ongoing Web work processes.		O	O	O	O	O	O	O	
note the *title* of Web pages I visit.		O	O	O	O	O	O	O	
note the *URL* of Web pages I visit.		O	O	O	O	O	O	O	
note when (*date/time*) I visit certain Web pages.		O	O	O	O	O	O	O	
capture *thumbnail images* of Web pages I visit.		O	O	O	O	O	O	O	
create annotations for Web pages I visit.		O	O	O	O	O	O	O	
save my ongoing Web work processes.		O	O	O	O	O	O	O	
rejoin a previous work process quickly and easily.		O	O	O	O	O	O	O	

ASQ2 for NetNotes Group

Code# ______

Please mark the oval of the number that most represents your response to the following statements, where 1 represents strong disagreement and 7 represents strong agreement (leave the answer blank if the statement is not applicable). **These statements all relate to the Scenario 2 tasks you just completed.**

EASE OF USE

1. I am satisfied with the ease of ...	*strongly disagree*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*strongly agree*
completing the scenario 2 tasks overall.		O	O	O	O	O	O	O	
noting the *title* of Web pages I visited.		O	O	O	O	O	O	O	
noting the *URL* of Web pages I visited.		O	O	O	O	O	O	O	
noting when (*date/time*) I visited certain Web pages.		O	O	O	O	O	O	O	
creating annotations for Web pages I visited.		O	O	O	O	O	O	O	
saving my ongoing Web work processes.		O	O	O	O	O	O	O	

EFFORT

2. Overall, I am satisfied with the ...	*strongly disagree*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*strongly agree*
amount of time it took to complete the tasks.		O	O	O	O	O	O	O	
amount of effort it took to complete the tasks.		O	O	O	O	O	O	O	
number of software applications I had to use to complete the tasks.		O	O	O	O	O	O	O	

STATUS QUO

3. Normally, I am satisfied with the software tools that I *typically* have access to for ...	*strongly disagree*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*strongly agree*
keeping track of my ongoing Web work processes.		O	O	O	O	O	O	O	
noting the *title* of Web pages I visit.		O	O	O	O	O	O	O	
noting the *URL* of Web pages I visit.		O	O	O	O	O	O	O	
noting when (*date/time*) I visit certain Web pages.		O	O	O	O	O	O	O	
creating annotations for Web pages I visit.		O	O	O	O	O	O	O	
saving my ongoing Web work processes.		O	O	O	O	O	O	O	

WISH LIST

4. **I wish I had better software tools to help me ...**

	strongly disagree 1	2	3	4	5	6	7 *strongly agree*
keep track of my ongoing Web work processes.	O	O	O	O	O	O	O
note the *title* of Web pages I visit.	O	O	O	O	O	O	O
note the *URL* of Web pages I visit.	O	O	O	O	O	O	O
note when (*date/time*) I visit certain Web pages.	O	O	O	O	O	O	O
capture *thumbnail images* of Web pages I visit.	O	O	O	O	O	O	O
create annotations for Web pages I visit.	O	O	O	O	O	O	O
save my ongoing Web work processes.	O	O	O	O	O	O	O
rejoin a previous work process quickly and easily.	O	O	O	O	O	O	O

APPENDIX B

EXPERIMENTAL SESSION 2

Consent

I would appreciate your continued assistance with this research project on Web-based notetaking. I plan to use the results of this study in my dissertation thesis. This research will help me understand the ways in which biologists currently take notes from the Web, and ways in which this process might be better supported with appropriate software tools.

All you need to do is to try to answer as many of the following questions as possible, which should take approximately 15-20 minutes. If you do not wish to participate, simply discard the questions. Responses will be completely anonymous; your name will not appear anywhere on the test. Completing and returning the test questions constitutes your consent to participate.

I would like to stress to you again at this time that the purpose of this study is to evaluate the process of notetaking. I am not evaluating your cognitive abilities, your memory capacity, your test-taking skills, or your personal skill as a notetaker. Please do not feel badly if you cannot answer any of the following questions—the information you are providing me by simply trying is incredibly valuable for my study.

After you have completed answering the questions, I will follow-up with some informal, open-ended questions. This should take approximately 5-10 minutes. Responses will be completely anonymous; your name will not appear anywhere on the question responses. If you do not wish to participate in this informal interview, that is fine. When we get to this part of the study, please indicate to me verbally your willingness to participate.

Again, your decision to participate in this session study is completely voluntary. Please be assured that your decision whether or not to participate in the testing portion and in the informal interview will not affect your relationship with the University of Oregon or the Department of Biology in any way. If you decide to participate, you are free to withdraw your consent and discontinue participation at any time without penalty.

Remember that you will be video and audio taped during this session (you signed a consent during the previous study session). Please sign the addendum below to indicate your continued consent to be video and audio taped. As during session 1, I will be monitoring the video camera and time during this session, so I will be unable to answer any questions you may have until the end of the study.

Keep this letter for your records. If you have any questions, please feel free to contact Yolanda Reimer (346-4425) or her faculty advisor, Sarah Douglas (346-3974) in the Computer Science Department at any time. If you have questions regarding your rights as a research subject, contact the Research Compliance Office, University of Oregon, Eugene, OR 97403, (503) 346-2510. Thank you again for your help.

Addendum: Express Consent for Videotaping

I have received an adequate description of the purpose and procedures for videotaping sessions during the course of the proposed research study. I give my consent to allow myself to be videotaped and audiotaped during my participation in both sessions of this study, and for those videotapes to be viewed by persons involved in the study, as well as for other professional purposes as described to me. I understand that all information will be kept confidential and will be reported in an anonymous fashion. I understand that the videotapes will be kept on file, in order to be available for further analysis in the future, for several years. I further understand that I may withdraw my consent at any time.

Signature ____Date_______________

<u>Overview</u>

Please read the following overview carefully and feel free to ask any questions you may have before the session begins.

1. In a moment, you will be presented with a set of questions relating to the Web tasks you completed during the first session of this study approximately 2-3 weeks ago.
2. To help you answer the questions, you should first refer to the notes you generated during session 1 of this study. You may select any hyperlink you may have in your notes to bring up a ZFIN page to help you find an answer. If your notes don't help you answer a question, then feel free to find the answer directly using the ZFIN Web site.
3. After answering each question, in the space provided, please indicate whether or not you could have answered the question without referring to your notes or to ZFIN (i.e., if for some reason you just "knew" or remembered the answer).

4. To refresh your memory, during the first session of this study, you were given two research scenarios to complete.

Scenario 1 involved the following tasks:

- Locating the Amemiya lab record and recording the lab's name and address, who the lab members are, and what the lab members look like.
- Recording just the 1999 publications from the Amemiya lab, including the year, hyperlink title, and authors.
- Changing the hyperlink title of one of the publications to your own special name (chordate hox).
- Locating the ZFIN record for Mutant allele b104, then recording the full name for this mutant and its development table.
- Creating a link to the primary publication for Mutant allele b104

Scenario 2 involved locating a number of different ZFIN pages, and then recording the following work process information about each page:

- Page title
- URL
- Date & time visited
- Annotation

5. As last time, I will be monitoring time and the video cameras as you complete the questions, and will not be able to answer your questions until after the test is over.
6. Once again, please remember that I am not evaluating your cognitive abilities, your memory capacity, your test-taking skills, or your personal skill as a notetaker in any way—the point of this experiment is simply to learn more about Web-based notetaking.

Please feel free to ask any questions at this point.

Tests

Scenario 1 Test

There are 5 questions on this test. Each question is located on a separate page. Please answer each question to the best of your ability. When answering a question, please refer to your notes first, and then to the ZFIN site only if you cannot find the answer in your notes.

Once you answer a question and move on, please do not revisit any of the questions or answers you have already completed. Please complete the questions in the order in which they are presented.

——————————— *page break* ———————————

1. Refer to the group picture of Amemiya lab members displayed on the Amemiya Lab ZFIN page to answer the following question.

   What kind of shirt is the man in the back row, right hand side wearing (your right when facing the picture)?

   a.) a white T-shirt
   b.) a plaid shirt
   c.) a shirt with the words "Duffy's Bar & Grill" emblazoned on it
   d.) a red button down shirt

   Could you have answered this question with certainty without referring to either your notes or to ZFIN?

   Yes ____ No ____

Please continue on next page after answering

——————————— *page break* ———————————

2. What is the SOURCE listed on the ZFIN publication abstract page for the primary publication of the Mutant Spadetail (mutant with Allele b104)?

   a.) Nature 337:358-362. (Journal)
   b.) Development 125:3389-3397 (Journal)
   c.) Development 125:3379-3388 (Journal)
   d.) Neuron 6:767-776. (Journal)

   Could you have answered this question without referring to either your notes or to ZFIN?

   Yes ____ No ____

Please continue on next page after answering

———————————— *page break* ————————————

3. What is the MEDLINE number listed on the ZFIN abstract page for the 1999 Amemiya paper entitled "Zebrafish YAC, BAC, and PAC genomic libraries"?

   a.) 99296837
   b.) 10664153
   c.) 99343976
   d.) 99108490

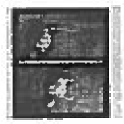
   Could you have answered this question with certainty without referring to either your notes or to ZFIN?

   Yes ____ No ____

Please continue on next page after answering

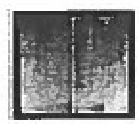
———————————— *page break* ————————————

4. Match each of the Mutant Spadetail's (i.e., mutant with Allele b104) development images with the correct Development Stage (draw connecting lines between).

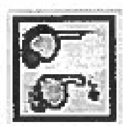


24 hours

1 days



13 hours



30 hours

Could you have answered this question with certainty without referring to either your notes or to ZFIN?

Yes ____ No ____

Please continue on next page after answering

———————————— *page break* ————————————

5. What is the SOURCE listed on the ZFIN publication abstract page for the primary publication of the Mutant Spadetail (mutant with Allele b104)?

   a.) Nature 337:358-362. (Journal)
   b.) Development 125:3389-3397 (Journal)
   c.) Development 125:3379-3388 (Journal)
   d.) Neuron 6:767-776. (Journal)

   Could you have answered this question without referring to either your notes or to ZFIN?

   Yes ____ No ____

Please continue on next page after answering

———————————— ***page break*** ————————————

You now have completed test 1.

Scenario 2 Test

There are 4 questions on this test. Each question is located on a separate page. Please answer each question to the best of your ability. When answering a question, please refer to your notes first, and then to the ZFIN site only if you cannot find the answer in your notes.

Once you answer a question and move on, please do not revisit any of the questions or answers you have already completed. Please complete the questions in the order in which they are presented.

———————————— ***page break*** ————————————

1. List the titles (not the URLs but the titles you gave) for all the ZFIN pages you kept track of during your scenario 2 work process, **in the order that you visited them from first to last.**

   Could you have answered this question with certainty without referring to either your notes or to ZFIN?

   Yes ____ No ____

Please continue on next page after answering

———————————— *page break* ————————————

2. Why did you visit the asha (achaete scute homolog A) gene page last time during your scenario 2 work process (i.e., write down the annotation you made)?

   Could you have answered this question with certainty without referring to either your notes or to ZFIN?

   Yes ____ No ____

Please continue on next page after answering

———————————— *page break* ————————————

3. What is Julie Cooke's FAX number?

Could you have answered this question with certainty without referring to either your notes or to ZFIN?

Yes ____ No ____

Please continue on next page after answering

——————————— *page break* ———————————

You have now completed test 2.

APPENDIX C

TIME AND TRANSITION COMPARISONS FOR SESSION 1 SCENARIO 2 TASKS

Task 1

A total of 9 NetNotes and 7 control group participants were able to completely finish scenario 2 task 1. As shown in both Table 16 and Figure 25, the amount of time and the number of application transitions required per participant was mixed. NetNotes participants scored both the highest and the lowest in terms of time and transitions, with control group participants mixed quite evenly between. All participants from both groups used two software applications to complete the task.

Table 16. Scenario 2, Task 1—Time and Transitions for Complete Successes

Code #	Group	Time (sec)	Application Transitions
10051NN	NetNotes	225	3
10052NN	NetNotes	130	6
17052NN	NetNotes	334	9
17053NN	NetNotes	172	7
18052NN	NetNotes	200	16
22051NN	NetNotes	410	1
24051NN	NetNotes	160	4
24052NN	NetNotes	144	3
24053NN	NetNotes	161	3
11051C	Control group	255	7
15051C	Control group	199	10
15052C	Control group	204	6
17051C	Control group	153	5
18053C	Control group	168	5
25052C	Control group	156	5
25053C	Control group	189	7

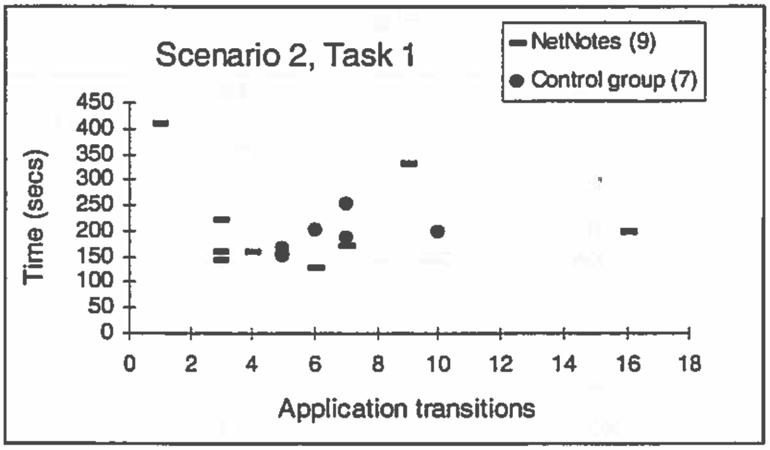


Figure 25. Scenario 2, Task 1—Time and Transitions for Complete Successes.

Task 2

As with task 1, 9 NetNotes and 7 control group participants were able to completely finish scenario 2 task 2. Also as shown in Table 17 and Figure 26, the amount of time and the number of application transitions required per participant was again quite mixed between the two groups. NetNotes participants took both the longest and the shortest amount of time to complete the task. NetNotes participants also required the fewest application transitions, and one participant was tied with a control group participant for the highest number of transitions. All but one control group participant used two software applications to complete the task; the one control group participant used three applications.

Table 17. Scenario 2, Task 2—Time and Transitions for Complete Successes

Code #	Group	Time (sec)	Application Transitions
10051NN	NetNotes	134	4
10052NN	NetNotes	115	4
17052NN	NetNotes	247	4
17053NN	NetNotes	94	7
18052NN	NetNotes	197	10
22051NN	NetNotes	215	3
24051NN	NetNotes	124	3
24052NN	NetNotes	135	4
24053NN	NetNotes	216	8
11051C	Control group	135	8
15051C	Control group	167	6
15052C	Control group	176	5
18053C	Control group	136	6
25051C	Control group	153	10
25052C	Control group	134	6
25053C	Control group	115	6

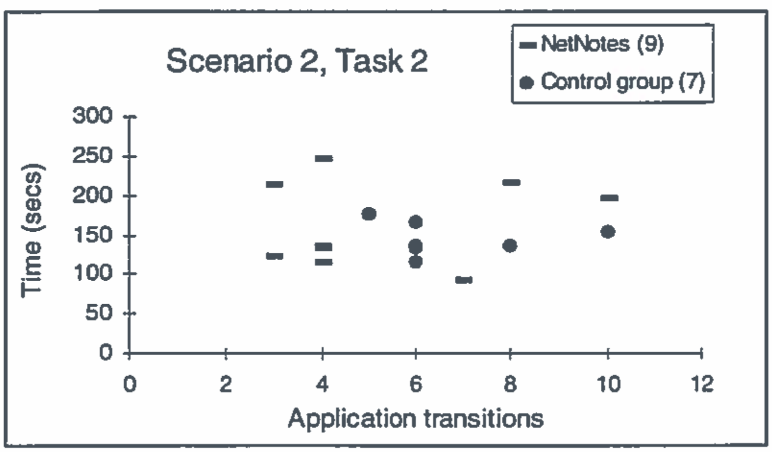


Figure 26. Scenario 2, Task 2—Time and Transitions for Complete Successes.

Task 3

As with tasks 1 and 2, 9 NetNotes and 7 control group participants were able to completely finish scenario 2 task 3. Once again, Table 18 and Figure 27 show that the time and transitions results were quite mixed. NetNotes participants required the most amount of time to complete this task, and all participants used two software applications.

Table 18. Scenario 2, Task 3—Time and Transitions for Complete Successes

Code #	Group	Time (sec)	Application Transitions
10051NN	NetNotes	179	4
10052NN	NetNotes	103	2
16051NN	NetNotes	163[a]	6
17052NN	NetNotes	258	8
17053NN	NetNotes	122	6
18052NN	NetNotes	112[a]	4
22051NN	NetNotes	343	10
24051NN	NetNotes	153	2
24052NN	NetNotes	154	4
11051C	Control group	119	6
15051C	Control group	157	6
15052C	Control group	199	4
18053C	Control group	133	9
25051C	Control group	161	6
25052C	Control group	101	2
25053C	Control group	120	6

[a] time and transitions adjusted for not saving (+10 seconds, +2 transitions)

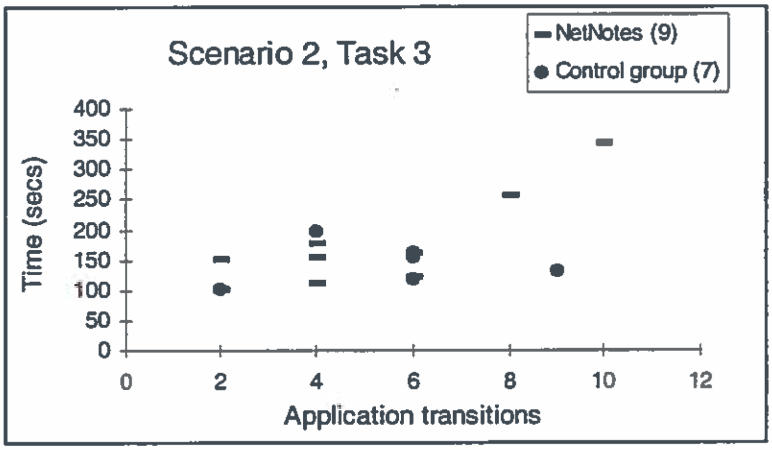


Figure 27. Scenario 2, Task 3—Time and Transitions for Complete Successes.

Task 4

Perhaps the most notable result of scenario 2 overall is that whereas all 10 NetNotes participants were able to completely finish task 4, only 4 control participants were successful. However, Table 19 and Figure 28 again show relatively mixed time and transition results, with NetNotes participants requiring both the fewest and the most application transitions. NetNotes participants also took the least amount of time to complete the task, and a control group participant required the most. One control group participant used three software applications to complete the task while all other participants used just two.

Table 19. Scenario 2, Task 4—Time and Transitions for Complete Successes

Code #	Group	Time (sec)	Application Transitions
10051NN	NetNotes	229	4
10052NN	NetNotes	88	4
16051NN	NetNotes	177[a]	6
17052NN	NetNotes	147	2
17053NN	NetNotes	283	5
18052NN	NetNotes	196	10
22051NN	NetNotes	84	2
24051NN	NetNotes	239	2
24052NN	NetNotes	127[a]	4
24053NN	NetNotes	151	2
15051C	Control group	384	5
15052C	Control group	185	6
25051C	Control group	102	4
25053C	Control group	150	4

[a] time and transitions adjusted for not saving (+10 seconds, +2 transitions)

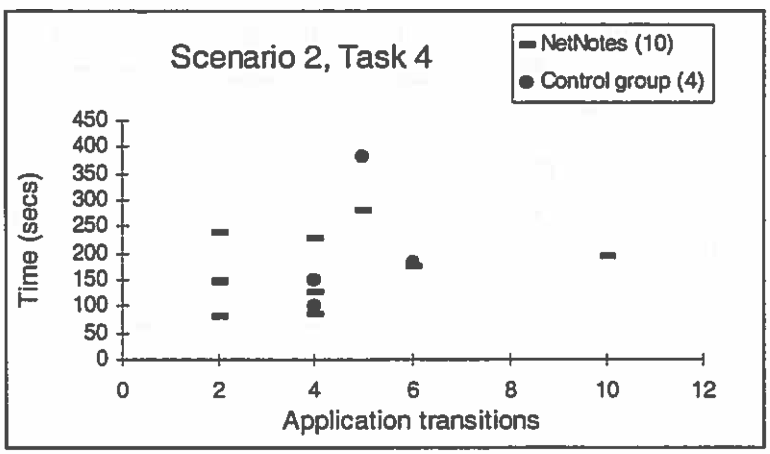


Figure 28. Scenario 2, Task 4—Time and Transitions for Complete Successes.

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