

Introducing a digital library reading appliance into a reading group

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ABSTRACT

How will we read digital library materials? This paper describes the reading practices of an on-going reading group, and how these practices changed when we introduced XLibris, a digital library reading appliance that uses a pen tablet computer to provide a paper-like interface. We interviewed group members about their reading practices, observed their meetings, and analyzed their annotations, both when they read a paper document and when they read using XLibris. We use these data to characterize their analytic reading, reference use, and annotation practices. We also describe the use of the Reader's Notebook, a list of clippings that XLibris computes from a reader's annotations. Implications for digital libraries stem from our findings on reading and mobility, the complexity of analytic reading, the social nature of reference following, and the unselfconscious nature of readers' annotations.

Keywords

Digital library, reading appliance, e-book, paper document metaphor, active reading, annotation, qualitative study, technology introduction, reference use, design.

1. INTRODUCTION

Early research on digital libraries focused on infrastructure: how would distributed information sources be identified, interconnected, searched, and maintained? At the same time, practitioners – libraries and other institutions – began efforts to collect digital holdings, and posed equally difficult questions about acquiring and preparing materials.

In the face of a more mature infrastructure and a growing number of useful digital collections, it is now appropriate to ask how people will read digital library materials. Will people download digital documents and print them as they need them, as Crawford predicts [5], thus swelling the volume of paper used by workplaces, libraries, and homes? Or will they read the documents online at desktop digital library terminals, as Bazin suggests in his account of the Bibliothèque de France's prototype reading

stations? These Computer Assisted Reading Environments would "allow the reader to work on a corpus of digitized documents culled from the library's immense reserves" [3].

We are investigating a possibility that lies somewhere between the two, a digital library reading appliance that combines the mobility and affordances of paper¹ with computational augmentation [15]. In contrast to the recent spate of electronic books [17], we intend digital library reading appliances to support a range of intellectual activities associated with active reading [2].

Our explorations to date have resulted in a research prototype, XLibris, that uses a *paper document metaphor* to support analytic reading activities [14]. The device reproduces the physical experience of working with paper: readers can hold electronic documents on their laps, moving the e-reader as appropriate to avoid glare; they can mark on the electronic documents with a variety of pens and highlighters; and they can turn from one page to the next by thumbing on the device. In essence, XLibris attempts to capture the materiality associated with reading physical documents (see Figure 1). Figure 2 shows a page of an electronic document that a reader has annotated with freeform ink.

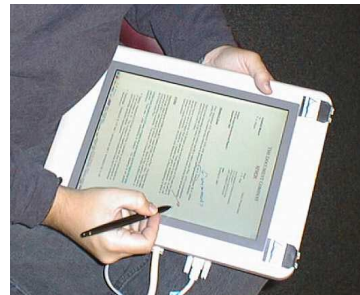


Figure 1. XLibris prototype in a reader's lap.

Why would digital library patrons use an e-reader if what it does is imitate paper? A primary emphasis of XLibris research has been to go beyond the affordances of paper documents. For example, the XLibris Reader's Notebook helps readers review their reading by gathering marked-up passages into a list, which they can use to navigate to source documents [14].

To investigate how such a reading appliance would function with digital library materials, we introduced XLibris into an on-going reading group. The reading group gathers weekly to discuss

¹ The affordances of paper are described in [16].

and personal, dependant on participants' knowledge of who is doing good work in the field and which projects are related to their own. Convenience matters: papers that are available in a colleague's office or easily accessible on the Web are more likely to be pursued as reading group papers. Participants prefer locally available papers despite ready access to an information center that can retrieve papers for them.

How the papers are read. Reading group members report that they read the papers most of the time; all six members read both papers during our study. They often carried the articles around with them until they had the time and inclination to read. For example, one group member reported that even though she ended up reading the paper in the office, she "took it home a couple of times, but it never got anywhere there...You can see that it's totally trashed. It's been to the pool. It's been just about everywhere with me."

How the meetings are conducted. The weekly meeting is an animated, lively encounter. Participants discuss the paper for about an hour, answering each other's questions, filling in interpretive gaps (many papers rely on *a priori* knowledge of specialized techniques or of previous work), and deciding which references to pursue. The meetings are (deliberately) critical of the papers:

"I don't think we went in and trashed it too bad as a group. We're usually much more brutal to papers. We're even brutal to our own papers when we do them in the reading group."

In both meetings that we observed, all participants brought their annotated papers to the meetings and used them to follow the discussion; one person also brought his notebook, but referred primarily to his annotated paper. Figure 3 shows a scene from the second meeting.

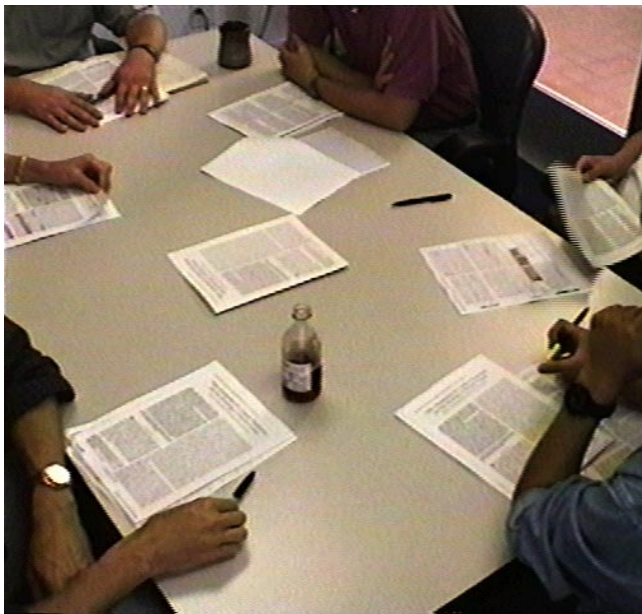


Figure 3. The reading group's second meeting. Each member has his or her own annotated copy of the article. Readers continue to annotate during the meeting.

What reading group members do with the papers after the meeting. By the time the meeting is over, the papers have the readers' annotations on them, and they've been discussed with the aim of coming to a shared understanding. Hence, they ought to

continue to be useful, unless the papers are bad or off topic. Indeed, all but one of the reading group members reported that they would save the paper, either in topical files, or in their piles of papers from the reading group. Their strategies are very much in line with those reported in other studies of how people organize their documents in the course of office work [9],[10]. The single outlying reading group member deserves brief attention, however, because we have observed his strategy elsewhere. He does not save papers, but rather explained that he throws them away, and said if "I ever need access to the paper again because I remember there was something good in it, I would be more likely to retrieve a new copy than to try to retrieve the old copy that I have on my desk."

4. INTERVENING IN READING

We intervened in the group's reading practice by introducing XLibris; each of the group's members read a digital document on XLibris to prepare for the second discussion. What did we hope to learn? First, we wanted to get a more complete account of one particular kind of analytic reading, and the associated activities of using references and annotating documents. Second, we wanted to learn what immediate changes in these activities would be brought about by introducing the device. Finally, we wanted to understand the implications of our results for the design of digital library reading appliances. In this section, we discuss the first two results: a richer characterization of the group members' reading practice, and the changes brought about by the device.

4.1 Using the appliance

How did the physical properties of XLibris change the overall experience of reading? Group members had basic concerns with the weight of the device (5½ pounds), its tethering cables (which they found awkward), and the readability of the article (see [6] for experiments on weight, resolution, and reading comfort). Interestingly, readability problems resulted as much from the low quality of the original (especially the figures) and the further distortions introduced by the scanning process as from the resolution (100 dpi) of the display. As one group member said:

"I can't read the figure. Is it the fault of the device or the scan and I don't know. And it wasn't until after when I saw what you guys had to work with originally that – even in our nice copy, the figures weren't all that great looking."

Despite these problems, for the most part group members appeared to read as they would using paper. One reader said:

"Of course I've seen the device before, but I was kind of surprised to see that it was more like paper than I thought before. Except for some small points. I wanted higher resolution, because it was kind of hard to read. But other than that, I didn't notice the difference between reading on this device, and reading with the actual paper. Of course, the weights are different and the shapes are different. But I usually don't read a paper this thick. [laughs]"

For each of reading, using references, and annotating, we describe characteristics of the activity common to use of paper and use of XLibris, and then any differences. We will touch on some usability problems as we go, but a detailed analysis of these problems (and our subsequent redesign) is beyond the scope of the paper.

4.2 Reading

How do members of the reading group read? At first glance, the answer to this question seems self-evident. We might suppose, since the papers are short, that they read from beginning to end, stopping to look at references in the back as they come up, or at figures as the authors call upon them to illustrate the text; that they make their way through the text, from one page to the next, interrupted only by ringing phones or colleagues at the door.

The interviews and the usage logs, however, both show the individual readings to be more complex than a simple description like “prepare for a discussion” might suggest. People skimmed and re-read; they looked back to remember what they had just read; they read in a way that prefigured how they will participate in the discussion; and they self-interrupted, pausing deliberately.

Skimming and re-reading. The reading group members characterized the papers as taking anywhere from 10 minutes to an hour to read. (For the XLibris round, we compared these subjective impressions of the duration of reading with the usage logs, and found general agreement.) In addition to focused reading, many reported skimming due to time constraints, lack of interest, or dismay over the quality of the research. For example, one member described his reading:

“But what actually may occur, given how pressed for time I was today, is that in a lot of our sessions I will go in and do a skim... But kind of doing that initial skim is okay – is there enough in here, is the paper good enough that it’s worth really spending the time to read through? So what I think is going to happen, I hope, sometime this weekend, is that I will very carefully read through things.”

When asked how he reads this paper’s equations, a form of skimming is also in evidence. The same reader said, “For my skim, I basically do something on the level of ‘Okay, they’re doing motion estimation, four parameters. Yeah, I know what that’s all about. Skip.’” Other reading group members recount similar experiences reading the paper, especially about the time they take to read it, and whether they skim.

Finally, group members sometimes read papers more than once. For example, someone would look over a paper before the meeting to decide whether the group should read it. Group members also reported re-reading a paper simply because they had read it before (outside of the reading group).

Looking back. Papers are not simply read front to back either, even aside from the references and figures. For example, one reader found part of the second paper directly relevant to his work:

“I read through all of it once, beginning to end, and then some passages a second time, where I wanted to get some additional detail. And then actually I started then marking up a few things. [...] And I wanted to discuss it in more detail with J to determine how much prior art there really was.”

At a more local level, readers occasionally turn back to a previous page for a few seconds, looking for an explanation of what they are currently reading. One group member explained his return to a previous page:

“So again, just trying to figure out what are their formulas for this dominance thing, right? So I didn’t spend a ton of time on it. It was like, ‘Oh, this seems to be nothing really big.’”

Reading by role. People read the same material differently in different circumstances (c.f. [8]). The contingent nature of analytic reading is further illustrated by the role of the discussion leader, a role that rotates informally with each paper selection. In both rounds, the discussion leader reported a higher degree of engagement with the text, with the specific aim of being able to focus the discussion. The leader of the first discussion said that while his typical reading behavior for the group is to skim the text and equations, this time he “sat down and read it carefully.” Discussion leaders also annotated more. The leader of the second discussion said, “if I’m reading it as the presenter, I will definitely highlight things that I want to bring out.”

Self-interruption. Does careful reading – or quick, focused skimming – suggest that interruptions are undesirable? Perhaps not. The reading group members not only reported uncontrollable interruptions from outside forces (for example, co-workers at the door), but also self-initiated breaks in their concentration. Participants reported stopping simply to stare out the window for a few minutes, or to work on an unrelated task, especially when the paper was complex or hard to read.

“So I would read the whole thing through, and I would find that by the time I was done, the brain disconnected in the middle of that reading. And although I scanned every bit of ink on the page, the stuff didn’t come in. That getting a little bit of interruption actually helped my understanding of things. It made me go back and figure out where I was and what my place was. And when I found my brain disconnecting, I could say, ‘Oh you know, somebody gave me a good URL, I look at that for a moment and then I’ll get back to the paper.’”

Is this a product of working styles many of us have adopted, in which our attention is shallow and divided (c.f. [7]), or is it a crucial element of analytic reading? Regardless of the cause, self-interruption seems to be prevalent.

How XLibris affected reading. How did reading change when we introduced XLibris? There were few obvious changes. What became apparent is that the paper document metaphor helped the device become ordinary, not a distraction from reading. The usage logs show that users spent little of their time interacting with the device explicitly: around 5% for annotation and 5% for navigation, compared to 90% for reading. And after using XLibris, three readers commented that they were surprised at how “paper-like” it was, even though they were all familiar with the XLibris concept before the study began.

More interesting are the subtle losses. One participant complained about the inability to fold a page so he could continue to see the text while he looked at a reference. Another participant talked about the importance of the activity and genre cues of reading on paper. As others walked by, he thought his pose or the visible form of the document should signal that he was “working” – reading a technical article, rather than a newspaper or magazine.

4.3 Reference use

Analytic reading invariably involves references to other works (either implicitly or explicitly; in this case they are explicit). How do members of the reading group deal with references? Do they consult the list of references in the back when they see one in the text? Do they ever interrupt their reading to obtain the actual document? Are the references by and large familiar, and shorthand for a body of work from a person or group? These questions are

central in designing searching and browsing services for digital libraries. We discuss reference use in terms of consulting them (looking in the back of the paper), marking them, and actually pursuing them.

Consulting. Reading group members consulted the list of references as they were reading. This practice is not only evident through their self-reported behavior – “You go through related work. ‘Okay. Who’s that? Who’s that?’ It’s almost better if they put names in there.” – but also through XLibris usage logs. Each log shows a pattern of brief visits to the references page at the end of the paper.

Marking. When a reader found a reference of particular interest, he or she often marked it, either in the text (by highlighting the number, or the author’s names, or with marginalia such as “lookup?” or “use as ref?”) or by annotating an entry in the references section (see Figure 4). Participants occasionally annotated these references during the reading group meetings as well. As one reader said, “Sometimes I make a little mark next to a reference ... and when I finish reading it and if it’s really interesting, I might go try to find it.”

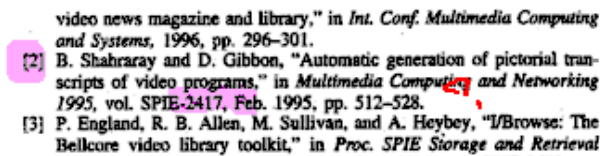


Figure 4. A reading group member’s annotation on the references page. The reader was interested in pursuing the reference, and in learning about the journal, which was unfamiliar to him.

Pursuing. Were these references then pursued? As one participant said, “The problem is with references, if you don’t know them and you’re not familiar with the sources, they’re usually duds.” Thus references were marked more to highlight them for future consideration than to label them for actual retrieval:

“I just marked them because they looked like they might be interesting. I don’t know whether I’ll follow them or not. And there was one that was marked during the group meeting. [...] I think someone said we might go look at this.”

The effort of pursuing references matters: as one reader commented, “It’s worth getting, but it may not be worth finding.” On the other hand, following references while reading may be distracting, and following references after reading requires that readers remember to follow up and that they have the time. As one group member explained when we asked her about a URL she had highlighted (but not retrieved), “Well, you know, it’s hard. Because during the reading, you don’t want to go to it. Right? Because it’s too distracting. Then, afterwards...”

Reading group members also reported that they may reach consensus that a particular reference should be located, and possibly read as a reading group selection. Thus reading group members rely on their colleagues to pursue – and to find – key references:

“In this case, this was just ‘we ought to get this.’ And the person who seemed to be the most interested in doing this was S. So S actually came around shortly after the meeting and said, ‘I need to find...’ He wanted to basically get all the references on the list, just so he knew about them. He

said, ‘Do you have this, this, and this?’ And you know, I had about half of them. Um. The ones that we had marked, oh we ought to go get these, were ones we knew that none of us had ever seen before. Which is why it kind of got brought up as ‘hey, somebody ought to go track that down.’”

How XLibris affected reference use. The XLibris interface made checking references somewhat awkward, and discouraged one reader from checking them as often as she would have on paper. Readers also discovered that they could no longer see the citation and the referring text together (which they can do on paper, even with stapled documents, by bending one of the pages). Some readers responded by saying that they should be able to view the citation for a reference without navigating at all – by having the citation pop up when desired.

4.4 Annotation

Annotation is a tangible reflection of a reader’s engagement with the text. Hence, just as we observed highly contingent, individualized reading patterns, so did we see individual patterns of marking. Some readers wrote extensively; others, far less. One did not mark on the first paper at all. Some readers used highlighters, even for marginalia; others underlined with pen or pencil and used margin bars.

Unselfconscious engagement. In the interviews, we made a particular effort to draw from participants the meaning of the marks that they had made while they were reading. We found that the meaning of the marks was often vague, and that participants forgot their specific intent in making the marks in the interval between the meeting and the final interviews. One participant admitted that a diagram he had drawn on the last page of the paper was now a mystery, but he was “sure it had some significance at the time.” This finding emphasizes that annotations – including freeform ink annotations in XLibris – are part of an unselfconscious engagement with the text, rather than the result of a fully formed interpretation of the material. They can indicate interest, but they can also indicate reaction, as in this reader’s assessment of a paper’s concluding paragraphs:

“And here I made a mark in the conclusions with a wavy line. It was my way of saying, this is something I ought to read through, and they are [weak] all the way through this as well.”

How XLibris affected annotation. Surprisingly, no readers complained about the feel of the Mutoh’s pen for annotating the second reading. In fact, the ratio of annotations to paper length, summed across all group members, was roughly the same for both readings.

If the markings were as numerous, were they also qualitatively the same? Comparing individuals’ marks on the two readings, there were noticeable similarities in style. For example, one participant generally highlighted sentences in yellow, both on paper and with XLibris. Another participant used a pink highlighter for short marginalia as well as for highlights. With XLibris, she began with her usual highlighter color, and even wrote with the highlighter.⁶ In general, we saw similar kinds of annotations on paper and in XLibris.

⁶ A previous paper study also found a decided preference for the implement that is already in hand [11].

On the other hand, XLibris offers the ability to switch easily between styles of ink (pen vs. highlighter) and among ink colors. Indeed, as readers moved from pen and paper to XLibris, they experimented with using more pens. They reported that they liked the ease with which they could do so. Furthermore, one reader liked being able to tidy up his annotations (and erase highlights, or untidy underlines). These changes were evident in the short term use of XLibris; long term patterns may be different as the device's novelty decreases. Annotation practice evolves (c.f. [12]).

One reader complained that the margins, which were reduced when we scanned in the paper, were too small for marginalia. We have observed this complaint in other uses of XLibris as well. This emphasizes the importance of large margins for encouraging annotation, but it also introduces a design tradeoff. Encouraging a fixed size display, and scanned or preformatted documents (e.g. Postscript or PDF), increasing margin size ultimately decreases readability.

5. THE READER'S NOTEBOOK

We have described the paper-like aspect of XLibris; in this investigation, we also wanted to explore how a digital library reading appliance could go beyond the capabilities of paper. So did our readers:

“I could have more from this device, because it was too much like plain, ordinary paper. And there must be a high powered computer behind it. But I wasn't really taking advantage of the power.”

The Reader's Notebook is an example of such a capability: it automatically generates a list of clippings from a reader's annotations. These clippings were intended to support review and navigation back into the document from the extracted segment. Figure 5 shows a portion of the Reader's Notebook generated from a group member's annotations.

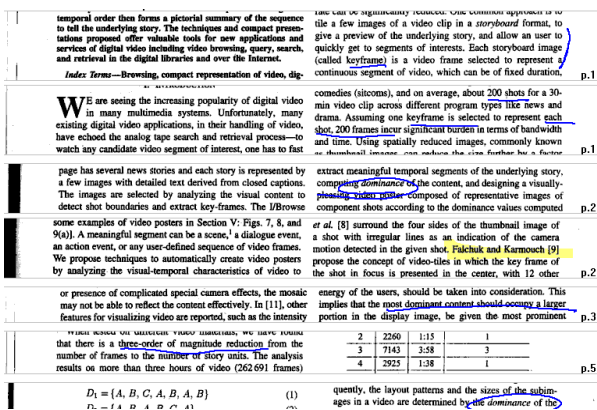


Figure 5. A portion of a Reader's Notebook generated from a group member's annotations. In XLibris, each segment can be used to navigate to the source page.

Because the reading group used XLibris only to prepare for their discussion (and not in the actual meeting), we gave XLibris users a paper copy of the Reader's Notebook for future use. This excluded navigation as a possible use of the Reader's Notebook.

Thus, our original expectation was that group members would review their annotations before and during the meeting using the Reader's Notebook. Only one participant did so. The meeting's linear progression through the document, with its unexpected

topical turns and emphases, made it more valuable for the group to see their marks in full context. One reading group member remarked:

“They [his marks] were all there in the physical document, and we'd gone from the beginning to the end anyway. And I wanted to get the context, so if somebody was saying something about something else, then I would have had it there.”

This expressed preference is consistent with Bishop's discussion of readers' reliance on context [4].

Group members also complained about the length and organization of the Reader's Notebook.

“Well, I looked at them first to try to figure out what they were. And then somebody said, ‘those are your clippings.’ And then I realized they're totally useless because I highlighted so much of the paper.”

This was partly due to various limitations of our prototype: the Reader's Notebook generates overly large clippings for text set in multiple columns and for long callout marks. Yet aside from these limitations, the sheer volume of some of the reader's annotations ensures that the Reader's Notebook will be quite long, and, perhaps, no more convenient to review than the original. This would seem particularly likely for the discussion leaders (who annotated 22 out of 95 and 46 out of 157 paragraphs – also see Figure 2 to get an idea of the density of a group leader's marks). Furthermore, group members had questions about how much context should be included in a clipping, for example with an annotated figure.

5.1 Searching and extracting

Although group members did not, by and large, use the Reader's Notebook to review for comprehension, three readers used the Reader's Notebook in unexpected ways. One said he used the Reader's Notebook to find a reference he annotated in the text. Another marked passages he intended to discuss with a colleague and then used the Reader's Notebook to coordinate a brief discussion outside of the reading group meetings. A third started to use a filter-by-color feature of the Reader's Notebook to build his own table of contents for the document, and began to label questions to ask in the meeting with a particular color, but abandoned the coding schemes (c.f. [12]).

Other readers were interested in using an electronic version of the clippings to find material they had previously read, possibly weeks or months previously. One reader said:

“I can imagine [the clippings] would be useful over time. Once they're collected from the pile of papers. ... Or even one paper. I mean, I've had the occasion where I've wanted to go find something that was in the particular paper. ... If you have like one or two clippings per paper that were sort of the highlights, I think then it would be useful.”

In general, the reading group members were interested in extracting a small amount of material from their documents. They imagined themselves searching for passages that they had read before (in which case, they sometimes wanted to navigate to the full document), or extracting a few relevant points for a situation outside the reading group (as one person did).

5.2 Automatic versus intentional

The automatic nature of the Reader's Notebook posed a problem for some readers. Readers annotate for a variety of reasons [11]. Some annotations, for example, indicate reaction rather than interest, and thus for heavy annotators, an automatic Reader's Notebook will include information of little lasting interest. An alternative is to give readers control over the Reader's Notebook, allowing them add, delete, rearrange, and resize.

For some group members, on the other hand, the manual effort of constructing a Reader's Notebook would not have been worthwhile. The reader who constructed a summary for a discussion was happy with the automatic approach because he normally does not annotate: all of his annotations were for a single purpose. And for the group member who found a reference in the Reader's Notebook, the extra effort to leaf through the paper would have been counterbalanced by any manual effort for modifying the clippings.

6. DIGITAL LIBRARY IMPLICATIONS

What are the implications of our findings for designing interfaces and appliances for reading digital library materials?

Readers are mobile. We do not think of computer science researchers as being mobile workers to the degree that doctors, pilots, or real estate agents are (see [1] for a broad survey of the reading habits of such workers). Yet reading group members reported carrying their papers around with them. They read papers opportunistically in a variety of places away from their desktop computers. And they met away from their offices to discuss the paper.

Thus we believe that terminals or workstations may limit readers' willingness to read digital library materials in digital (as opposed to printed) form; mobile devices will provide better support for reading. Mobility, in turn, has further implications for the caching and retrieval of materials, a topic we will return to later.

Analytic reading is, above all, reading. Readers employed complex strategies, including self-interruption, re-reading, time-constrained skimming, reference checking, and annotation. XLibris's paper document metaphor supported these existing practices. Furthermore, usage logs showed that readers spent little of their time explicitly interacting with the device (annotating or navigating).

These findings suggest that designers should focus on readability, document layout, and physical comfort if they expect digital library materials to be read digitally. Acquisition, digitization, and presentation strategies will need to be designed around the digital medium.

Reference pursuing is important, but rare and deferred. References were frequently checked, often marked, and rarely pursued. Nevertheless, reference following was an important means of getting new materials. Retrieval was based not only on content, but also on the participants' sense of who was doing what in the field, on which work was important, on the status of particular conferences and journals, on the opportunistic availability of papers, and on group consensus that brought together all of these other factors. In short, much goes into a reader's decision about whether or not to pursue and read a new paper.

While designers might want provide ready access to a broad set of materials based on these criteria, it is not clear that the reader

wants them to be visible or has time to read them. On the one hand, interfaces for reading digital library materials should not distract readers from the paper at hand; on the other hand, they should support the deferred pursuit of references.

When readers were interested in pursuing a reference, they were sometimes deterred by the effort involved, especially when they were uncertain of the reference's value. To make evaluating references and pursuing them easier, creators of digital libraries should digitize or acquire explicit hypertext links and citation metadata.

These links have further implications when we take mobility into consideration. Should referenced articles be downloaded together with the article that cites them? Or should actual downloading depend on further indication of a reader's interest? In this scheme, it is possible that metadata and abstracts would suffice for a reader to decide whether to request the document.

Annotations are unselfconscious. Annotations are a vital means of interacting with materials. In our study, we saw them used for a variety of functions. Although one major function of annotations is to set apart important information (c.f. [4],[13]), they also are used to react and otherwise engage with the material. The meaning of these annotations is often unclear after the fact, even for the annotator. Designers of reading appliances should beware of attempting to interpret these marks without some reader guidance.

Readers want to return to key material and extract it. Readers were interested in locating and extracting small amounts of material from their documents. We observed readers compiling short lists of references and extracting key points for discussion. Designers should consider how readers will *use* what they read.

What do these five findings suggest for future work? First, our experiences with the Reader's Notebook suggest that we need to involve readers in defining computational services if they are to be useful to them. Second, understanding other settings will enable us to deepen and extend these results. Finally, we plan to investigate activities surrounding reading to tell us, for example, how annotations are used in subsequent work, or how facilities for link-following, as on the Web, affect analytic reading. More broadly, we want to understand and support the eventual use of digital library materials in a range of real settings and situations.

7. ACKNOWLEDGMENTS

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