Co-Reading: Investigating Collaborative Group Reading

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ABSTRACT

Collaborative reading, or *co-reading* as we call it, is ubiquitous—it occurs, for instance, in classrooms, book-clubs, and in less coordinated ways through mass media. While individual digital reading has been the subject of much investigation, research into co-reading is scarce. We report a two-phase field study of group reading to identify an initial set of user requirements. A co-reading interface is then designed that facilitates the coordination of group reading by providing temporary 'Point-out' markers to indicate specific locations within documents. A user study compared this new system with collaborative reading on paper, with a positive outcome; the differences in user behavior between paper and the new interface reveal intriguing insights into user needs and the potential benefits of digital media for co-reading.

Keywords

Co-reading, Documents, Collaboration, Slate PCs

Categories and Subject Descriptors

H.3.7 [**Digital Libraries**]: User Issues

General Terms

Design, Experimentation, Human Factors

1. INTRODUCTION

The commonplace act of reading is often portrayed as a solitary activity. Looking deeper, however, it becomes apparent that reading in groups is actually surprisingly common [20]. For example, children are encouraged to read in a variety of collaborative forms for much of their school careers (i.e., reading novels, reciting plays, or studying for exams). Many adults also unwittingly read together on a daily basis, whether it be looking at posters, web-pages or even television screens. There are also many examples of more structured collaborative reading sessions such as research groups and book clubs. Reading in groups is both pervasive and important, yet to date there has been surprisingly little research into the topic of *collaborative reading*, or *co-reading*.

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> Jack, Jill, Wendy and Peter are sitting around a desk reading a research paper in an attempt to understand its relevance and impact on their work. They each have an individual paper copy of the article which they annotate independently. As the group is small, they sit near each other and can point out areas of interest using hand gestures coupled with spoken directions. Despite this, they have problems co-ordinating at specific areas of a document: half way through the session, Jack notices a useful quote near the end of the paper. He says "look here, on page 10, column two, paragraph three—that quote is useful". Wendy quickly navigates to the correct page but struggles to locate the exact quote Jack is referring to.

Figure 1: A typical co-reading scenario.

Co-reading has many facets, and in some cases books have been written or printed with special structures to help readers share understandings of the text. One established case is in religious texts, such as the Bible, where standardized structuring of books, chapters and verses allow two (or more) people to identify the same words, even in different editions with different paginations. The use of chapter-and-verse references allows particularity without verbose quotations, and in the context of a shared reading in worship or study, a familiar and rehearsed form of identifying locations can be exchanged due to a common document markup.

However, such structured documents are not always used during collaborative reading, which can lead to challenges for both the group as a whole and the individuals within. Figure 1 provides an example where four co-readers are using multiple paper copies of a single document. A challenge for each member is to accurately point-out specific point in the text to the other members; in this case, a useful quote. Upon locating the quote, each member may make their own notes, creating four distinct artefacts. This scenario demonstrates how users need to coordinate their reading within a group environment: a challenge we term *mutual navigation*.

These variations suggest that co-reading is not a single activity but, rather, a range of different tasks that have varying requirements and goals. In this paper we focus on the specific needs of a peer group that reads together, in the same place, at the same time, using individual media. We investigate user needs by two fieldwork studies, develop a system to support the identified requirements, and evaluate its interaction and use in a laboratory test.

2. BACKGROUND AND MOTIVATION

We will now briefly recap some recent related work of particular and direct relevance to our work. Further literature will be discussed in later in Section 7.

Digital reading and hypertext have been the subject of a vast amount of research since the early days of PCs. Performance has been studied through measures such as reading speed and comprehension, often with particular consideration of screen size and display technology. The wide-scale adoption of mobile devices and the popularization of commercial reading appliances such as the Kindle have sustained an interest in the topic of digital reading and have given rise to numerous research projects in the area.

As Cathy Marshall has noted ([20], Chapter 4), the predominant focus of this long tradition of research has, however, been on *individual reading*. This is despite good evidence that reading in groups is an important aspect of information work [1]. Furthermore, contemporary innovations in technology have started to provoke questions about the appropriate technological configurations for supporting reading in groups [22].

In contrast, collaborative writing has been a subject of extensive research (e.g., [13]). It has long been established that reading is closely connected to writing [1], and research in collaborative writing has considered reading within a group of co-authors. However, within this collaborative context of group writing, reading has still been seen as a primarily solitary activity.

Just as group writing and personal reading are connected, group reading and individual reading are also related. Marshall et al. [21] undertook an early investigation into co-reading, introducing a reading appliance, XLibris, into a reading group. XLibris was used individually, prior to a group meeting, not in the meeting itself. During the group discussion, further reading was done on paper. While most of their paper focusses on individual reading, the interaction between members during the group meeting is reported, if only briefly. Nonetheless, this insight does show the value of having an individual copy of the text when reading as a group: each person can make their own notes and interleave discussion with independent reading. That work, and Marshall's later re-analysis of the same material [20] also suggests that the coordination between group members of their shared reading is a complex activity that occurs alongside brief individual phases of reading.

Our own recent research on information work added further confirmation of the value of individual copies in the context of group reading. Observations of study groups in a university library [7] concluded that groups often had multiple copies of the same book or notes, frequently one copy per person. Notes taken during that work suggested that coordination and sharing of reading was a complex activity. However, as with the work of Marshall et al, our primary focus was elsewhere.

We also mirrored Marshall's observation that coordinating group reading is a complex activity. This reminded us strongly of an emerging theme in the understanding of reading as an interactive activity: specifically, the role of cognitive attention. Research on reading has started to suggest that during attentive reading, the vital cognitive state of flow [9] is particularly vulnerable to disruption by the attention demanded by secondary tasks [28, 26]. Unfortunately, the insights we presently have reveal only a little detail of the appropriate management of attention in the context of collaborative reading. Given the social complexity of this reading activity, it is likely that cognitive attention is handled very differently than the processes used when reading alone. It is therefore vital to understand how readers coordinate with each other and read together.

The best existing research has not directly focussed on co-reading as its primary interest. This suggests that an important literate activity is under-researched. We have taken a formulative approach to discovering collaborative reading practices by studying group work first on paper. We then designed, implemented and evaluated an interactive system to aid coordination within group reading sessions.

		Time	
		Same	Different
Location	Same	Book Club	Notice Board
	Remote	Tele-Conference	Article Reviews

Table 1: Different types of collaborative reading

By probing co-reading in this way, we were able to discover several notable differences between the two media as well as the potential benefits of digital implementations for group reading.

3. OBSERVING GROUP READING

Reading in groups can take many forms: for example, reading individually in the context of a wider group task, reading for recitation or performance, or reading at the same time in different places. In undertaking an investigation into reading, we first narrowed our focus to a specific form.

One classification of collaborative work is the two-dimensional CSCW matrix of time and space [15]. In terms of time, work may occur at the same moment (synchronous) or at different times (asynchronous). Similarly, space, or location, may be either be co-located or remote. With the four different combinations that this matrix creates, different user needs will emerge (see Table 1).

Group structures can also vary: a group of peers (e.g., a leisure reading "book group" discussing a novel); or a hierarchical group led by an authority figure (e.g., a teacher leading a group of junior school students). Similarly, there is a question as to whether the medium being read is shared (e.g., a large single display), or if each person has an individual copy.

In selecting a focus for our research, we first considered the practicalities of observation and experimentation. Studying groups that read at different times seemed problematic: a realistic setting would require many individual reading sessions and extensive coordination. Reading at the same time appeared to be much more viable. Remote, synchronous reading would require a number of experimental observers, and consistency would become a problem, or logging could be used (with a loss of detailed insight). Researching co-located, simultaneous reading would allow one set of observations and minimize the challenge of coordinating groups.

We also considered the extent of exisiting research. We already possessed observational data on co-located, contemporary group reading [7]. Marshall [21] had reported individuals' personal reading activity within a group context (remote, asynchronous mode), with some additional information on co-located, synchronous reading. It was these two modes where the existing material gave us the greatest volume of information on readers' needs.

The two possible focii were thus synchronous, co-located; and remote, asynchronous reading. The first was more achievable logistically, and we also had more direct primary data of our own upon which to build. As a result, we targetted studying collaborative reading in the same place, at the same time.

3.1 Method

To pursue our interest in collaborative reading, we ran two sets of observations to gather requirements. The first extended our previous observations [7] of reading groups in libraries. Our aim here was to confirm or eliminate a number of potentially interesting research areas from our earlier work. In particular, we aimed to identify an initial set of activities within collaborative reading from which a wider body of knowledge can later be derived.

Following the first phase of observing groups in the library, we undertook a second phase to add detail to the initial set of co-reading tasks. We adopted an autoethnographic approach [10], and one of the authors joined two active research reading groups. In total we participated in seven sessions with one group (on multimedia); and five with the other (on cultural studies). Our researcher was already a regular member of one other reading group, but did not participate in it for the purposes of investigation. The groups and their members were informed of the purpose of participation, and both topics were areas of research where our researcher already had an active interest. While this may have created some artificial behavior, disclosure was deemed necessary for ethical reasons. The aim at this stage was to better understand the needs of group reading from the 'inside'. Rather than diversify our research goals, we decided not to investigate new issues, as basing any requirements on a single user's needs or experiences is clearly poor practice.

3.2 Observation Results

Most of the group members pre-read material, but in every group reading, at least one member had not pre-read the material. In either of the groups, the unprepared readers were not consistently the same person. The texts were, nonetheless had typically already been read by half or more of the reading group. This contrasted with the library groups, where most group members, and on approximately half the occasions, all, had apparently not encountered the text before. We now synthesize the main patterns discovered in the two complementary observations:

Loose coordination Reading was only periodically closely synchronized on a particular page by the whole group; all groups demonstrated periods where individual reading occurred before shared reading was resumed.

Localised synchronization Within loose coordination, there were periods where the reading of the group appeared to focus on the same part of the text, before the reading de-synchronized again. This pattern was found in all the observation sessions.

The difficulty of identifying the 'end' of more coordinated periods of reading became evident during our participation in the two reading groups. While there were occasions where groups did wait for everyone to complete a part of a paper, this was exceptional (only three instances per group, in a total period of five hours or more). More typically, after some individual reading, one person would respond to part or all of the text, and this would occur in parallel with others continuing their reading (perhaps paying selective attention). Others would participate in discussion before returning to their own reading. Though the 'start' of a synchronization was not perfectly co-ordinated, there was always some utterance by one of the group members that signalled a call for others to join them in reading a particular part: e.g., 'Ah, this bit seems interesting' (followed by guidance to the content).

View competition Where two or more readers had to share a copy of the book, there was some conflict over the resource. This occurred in seven groups in the library setting, and when the group read as a 'whole', the text could be shared, but this regularly broke out into swapping between the sharing readers for individual study. In contrast to the library situation, the reading groups had individual copies of text. On three total occasions (of eleven sessions) one person did not bring their own copy; two of which were resolved by printing or copying another individual text. When members were reading with content in their lap, there was a similar conflict between documents or pages for visibility.

Mutual navigation When the loose coordination of a group synchronized more closely to attend to the same point in the text, considerable time and effort was made for everyone to arrive at that point. This involved the use of page numbers, geometry of the page and reference to content (e.g., "below the big diagram", or "The paragraph that starts 'The European Free Trade Agreement"'), plus turning the document to other members and physically pointing at the desired location.

During the participatory phase, further detail emerged. During mutual navigation, where one participant was endeavouring to direct the attention of others onto a point in the text, all but one case commenced with spoken instructions. These sometimes (10%+ of cases) started with a description of the content, in those and all other cases proceeded to identifying the page (more easily where page numbers were present), and then the point on the page. The latter was described in one or both of two ways: first, the starting words of the paragraph (70%+); second, the sequence of the text in a page or column (e.g., 'third paragraph down') was given (< 40%). Occasionally, other approaches were used - e.g., landmarks like large diagrams were used as waypoints towards the content.

If spoken instructions failed, pointing out of the content was used. One participant regularly used the pointing method by default, but this was exceptional. Requests for the repetition of details occurred in almost all cases too. Communication seemed to be more effective among regular group members, but due to our small sample, full conclusions cannot be drawn.

Negotiated navigation On three occasions during the library sessions, mutual navigation involved conflicting interest in two different locations at once, which the groups had to negotiate.

The order of reading was regularly discussed by the research reading groups, but we saw minimal evidence of any use of note-taking or other explicit action to direct the planned reading. In all cases, the group appeared to rely on at least one member remembering what the agreed plan was, evidenced in comments like "what part was it we're going to read next?".

Parallel reading In seven groups one or more members were seen to read two or more documents at the same time, or very quickly interleaved. In six of these groups, this occurred alongside synchronized group reading - i.e. the individual was apparently working with the 'shared' view of the moment, and alongside that undertaking a separate, individual reading. This was also observed in periods when the group reading was not synchronized.

During our participatory phase, we encountered three sessions where the group read more than one text; twice this was due to a member bringing a new text that they thought might be relevant. This suggests some planning, following Marshall et al. [21]; but it also increased the frequency of parallel reading. Personal notes and papers were more involved as parallel texts, with note-taking (on separate paper) being observed in seven sessions, and other personal papers being used in six sessions.

3.3 Prioritisation and Requirements

Examining these findings, we were able to reduce the scope of our research. We first eliminated each action that appeared too complex to support in software or that was better conducted as a discussion between users, and where, consequently, designing new digital tools is unlikely to be beneficial.

Negotiated navigation and localised synchronization both involved considerable social negotiation between participants in the group. It did not appear likely that technology could assist a conversation between the group, and further intervention would probably only add to the work of the members.

View competition appears to be a consequence of limited resources, and while it will be a key aspect where views are shared, individual copies vastly reduce its occurrence. While designing within constraints can be useful, we concluded that any viable solution revisited a topic that we had previously researched [6], and this overlap reduced the scope for adding to the scientific literature. Parallel reading is a complicated issue, particularly if content is displayed on a single device. However, solutions are not too complex to imagine (e.g., two rapidly switchable views, each of which preserves their state), and more complex solutions would require closer understanding again of the dynamics of group reading. Again, previous research seems to suggest some early directions, such as different combinations of display hardware [22]. Furthermore, we should as there are more critical actions among this set, these less frequent interactions should be set aside for now.

In contrast, mutual navigation appeared to be tractable, as much work was spent articulating where content was. These indications often had to be restated due to loose coordination: momentary inattention by one or more members meant that such repetition was commonplace. One further point that we observed from the participation in these groups was a regular return to points in the text that had been read – and discussed – together. However, informal interviews with group participants, including a discussion of their annotation practices, revealed that these locations were seldom explicitly recorded, and had little role outside of the group reading. Mutual navigation also is closely connected to the overall pattern of local synchronization. Mutual navigation also seemed to more readily suggest effective tool support, as synchronizing reading speeds between users, whilst viable, was predicted to cause irritation as, in fact, individuals read at different speeds, and previous research has shown that reading is not, in truth, a linear activity [1]. We thus arrived on a primary focus on mutual navigation.

The requirements for mutual navigation are teasingly simple. While coordination can be done using page numbers, describing paragraphs or diagrams, often the most effective method we observed was the simple gesture of turning your own copy of the document towards the other members of the group, and pointing to the desired place with your finger. The inconsistent presence of page numbers (and their variable location), variable discriminability of paragraphs (e.g., due to similar beginning phrases) and other factors make other methods less effective. However the person making the gesture cannot then see the content, and continuing to talk about it becomes cognitively demanding. The transience of gestures also appears to be valuable. Across a session, mutual navigation occurs many times, and few of these instances appear to be, in retrospect, of particular long-term value. Thus, an 'idealized' mutual navigation tool would be indicative, transient and automatically place the reader on the right page. However, as noted above, other group members join the synchronous reading phase in a loosely coordinated fashion, after completing their own localised reading. This further suggests that the receiving group members should be able to engage in mutual navigation after a short time delay of their choosing. In any interaction design, a degree of speculation is inevitable – as here – but we will examine, and re-validate, these insights later through a laboratory experiment.

4. SUPPORTING CO-READING

Before designing our system, we first reviewed the literature to identify potential solutions to the question of mutual navigation. We did not identify any full solutions to mutual navigation in an extensive review of existing digital library, hypertext, CSCW and human-computer-interaction research.

4.1 Mutual Navigation

One partial solution to the challenge of mutual navigation could be Telepointers [17]—representations on the display of one group member of the pointer locations indicated by another, which provide real-time gestural foci and enable mutual coordination on a group workspace during discussions. Typically, telepointers are used to indicate a focus of attention to other participants. This has some potential for group reading. It is known that when reading at home, adult and child reading pairs can point to a position in a document using a finger, or some technological counterpart [29]. However, it is important to analyse these interactions with care.

Telepointers were envisioned for remote working between two or more collaborating groups. One group can indicate a point of interest on a shared view to the participants in other locations. While indicating location, telepointers are transient and 'real-time'. There is no record of the gesture: the pointer behaves just like a laser-pen on a shared display, or a mouse pointer being used to gesture on-screen content to a colleague. Replaying the gesture requires the original performer of it to repeat the indication again, or, alternatively, it demands the immediate attention of all group members.

Demanding continuous attention from a group of readers is, unfortunately, likely to prove problematic. In the context of co-reading, which includes many elements of 'active reading' [2], users need to manage their cognitive attention with great care [9]. Marshall alludes to [21] and Buchanan confirms [7], that there are tensions between the need to collaborate and the individual's need to maintain attention to complete their reading: e.g., oral directions to a location in the text had to be restated when a member's own reading distracted them from the discussion, or when the discussion was interrupted so others could complete their reading. Extending the underlying principle of the telepointer, there is a need for a shared pointer that can be individually reproduced at will.

As noted in Section 3.2, within a group's collaborative reading, individuals will frequently indicate items and locations to other group members, e.g., "look at this figure on page 45." When working on a single document or machine, this process is straightforward: the user can simply point out the section they are looking at with their finger. Assuming all members of the group have visible access to the shared document or screen, they will easily see the required information. When collaboration occurs over multiple copies of the same document however, this process becomes more troublesome as there is no single shared view.

4.2 Collaborative Reading

As we noted in Section 1, reading has been a consistent topic within digital-library research for some years. The primary focus of research on digital reading has been on the individual [20]. However, the existing literature on reading and information does indicate that collaborative work is valuable in its own regard, and collaboration is frequently a key element of the context within which individual work sits [1].

We approach reading as an interactive process. DL research on collaborative reading as interaction is relatively rare. One good example is Liu et a [18] which studies the provision of children's picture books on a digital table. The main focus of the paper is on providing interactions for both an electronic bookshelf and a set of digital books that are consistent with the physical originals. Though the reading is among a group of peers, and is co-located at the same time, comparison is tenuous given the differences between our focus on novel interaction during reading rather than the completeness of digital metaphors with the physical world.

5. DESIGN AND IMPLEMENTATION

To reify the requirements gathered in the previous section we implemented BuddyBooks—a collaborative reading interface that we deploy on multiple iPads. The slate PC form factor allows users to sit around the same desk while providing them with a personal document view as well as instant updates of all mark-ups (e.g., annotations, bookmarks and highlights) made by other members of the group. The key feature of the BuddyBooks interface is the 'Point-out' tool which facilitates the coordination of group members via direct pointers to specific parts of the document. Creating this interface later allowed us to compare group reading practices using paper documents against our prototype.

In this section, we first report the conceptual design, followed by the system architecture, before describing the interaction design and, specifically our support for mutual navigation, annotation. Following this, we describe how we envisage the system in use, demonstrated by a scenario. In the following section, we then report a laboratory study of BuddyBooks in use.

5.1 Conceptual Design

One key initial design decision was which hardware platform to develop an application on. Our own observations had highlighted the value of having individual documents, and this led us to consider an individual display. Marshall et al's work on XLibris demonstrated the benefits of the 'reading appliance' form factor [21]. Our observations of library reading, and participation in reading groups, also both underlined the same point and, comparatively, the disadvantages of desktop and laptop PCs which create a more marked constraint on the seating – and hence communication – of each group.

An alternative form of collaborative reading occurs in classroom or brainstorming situations where large physical displays are used. Large computerized screens now offer multi-touch capabilities; for example interactive white boards and touch-screen table tops [14, 23, 31] which can promote simultaneous collaboration. Although this approach makes it easy for everyone to see the material, it does sometimes lead to the situation where there is one "leader" doing all the writing and can hinder collaboration [20]. Such concerns led us to adopt a reading appliance approach instead.

Our work coincided with the launch of Apple's iPad device, and this provided an opportunity to develop a system without the tethering cables that the original XLibris had been forced to use. In contrast to Amazon's Kindle and other electronic ink e-Book readers, the iPad was not a closed software environment, and developing bespoke applications was straightforward. In our recent work on reading support, a continuous reservation has been the need to use laptop and desktop PCs, and embracing a form factor that appears to be of increasing importance as a reading device seems to be timely. Given that recent research has indicated the slate or tablet device form-factor has many advantages for active reading by individuals, this seemed to be a judicious starting point [22].

In designing the system, we generated a number of usage senarios to envisage its use. Figure 2 illustrates one example of a possible co-reading session. The real-time aspect of the system ensures that each member of the group has immediate access to all notes made by other users as well as facilitating an easy method of referencing specific sections to support mutual navigation.

Kris, Joe, Laura and Hannah are studying for an exam. They each have a copy of the course text on their individual iPads and are discussing the material around a table. Joe notices that there is a section within one of the chapters that is not fully explained. He read a web article on this topic earlier today and decides to make a note clarifying the information for the benefit of his friends. Immediately after he makes the note, it automatically appears on the others' iPads. Later in the session, the group are discussing a past exam question and decide to look up the answer within the document. Kris finds the appropriate page and paragraph and 'points it out' to the other three via the system's Point-out tool. Joe, Laura and Hannah's iPads instantly recognize that Kris is indicating a place and offer them the chance to automatically jump to the appropriate page and view the exact location Kris chose.

Figure 2: BuddyBooks Usage Scenario

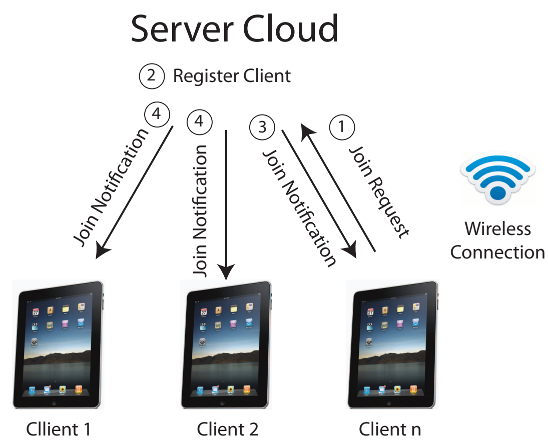

Figure 3: The BuddyBooks Cloud Architecture

5.2 System Architecture

BuddyBooks uses a central server to connect each iPad with others in the group. The server allocates each user a unique color and nickname which is used to distinguish between the activity of different readers, and IP addresses are currently used as a simple means of identifying a specific iPad. The server receives notifications of any mark-up that a user adds to their document, and then forwards that information to all the other devices in the group. BuddyBooks allows users to collaboratively *read* a common document; it is not, therefore, concerned with the collective *editing* of a document, but rather is an aid to mark-up and coordination of content where the original text remains unchanged.

The basic architecture of BuddyBooks is shown in Figure 3. To join the working group, a client iPad must first send an XML join request ① to the server passing it its IP address and a user defined nickname. The server, after receiving a join request from a new client, creates a new thread to deal with any more incoming messages and adds it to its active client list. The server then uses the clients position in the clients array to allocate it a unique color which completes the client registration ②. Following a successful join, the server then distributes a join confirmation back to the client ③ and join notifications to all other active clients within the working group ④.

Once an iPad is connected to the group, any annotations made are encoded into an XML format and sent to the cloud service, before being forwarded instantly to any other connected devices. The other iPads receive the XML message, decode it, and display the annotation accordingly. The server retains a log of all messages with a timestamp, and a device that connects to an existing group will be updated with the stream of previous messages.

5.3 Supporting Mutual Navigation

BuddyBooks includes a 'Look-at-this' queue that allows users to point out specific areas of the original document to other members of the group – a key requirement to support mutual navigation. The

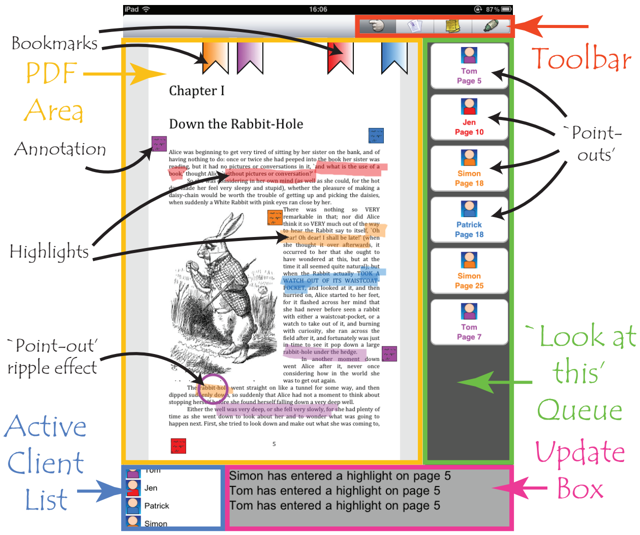

Figure 4: Screen shot from BuddyBooks.

Look-at-this queue is designed to hold a list of temporary placeholders made by members of a working group to allow them to quickly and easily navigate to the exact area of the document indicated by the original creator.

When a 'Point-out' is made by a member of a group, it is subsequently added to the top of every member's Look-at-this queue along with the color and nickname of its creator. Receiving a Point-out from another member of the group does not automatically navigate every user to the point in the text at which the point-out was made, however. Rather, each entry in the Look-at-this queue is hyper-linked, so users can choose a convenient time to access the information. This allows the users to complete personal reading before choosing to follow an indication from another group member. This avoids immediate disruption of their reading, and also means they can 'catch-up' without having to ask the group to repeat the directions to the current point of attention. For all group members, we are therefore reducing the number of interruptions that they must cope with. A 'point-out' has no associated annotation - it simply indicates location.

Figure 4 shows an example of BuddyBooks in use. Clicking on an entry in the "Look-at-this queue" (on the right) navigates the user to the correct document page and animates a ripple effect (a circle outline that pulses in and out around the coordinate point for several seconds – see lower left) to indicate to the user the exact location at which the Point-out was made. The user can select any item from the look-at-this-queue at any time.

5.4 Basic Annotation Tools

The BuddyBooks interface includes several basic mark-up tools which we incorporated to provide a fully functioning reading prototype for use in a comparative study. We noted in our preliminary studies that participants did undertake personal annotation within the context of collaborative reading. Omitting fundamental support for annotation would have multiple undesirable effects on a study: it may force participants to either co-opt our support for mutual navigation for traditional annotation purposes, or, alternatively, to reject the system outright due to the absence of vital features.

BuddyBooks therefore includes a range of traditional annotation tools. The text tool supports written comments, each note being represented by a small marker on the page, that interacts as a pop-up once the note is written. Pressing on the mark reveals the comment, and touching away from the expanded text closes it again. The small marker minimizes the visual impact of the note, and improves visibility of the main text. There is a highlighter tool, which when selected leaves a permanent colored trace on the page, like a real-world highlighter. Finally we provided a simple bookmarking function; tapping the bookmark created a bookmark for the current page that could then be selected later in the session, and return the reader to the chosen page. Each of these mark-ups will appear in real-time on every group member's iPad, and can be distinguished by each user's unique color.

Figure 5: BuddyBooks running on four iPads

A screen shot of BuddyBooks is shown in Figure 4. The toolbar containing the annotation tools appears on the top-right corner, with example highlights, bookmarks and annotations shown on screen. This is a demonstration document that is intended to show all the potential features – it does not represent a display from 'real' use.

6. EVALUATION

To investigate how co-reading is performed on paper and how it could benefit from a digitized solution, we conducted a comparative study of BuddyBooks against paper-based co-reading. We recruited 18 participants (10F, 8M) aged between 22 and 61 to take part in the study. All participants were educated to Bachelor's degree level or above, in a range of academic subjects. To mimic collaborative working sessions, we recruited participants in sets of four, which, due to two potential participants not attending, led to groups of 3 and 4 (3 groups of 4 and 2 groups of 3). Each group was asked to perform a reading task together. Group sessions took on average 1½ hours to complete and participants were given a £10 gift voucher for their time.

Before the study, participants completed a short questionnaire to gather information on their experience of reading in groups, including how often they read in a group, and the purposes for which the reading was done. The media and software that they use for group work was also elicited, in order to provide a backdrop against which any main results could be interpreted.

Each study began with the group performing a comprehension-style reading task on a paper document, with individual particpants starting with their own unmarked personal copy. A range of writing implements was given for personal markup purposes (highlighters, pens, etc.). This style of reading reflected the activity that we had observed and participated in while investigating co-reading. After completing their work on paper, the group undertook a similar task on a different document using BuddyBooks.

The two documents were of the same length and overall format, and of similar complexity. The topics were different (to avoid learning effects from the material being read); one being on an envi-

	Paper		BuddyBooks		Mann-
	Avg	SD	Avg	SD	Whitney
Q1: How *easily* could you point out bits of information to one another?	5.06	2.29	8.17	1.62	p<0.0005 U=281.5
Q2: How *quickly* could you point out bits of information to one another?	5.22	2.62	8.61	1.29	p<0.0005 U=281.5
Q3: What score would you give each system overall for co-reading?	5.67	2.25	8.56	1.34	p<0.0005 U=283

Table 2: Average subjective ratings (out of 10).

ronmental issue, and the other on a social concern, and were taken from a current affairs periodical. The goal of the group reading was to identify weaknesses and errors in the paper, and to mark these on the document. To ensure an unbiased experimental design, we alternated the order these documents were presented to each group. Both documents were unseen, as requiring prior reading from participants was unlikely to be consistently complied with, and reading the documents individually only moments before the group reading would not match any behaviors we observed in natural settings. After the study was complete, each participant was asked to fill out an in-depth questionnaire probing their thoughts on the major aspects of each method of collaboration.

The experiment was conducted in a quiet, naturally well-lit room. The iPads used were connected to a local WiFi hub to which the BuddyBooks server was directly wired, so as to minimize network latency effects. During the study, the users' annotations using BuddyBooks were logged, and the paper documents gathered for comparison. Observational notes were taken throughout.

Through the experiment, we wished to identify: first, if the point-outs would be adopted by the participants; second, if the transient point-outs would be used in preference to other shared, permanent annotations; thirdly, what the impacts on the BuddyBook system were on the collaboration between the group members.

6.1 Results

The pre-study questionnaire revealed that 11 of the 18 participants regularly participated in group reading for work, with a mean reported group size of 3.56 people. The main purposes reported included: to assist writing (10 participants); studying (9); reviewing (6) and proofreading (4). The media used included paper (15 participants) and digital (11 participants), with only 4 using computers as their primary medium. Taking collaboration more generally, Google docs were used by two users, while six participants used Word's annotation and change tracking tools.

Taking the post-study responses, the first part of the questionnaire asked participants to rate each co-reading method (paper and BuddyBooks) out of 10 (1=low, 10=high) for a range of attributes. To test the statistical significance of these subjective ratings, we conducted a two-tailed Mann-Whitney test. Table 2 shows a selection of the ratings most relevant to this paper.

This evaluation indicated a strong preference for our interface (Q3), producing highly significant ($p < 0.0005$) average ratings of 5.67 (paper) and 8.56 (BuddyBooks). Preference for our implementation was also detected during later discussion; one user from group 2 stated under Additional Comments, "*I really like it, it's ace*" and one from group 4 commented "*I would love to adopt this over the reams of paper*".

These subjective ratings also showed a distinct fondness for the Point-out tool with users ranking it both *easier* (Q1) and *quicker* (Q2) to point out bits of information in BuddyBooks than on paper ($p < 0.0005$ in both cases). This was backed up by subjective responses from participants, with a member of group 1 stating "*I preferred BuddyBooks to paper because the group work could be much more interactive and dynamic, I was able to say 'look at this now' by using the pointer, whereas on paper I would have to say 'go to page 9, 2nd paragraph down 3rd word from the left'*," one from group 3 stating "*the pointer made it easy to get everyone to look at the same thing at the same time*" and another from group 1 saying "*the point out thing is great! You can just say here and there it is*". Conversely, difficulties were reported with using paper: "*takes too long to explain where you are pointing at*". Our observations taken during the studies suggested similar differences. Groups scarcely discussed where to look, with only the occasional cue being used to attract attention when someone wanted to discuss another point in the text (e.g., "look here").

The use of the different tools also bears some attention. Point-outs were used regularly by the groups, typically every 2-3 minutes (just over 17% of all marks used), while highlighting was used extensively (just under 75% of all marks), and annotations and bookmarks only minimally (5% and 3% respectively). For example, group 1 used 13 point-outs, 66 highlights, 5 annotations and 2 bookmarks. For the three established tools (highlights, annotations and bookmarks) this pattern generally reflects their relative frequency in previous research on digital annotation [28].

One possible response of our participants could have been to use familiar tools such as bookmarks to indicate positions to each other, as these were shared with other participants. However, in practice they were used much less frequently than point-outs, and discussions amongst the groups never suggested their use for mutual navigation. Similarly, highlights could potentially be used to indicate position for navigational purposes, but this was not observed during the five group sessions. The 'point-outs' were adopted by the groups for mutual navigation while traditional annotation tools continued in their established roles.

During our observation of the groups, we uncovered several notable differences in behavior between paper and the BuddyBooks system. Perhaps the most interesting difference was the apparent difficulties group members experienced while attempting to coordinate each other's mark-ups when using paper. Comments made by participants included: "*Did someone already say this?*"; "*I suggest we adopt a new strategy where we don't move on to a new page until we are all ready because I'm really lost*" and "*I need more information than that—what page are you on?*"

This evidence suggests that participants found it difficult to keep up with mark-ups made on paper. In contrast, there were no such comments made when using BuddyBooks: group members successfully used the Point-out tool to indicate to others where they were in a document.

The pattern of communication observed during the BuddyBooks portion of the study was distinct from that seen when using paper. Specifically, using paper led to repeated discussions about the *location* of parts of the document (e.g., "*over here on page 10, half way down paragraph 2*")) whereas these directions were absent when using BuddyBooks. Speech was still used to attract the attention of the group members when moving along the document (e.g., *"I think there's a problem here"*, the participant then used a point-out).

Our co-reading support enabled participants to see others mark-ups, and to co-ordinate their reading through the temporary Point-out markers. Participant responses in the post-study interviews established this point: "*There was no need to communicate verbally with BuddyBooks. You can basically just look at the screen and that is it!*"; "*It's very useful to be able to mark specific places and have a tab to instantly reach that spot unlike trying to find some-*

thing from people's descriptions" and "*pointing things out...is much better than explaining where you're looking—like on paper*".

Our observation data and interview feedback suggests that the absence of navigational directions resulted in an increased focus on the content of the document itself. One participant commented: "*I would use this out of choice, as it encourages discussion of the [mark-ups] being made as opposed to where they exist*", while another reported "*I preferred BuddyBooks ... the group work could be much more interactive and dynamic*" It may be that BuddyBooks actually promotes effective group discussion—an extremely desirable situation that greatly supports collaboration.

Returning to the findings of our preliminary research (see Section 3.2), we were able to validate our earlier insights. The patterns of location description mirrored what we had observed earlier, and it was notable that the participants' responses in the post-study interview also reported these strategies. For example, one participant commented about how *"On a paper document you have to explain first which page/section/line etc."* and another seven participants described ways of indicating locations to others.

7. DISCUSSION

Having investigated the activity of co-reading, we built a system that provided a number of common annotation tools. To that familiar set, we added support for one aspect of collaborative reading – mutual navigation – in small, co-located groups. Subjective feedback, observational data, and logging of the participants' activity all suggested that the specific support of mutual navigation via the point-out tool was beneficial to the groups' reading. The adoption of point-outs *reduced the frequency and length of discussion about navigation dramatically*. The temporary, transient nature of point-outs was positively received, and participants appeared to select permanent or temporary place indicators with minimal distraction.

We have noted the importance of managing, or supporting, the user's attention during reading tasks (Section 2). Marshall has reflected that switching tasks (or tools) undermines reader attention to a text [20], and our work on individual reading concurs [28]. Our observations of real-world use suggested that this is also a key problem in collaborative reading. Mutual navigation was a specific issue (Section 3) that motivated our idea of the 'point-out'. When using BuddyBooks' collaborative tools, less discussion was needed for mutual navigation, and participants reported a lower level of interruption, compared to traditional paper. Using print caused repeated descriptions of the location of specific text in the document.

In the field work phase of our research, mutual navigation seemed to consume a lot of effort for work that was not central to the groups' task. The observations during the experiment, and participant responses both suggested that attention to reading was better supported when the secondary task of mutual navigation was reduced in complexity through the point-out tool. This in turn encourages more exclusive focus and a state of Flow [9] with the primary task of discussing the document.

Returning to the wider view of collaborative reading with which we started the paper, there are other circumstances in which collaborative reading occurs. For groups that read together at the same time, but in different locations, we believe that it is likely that support for mutual navigation will still be of value, and give similar benefits to groups reading in the same place. The common methods for supporting such groups at present are variations on teleconferencing. When using such technology, it is likely that the practices for mutual navigation will be similar, but identifying specific locations by physically pointing would be less effective when using remote cameras rather than being in the same room.

The case of reading at different times (asynchronously) seems to be a poorer fit for the point-out tool. Our field studies suggest that mutual navigation is tied to contemporaneous interaction, and traditional, enduring annotations may prove more effective when interactions are diffused across time. The design of effective support for reading at different times needs further primary field research to identify the frequency, operation and requirements of that work style. We set this topic aside in the the course of our own research, because of the challenges of data capture. If 'permanent' markers are more useful, then one caution is that Marshall [19] has noted the difficulty of an individual understanding their own mark-up from reading a text. One area, therefore, for initial research would be the interpretation of marks and comments in asynchronous reading.

In Section 2 we drew attention to earlier work that had touched on group reading. Our observational work produced a set of six behaviours within this context. A return to the existing literature allows us to further triangulate our results. Marshall et al. [21] noted the use of two different documents by individuals: an example of *parallel reading*. Furthermore, Marshall's recent return to the same material [20] identifies the difficulties of "shared focus" – a compound of our *localised synchronization*, *mutual navigation* and *negotiated interaction*. We can also identify instances of *localised synchronization* and *view competition* in our own previous data [7]. Our current work provides a more thorough underpinning of what appeared to be promising glimpses snatched during earlier research, and allows us to disentangle and separate phenomena that were previously conflated. Further work can separate and better define these different strands. One further point is that there will likely be different behaviours depending on whether many or no group members have previously read the document - an issue we have only reported briefly here.

The XLibris project identified the value of digital annotation, and provides the fundamental research on the interaction of reading upon which all subsequent work has been built [21]. In the years since, the focus of most research – including our own – has been on improving and developing on the touchstone of XLibris. Novel forms of annotation and placeholding have been rare: highlighting, notes and drawing have remained as constants ever since. BuddyBooks has added a new type of mark to this existing repertoire: a transient, shared placeholder that can be replayed at will, but relies on social context and user selection to be used.

We will now consider the impact of our work on a wider range of DL research, and the issues and factors that require further study.

7.1 Reading and Collaboration

In Section 4.2 we reviewed some of the existing literature on collaborative reading. We noted then the paucity of work on the topic. Recently, Golovchinsky, who played a major role in XLibris, has returned to the issue of reading, now including a greater collaboration with his new ARA tool [11]. Though that work is at an early stage, it demonstrates the timeliness of our own research.

One area where collaboration in the context of reading has been regularly researched is around the activity of annotation. An early example of this is the work of the DEBORA project [25], and this was followed a stream of increasingly mature and insightful work from Agosti and others [3, 16]. The technical infrastructure that underpins BuddyBooks bears a close relationship to the architectural elements of such research. However, our main emphasis is on the interactive properties of the system, rather than a complete system for a wide range of annotation. A common motivation for collaboration support, and associated features such as social filtering, is typically for remote users working together at different points in time – a stark contrast to our own interest on co-located, contemporary reading. Furthermore, the purpose of the point-out tool is to support transient information marking for navigation, or 'placeholding', rather than more permanent interpretative annotation [8].

The recent emergence of social tagging and social bookmarking sites has led to them taking a role in reading. Nelson et al. [24] investigated one such tool – SpartTag.us – in the context of group sense-making and reading. Like similar research, they investigated the impact of social markup on individual activity (specifically, learning), but did not pursue an understanding of group work within the wider community. In contrast, we focussed on groups that meet together. It would be intriguing to investigate how such groups would interact with wider social material and other teams in different locations, or who read at different times.

The social selection of books for book groups has also been addressed [27]. In this popular form of reading, book choice was also a social activity, including an extended range of friends and family. While this work addresses another part of the reading process, it serves to demonstrate the ubiquity of collaboration as a context for reading. The specifics of book groups seems to be a potential focus for understanding group reading in detail, and the interaction between book choosing and reading may be one valuable angle.

7.2 Collaborative Information Seeking

Information seeking is a major focus of research in digital libraries. Across the last decade, collaborative information seeking – particularly interactive retrieval – has received increasing attention from researchers [12], and is becoming an active and fertile field for research. However, it is premature to expect a substantial theorized understanding of collaborative information work in general, and so it is difficult to find appropriate material against which our findings can be directly compared.

Reddy and Jansen examine the reasons for moving from individual to collaborative information seeking. Tget suggest that lack of domain expertise plays a key role [30]. Our previous and current observations partially confirm this, with student reading groups seeming to form in a context of uncertainty. However, while understanding the motivation for group work tells us *why* collaboration occurs, it is less helpful in telling us *how* to provide good support.

In contrast, Golovchinsky et al. examine different group structures such as peer groups, novice/expert groups etc. [12]. This provides useful contextual categorisation to understand potential group dynamics, but does not directly provide guidance in terms of interaction design. Our focus on peer groups is a limitation to our work that can be addressed through adopting Golovchinsky's classification of group structure.

CoSearch [5] provides support for co-located collaborative search, and raises a number of issues in common with our task. The problems of varying reader pace, pointing and loose co-ordination all are indentified as key concerns. However, there are profound differences. For one, their use of pointers is a very close mirroring of traditional telepointers, albeit providing one per user. There is no provision for replay, in contrast with our point-outs. Furthermore, CoSearch emphasizes negotiated search sequences (a parallel to our negotiated navigation from Section 3.2), and annotation capture was through an emailed set of notes, due to the dynamic nature of web search content. As a result, an annotation is necessarily separated from the material it refers to.

7.3 CSCW and Placeholding

Another relevant domain is, of course Computer-Supported Collaborative Work (CSCW). We introduced telepointers in Section 4. Telepointers are a key technique to compare against our own approach. As we noted earlier, telepointers, are like the mouse position on a GUI interface, and cannot be replayed without external software support such as a screen recorder. Furthermore, telepointers are usually used in the context of remote working, and where displays are often shared by more than one person. In contrast, point-outs are readily replayed by individual users on their personal device after they occur.

7.4 Annotation and 'The Cloud'

The use of cloud–based storage to coordinate reading has recently been introduced commercially. The most common example is, perhaps, Apple's iBook application for the iPad. In iBooks, the bookmarks made by a user can be transferred via the cloud between different iPads registered as the same user. Our method here is similar in that we use "cloud" technology to coordinate bookmarks and annotations. However, we differ from Apple's technology in a number of ways. First, our cloud supports a collaborative, multiuser context, which is private to the group, while iBooks collates private, personal annotations to identify commonly annotated spans of text to *all* users, as well as the user's own personal bookmarks. Second, our "point-out" marks are transient and pinpoint specific locations in the text, and are specifically intended for group work, whereas iBook's "bookmarks" specify a whole *page* and are private only. In addition to point-outs, we do provide the classic bookmark and annotation tools that are offered both by iBooks and established DL annotations services such as DiLAS [4]. In other words, we offer a clear superset of existing annotation functionality, and support collaboration between a known group through reading tools specifically for group work. Furthermore, there is no current available information on the usability issues surrounding iBook's design. Had iBooks Cloud technology been available during this research, we would have been able to undertake such a comparison.

8. CONCLUSIONS & FUTURE WORK

The experience of shared reading remains a popular activity in many social and working environments. Some technological responses of this can be identified in popular devices. Systems like Amazon's Kindle support collaborative highlighting, but in rather modest way: there is no substantial communication between readers, and little shared critical engagement with the text. Some of the techniques provided – e.g., showing the popular parts of a text – have a limited semantic value. Arriving at a rigorous scientific understanding of collaborative reading would help us better critique our current approaches and identify new methods to enhance it.

We have reported an investigation into the practice of co-located, contemporary reading. We identified six practices that support this activity, and outlined some requirements of each. One practice – mutual navigation – was chosen as our initial focus, and we demonstrated the effectiveness of a novel interaction to support mutual navigation through a laboratory evaluation. Through this, we have shown both the need for tools to support co-reading, and the potential value that such tools can bring to social reading. The use of a device with a similar form factor to paper, and that allows users to sit near to each other has a great potential to open new shared interactions around reading.

As we noted at the start of this paper, we have focussed on one particular form of collaborative reading: at the same time, in the same place, among a group of peers. By adopting individual devices, we allowed for independent personal views of the document. There are a host of different styles and contexts of collaborative reading, and there is plentiful scope to embark on further research. One route would be to explore the tactical activities we observed. One intriguing topic we did not explore is the issue of parallel reading. While there are possible methods for supporting this already

[6], it is a need that is poorly understood even with individual reading, and the current work is limited in scope.

Alternatively, one could approach a different context, and address remote or asynchronous reading. While researching remote collaboration is challenging, it is a problem commonly faced by CSCW researchers. There seems ample scope for ambitious research to address this topic, and the growing use of digital reading devices would make an investigation highly timely.

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