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ABSTRACT

The design of systems, including digital libraries, is often inspired by what technology makes possible. In user-centered design, design emphasizes users, their tasks and needs. The majority of current digital libraries are not designed for children. For digital libraries to be popular with children, they need to be fun and easy-to-use. This paper shows how observational and participatory work with children (11 to 14 year olds) as users resulted in the design of a digital library with novel-and useful-features. Beyond summarizing the design itself, a main contribution of the paper is making explicit the relationship between design and observational study, in particular, video analysis, that inspired the refinement of the initial design of the dynamic component of a children's digital library. The paper also addresses implementation and security, and discusses directions for future work. (Contains 26 references.) (AEF)

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Dynamic Digital Libraries for Children

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ABSTRACT
The majority of current digital libraries (DLs) are not designed for children. For DLs to be popular with children, they need to be fun, easy-to-use and empower them, whether as readers or authors. This paper describes a new children's DL emphasizing its design and evaluation, working with the children (11–14 year olds) as design partners and testers. A truly participatory process was used, and observational study was used as a means of refinement to the initial design of the DL prototype. In contrast with current DLs, the children's DL provides both a *static* as well as a *dynamic* environment to encourage active engagement of children in using it. Design, implementation and security issues are also raised.

Keywords
Design process, design partners and testers, participatory design, collaborative writing, observational study, ethnography.

1. INTRODUCTION
The design of systems, including DLs, is often inspired by what technology makes possible. In user-centered design, design emphasizes users, their tasks and needs. This paper shows how observational and participatory work with children as users resulted in the design of a DL with novel — and useful — features. Beyond summarizing the design itself, a main contribution of the paper is making explicit the relationship between design and observational study, in particular video analysis, that inspired the refinement of the initial design of the dynamic component of a children's DL. The paper also mentions implementation and security, and discusses directions for future work.

We will argue that if DLs are to be popular, they need to be easy-to-use and empowering for users both as *readers* and as *authors*. DLs should provide both static as well as dynamic features.

1.1 Static vs dynamic DLs
The history of DLs is rich and varied because the "digital library" is not so much a new idea as an evolving conception of contributions from many disciplines. In recent years, there has been an emergence of subject-based DLs on the Web. Many people have contributed to the idea, and everyone seems to have something different in mind! The metaphor of the traditional library is both empowering and constraining [8]: empowering, because DLs automate and extend opportunities offered by traditional libraries, as well as harnessing opportunities not possible on the anarchic web; constraining, because the metaphor evokes certain legacy impressions, many originating in arbitrary physical constraints.

Because DLs mean different things to different people, the design of the DLs is, therefore, dependent of the perceptions of the purpose/functionality of DLs.

To the library science community, the roles of traditional libraries are to [13]: (a) provide access to information in any format that has been evaluated, organized, archived and preserved; (b) have information professionals that make judgements and interpret users' needs; and (c) provide services and resources to people (students, faculty, others, etc.). Others think that DLs may mean carrying out functions of libraries in a new way (e.g., [8; 18] etc.). It may be encompassing new types of information resources, new methods of storing and preservation, and new approaches to classification and cataloguing.

To the computer science community, DLs may refer to (e.g., [8]; etc.) a distributed text-based information system, a collection of distributed information services, a distributed space of inter-linked information system, or a networked multimedia information system.

Levy and Marshall [12] argue for DLs to be broadly-construed so that "the design of DLs must take into account a broader range of materials, technologies, and practices," and they emphasize the importance of access and use of the collection by a community. Miksa and Doty [14], however, argue for a narrowly-construed definition of DLs, emphasizing the role of collection and intellectual access to it.

Hence, we have the difficulty of precisely classifying DLs. In this paper, we will group them according to their collections and whether there are features provided in the DLs to allow user-initiated activities (for example, annotations, reviews, etc.) to append additional data to the organisational memories of the collections. Organizational memories may include, for example, informal information, time-sensitive information or bulletin board mechanisms, and they tend to be more dynamic [2]. We agree with Levy and Marshall [12] that DLs should contain "transient as well as permanent documents, fluid as well as fixed materials, paper as well as digital technologies, and collaborative as well as individual practices" (p. 163).

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In this paper, we call these kinds of DLs *dynamic*, in that the organizational memories of the collections can be modified through user-initiated actions, and the environment provides a social space for collaborative and individual practices. In contrast, DLs that permit only browsing and retrieval are termed as *static*. Of course, in both static and dynamic DLs, the collections generally grow over time, but the emphasis in a dynamic DL is that the authors are primarily in control of the collection.

Table 1 identifies various features of a representative sample of DLs that have been implemented. The list is not exhaustive (and not intended to be) but gives a flavor of the nature of current popular DLs for academic and commercial purposes designed for adults and children. (Owing to constraint of space, we will not describe the collections contained within these DLs but we have given the URLs for those who want to find out more about them.) Except for **Wiki Web** (which some might argue is not a proper DL), the majority of current DLs are static, that is they contain mainly repositories of information that can be retrieved using the search and browse facilities, but the collections are built and maintained by specialists — typically modifying the collection may mean an interruption to user services. However, Wiki does not have any security to ensure the quality of its collection, and this really disqualifies it as anything better than a "departmental" or private library. Although **Stories from the Web** allows children to submit stories and write reviews, it does not permit full-text search.

Table 1. Digital libraries and their features

	Static		Dynamic		
DL	*Search*	*Browse*	*Annotate*	*Review*	*Create*
For academic purposes					
NZDL	Y	Y	N	N	N
NCSTRL	Y	Y	N	N	N
ETD	Y	Y	N	N	Y
CDL	Y	Y	N	N	N
For public					
BL	Y	N	N	N	N
LIC	Y	Y	Y	Y	Y
Wiki Web	Y	Y	Y	Y	Y
For commercial purposes					
IDEAL	Y	Y	N	N	N
ACM	Y	Y	N	N	N
For kids					
Stories from the Web	Y	Y	N	N	Y
Story Place	N	N	N	N	N

ACM: ACM Digital Library (http://www.acm.org/dl/)
BL: British Library (http://portico.bl.uk)
CDL: California Digital Library (http://cdlib.org)
ETD: Electronic Thesis and Dissertation (http://etd.vt.edu)
IDEAL: IDEAL On-Line (http://www.idealibrary.com)
LIC: Library of Congress (http://lcweb.loc.gov)
NCSTRL: Networked Computer Science Technical Report (http://cs-tr.cs.comell.edu/)
NZDL: New Zealand Digital Library (http://www.nzdl.org)
Stories from the web: (http://www.storiesfromtheweb.com)
Story Place: (http://www.storyplace.org)
Wiki: (http://wiki.org/wiki.cgi?WikiWay)

1.2 Design Philosophy

In this section, we briefly revisit our previous work so that its methods and findings can provide a background for the body of this paper and the issues explored within it. The theoretical motivations, commitments and assumptions that have shaped the design and development of a children's DL prototype of stories and poems written by and for 11-14 year olds are also described.

Most contemporary DLs are not designed for children [6]. Using a concrete example to demonstrate our design philosophy and research approach, a DL of stories and poems for children aged 11 to 14 has been built. The work was carried out as part of a project funded by the UK Engineering and Physical Sciences Research Council (EPSRC) in collaboration with a secondary school, St. Albans School (UK).

From the start, we wanted our project to be a thoroughly collaborative endeavor as we wanted to design the DL with and for children. We invited a class of 23 boys and their English teacher to be our design partners. These children were selected because they were competent web users and would be able to give more informed comments on the efficiency and effectiveness of DLs, compared to say, novice users. (Also, one of this paper's authors is a Governor of the school.)

Two separate sessions were conducted during a 70-minute English lesson between November and December 1999 to carry out participatory design, engaging children as *design partners*. At the end of the second session, the children developed a list of requirements:

- DL should be like a "traditional" library providing efficient search facilities to retrieve relevant materials;
- DL should be more game-like;
- DL should offer opportunities to children to submit materials;
- DL should give recognition for good stories submitted by listing the top ten books/authors;
- DL should be fun to use; and
- DL should provide opportunities to chat with and get feedback from other readers.

A third session was conducted in February 2000 to carry out *participatory evaluation*, engaging children as testers. The aim of the third session was to get a quick impression of the children's responses to the "look-and-feel" of three different interface designs, prototyped in the meantime. When we started with this project, we were uncertain as to the likes and dislikes of this age group (11–14 years old). From initial evaluation, their preferences were for fun and interest, as well as functional. Further details of the requirements gathering and initial evaluations can be found in [23, 24].

1.3 Design Choices

The children's DL was built using the Greenstone DL software, an open source system for the construction and presentation of information collections [26]. Our children's DL collection provides effective full-text searching and metadata-based browsing facilities, as offered by Greenstone. The collection is easily maintainable and rebuilt entirely automatically. Because special features are required, customised plug-ins have been developed.

Figure 1 shows the horizontal navigation bar, which contains the usual browse and search facilities provided by *static* DLs. Users can browse the DL by category: the stories and poems are classified according to twelve categories by author and title, in alphabetical order. The stories and poems are contributions from

authorised children users, explained in more details when we describe the dynamic features provided in this children's DL.

Users can perform simple search by typing in the search terms as well as restricting the search space to specific collections.

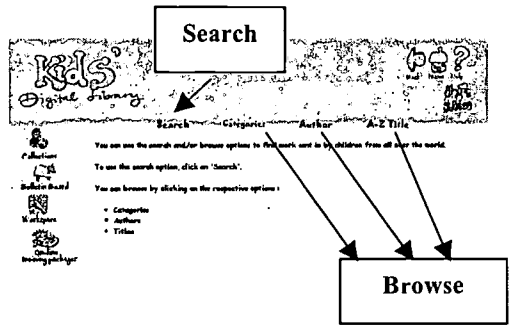

Figure 1. Static features of the children's DL.

2. DYNAMIC DLs

Although subject-based DLs are beginning to emerge on the Web, and promise opportunities we never had with traditional libraries or even the Web. DLs in general have not taken up in a "big" way compared to the Web (or, indeed, many other applications such as word processors or even e-books). One reason for the Web becoming popular almost overnight was the introduction of Mosaic, a graphical user interface which made it "very easy" for anyone to explore information. In contrast, because the majority of current DLs are mainly repositories of conventional-media information, users' experience in DLs is passive and less engaging compared to the Web. Furthermore, many DLs remove social exchange and interaction, focusing narrowly on the technical mechanisms of information access [1; 5].

In an excellent review of the field of computer-supported cooperative work (CSCW) with respect to DLs, Nichols and Twidale [25] urge designers not to be captivated by new technologies but to learn from librarians who have been doing something analogous for years in a well-laid out library with carefully designed signage, access points to cataloguing and indexing sources using physical media, such as paper and index cards. They suggest that careful analysis of the design and evolution of these physical artifacts and conventional face-to-face collaborative interactions may be useful to inform the design of DLs. This knowledge *combined* with new technological opportunities presents many possibilities in supporting different kinds of information retrieval to support the usability, usefulness and acceptability of DLs.

2.1 Initial Design Choices

Work carried out to develop educational applications of DLs across all disciplines ranging from primary school through graduate school include [e.g. 3; 5; 11; etc.]. One of our main interests is how the use of DLs can promote collaborative writing among children.

Presently, we have implemented one kind of collaborative writing — collaborative review — allowing children to create and submit their own stories and poems to a workspace and permitting others such as their teachers and peers to read and give feedback by sending their comments via email to the children authors. Thus, in contrast to other work [e.g., 11; 16; etc.], a distinctive feature in our children's DL is the opportunity for children to *create* their own stories/poems and upload them into the bulletin board (see Figure 2) for reviews from their teachers and peers, before submitting to the permanent DL. Only material approved by the teachers can be submitted to the 'core' DL, thus ensuring the quality of the documents. To encourage *collaboration*, children can query and browse stories and poems written by other children. They can read stories, give reviews, read other children's reviews on stories and email authors for other comments.

The DL environment also provides a display of the top ten stories/poems; information about the authors, and a message board to post and discuss ideas.

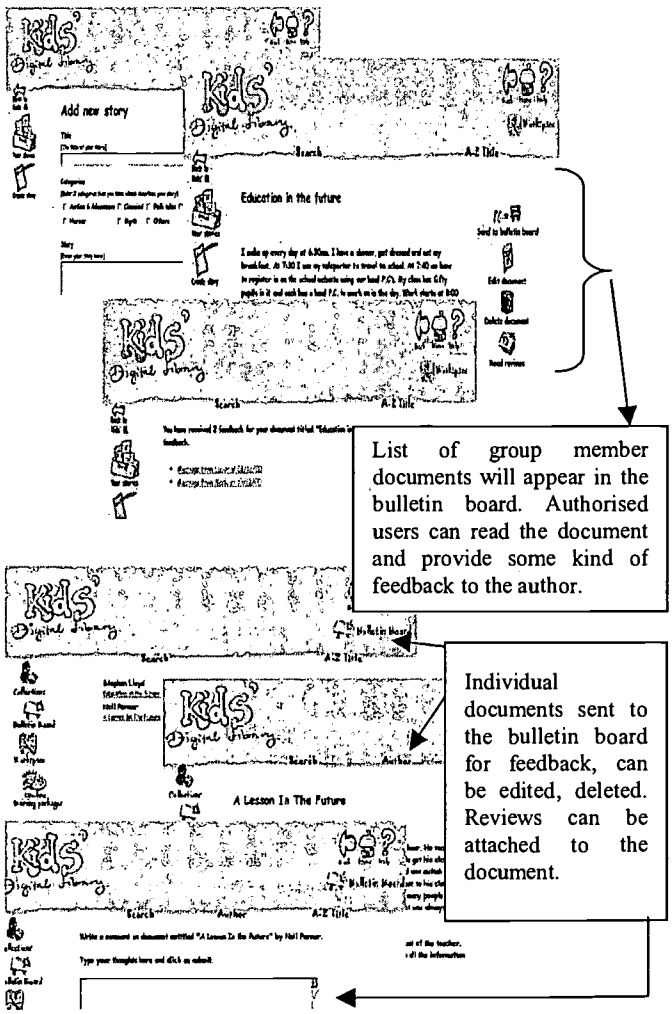

Figure 2. Dynamic features implemented in children's DL.

2.2 Collaborative Writing Behavior

While children can be extremely honest in their feedback and comments, much of what they say needs to be interpreted carefully within the context of concrete experience [7]. While there is a great deal of variability subsumed within the practice of ethnographically-based studies, most practitioners agree that there should be a commitment to studying activities in the natural

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settings in which they occur, and to focus on what people actually do, not simply on their own accounts of behavior [15].

Observational study was used as a means of refinement of the initial design of the dynamic component of the DL. We hoped to gain insights from the observational study on how the DL collaborative writing environment should be conceptualized not just from what children said they wanted or what we thought they wanted, but on what they actually did. Our priorities were:

- To understand how children carry out collaborative writing in their natural classroom setting; and
- To draw insights from analyzing the children's natural writing behaviors, to refine the initial design of the collaborative writing environment.

Our study was inspired by Robertson's work on structuring the results of a field study in such a way that they might bridge, or reduce, the gap between the description of the work and the design of the technology to support the work [17]. Video recording of people working, talking about their work is viewed by Suchman and Trigg [21] as a valuable resource in later analysis and reflection. In our study, results of the video analysis will be used to understand the relation between collaborative writing and visual conduct to give us insights into the design of our DL that might support collaborative writing over distance. The analysis of the video recording is based on the taxonomy defined by Robertson [17], to connect backwards to our study the children's collaborative writing behaviors and forwards to the refinement of the initial design of the dynamic component of the children's DL.

2.2.1 Experimental protocol

Three sessions were conducted with twenty-three Year 2 (Class 99/00) boys at St. Albans School (UK). Their roles were that of design partners and testers. To carry out in-depth analysis of the design of the children's DL, we worked with a smaller group of six children, encouraged by established researchers in the design of children technology [9].

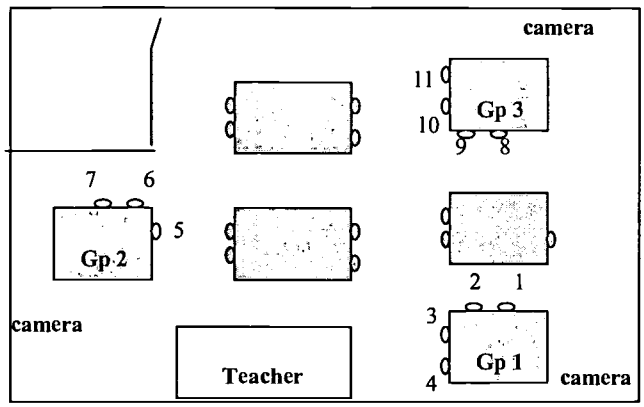
To evaluate the children's DL, we invited another class of twenty-four Year 2 (Class 00/01) boys at the same school. In contrast with the first batch of boys, these boys have not been introduced to the concept of DLs. The same English teacher is teaching this class.

The observational study was conducted during an English lesson in November 2000. The main objective was to observe behaviors in collaborative writing within the classroom. Results were used to verify whether what the first batch of boys (Class 99/00) wanted in the collaborative environment matched with the collaborative writing behaviors of the second batch of boys (Class 00/01).

Prior to the English lesson, Class 00/01 boys were asked to read the chapter "The Black rocks of Brittany" in the book *The Road to Canterbury* by Ian Serraillier. The session began with the teacher explaining what the task was: to discuss which character in the story was the most generous. Next, they were to write in their exercise books the reason(s) for their choice. At any time, the group could exchange drafts and comment on each other's writing. The class would convene for the last fifteen minutes for discussion.

Figure 4 shows the seating arrangement and the positions of the video cameras. The boys were divided and seated in groups of three or four, forming a total of six groups. (Two boys were absent during the video-taping session.) Video recordings were made on three groups working together throughout the 45-minute session.

Figure 5 shows a video segment of Group 1's activities during period 10-15 minutes (pre-writing). Because the teacher was called away from the class to attend to some urgent matters, the class was left unmanned for about 30 minutes during the periods of writing and reviewing. This explained the absence of the teacher's interactions with the groups during these periods.



Gp 1:	Gp 2:	Gp 3:
Boy 1 - Bhavin	Boy 5 - Neil	Boy 8 - Alex D.
Boy 2 - Lucas	Boy 6 - Nicky	Boy 9 - William
Boy 3 - Alex	Boy 7 - James F.	Boy 10 - James T.
Boy 4 - Ravi		Boy 11 - James E.

Figure 4. Seating arrangement and positions of video cameras

2.2.2 Results and analyses

Situated action, proposed by Suchman [20], is a term to "underscore the view that every course of action depends in essential ways upon its material and social circumstances (p. 50)". Suchman went on to explain that rather than attempting to abstract action away from its circumstances and represent it as a rational plan, the approach is to study how these people use their circumstances to achieve intelligent actions. Robertson [17] put a case for human embodiment as the fundamental consideration for designing systems that support people working over distance. She used "embodied action" to name the publicly available, purposeful and meaningful actions that people rely on to interact with others and their environment.

Using the taxonomy proposed by Robertson [17], we categorise embodied actions into group and individual activities. In the first viewing of the tapes, we were interested to simply observe what the groups were doing in general. The group activities were constituted by individual embodied actions. These actions define shared activities in a shared physical space. Robertson's taxonomy is modified to describe the embodied actions observed in the boys' collaborative writing behaviors and they include:

- *Conversing/discussing/arguing*. These are actions or activities that describe face-to-face interactions between the children within the groups. They can involve either

maintaining a single conversation/discussion/argument involving the whole group or maintaining more than one conversation involving different individuals but within the same space.

- *Looking together for an answer (book).* This activity involves looking at the textbook from which the story is taken.
- *Focusing attention.* This action is generally initiated by an individual resulting in the group re-orienting its attention.
- *Breaking up/interrupting.* 'Breaking up' is an action generally initiated by an individual for the group to move into an individual activity such as writing.
- *Reforming.* This action is brought about by the teacher or an individual in the group to come together.
- *Questioning/clarifying.* These are actions that members of the group take advantage of other members' understanding and knowledge of the task at hand.
- *Doing something else/uninterested.* Individuals occasionally did something other than the group activity, while remaining in the same physical space. These individuals can get back to the group's activity by changing their spatial position and orientation.
- *Writing.* This activity is carried out by an individual.
- *Listening to teacher.* This action can either be initiated by the teacher or by individuals who want the teacher to clarify things.
- *Affirming/listening.* These activities are essential in encouraging whether members of the group are doing the task right.
- *Reading a book.* This action involves the individual reading the book by Ian Serrailler.

Tapes were viewed again from the perspective of what the individual boys were doing when they were carrying out embodied actions in relation to:

- *Teacher.* The actions involve individuals raising hands to attract the attention of the teacher as well as clarifying, discussing and listening to the teacher.
- *Other group members.* Activities involve exchanging and reading draft, giving and getting feedback. Other actions include pointing, shifting gaze and initiating change.
- *Class.* These actions include reading draft, affirming and giving feedback. They can also include moving round within the workspace. Sometimes these actions contribute to the current class activity.
- *Physical artefacts.* These include affordances of the physical environment, for example, paper, pen, book, table, etc.

A map of the embodied actions of the three groups throughout the 45-minute sessions at intermittent intervals is shown in Figure 6, which provides examples of how the embodied actions, defined in the taxonomy, were performed over time by the children both individually and as part of the group activities. The activity of the class is recorded in the top row. The other rows record the embodied actions of the three groups. Within each group, individual embodied actions are recorded. Each of the categories defined in the taxonomy is allocated a symbol. A single symbol means that the individual, whose actions are represented in that row, performed the action. (The duration of the action is not to scale by the length of the symbols used to represent them.) Some rows seem empty, because individuals are participating in the group or class activities.

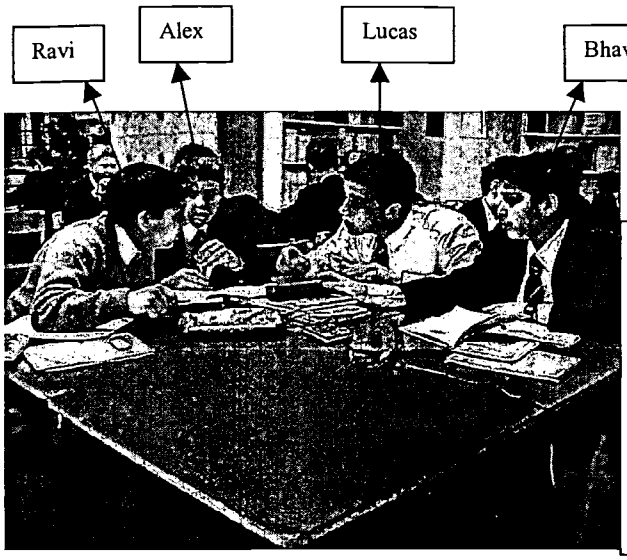
Figure 5, for example, shows a video segment of the boys in Group 1 during the period 10-15 min. Lucas and Ravi were engaged in a discussion, so are mapped to Figure 6, given a ☺ symbol. Bhavin was listening, indicated by ☼ . Alex seemed uninterested and he was playing with his pen, and this is indicated by ⧖ .

Consistent with Robertson's findings [17], the mappings show individuals perform a number of different actions during different stages (starting, pre-writing, writing, reviewing and reporting), as identified in the writing process. From the observations of the three groups' collaborative writing behaviors, the transition through the stages was not distinct. However, there are certain patterns defining these stages (see Figure 6): for example, in the first 5 minutes, almost all three groups were engaged in group activities such as conversing/discussing/arguing or attention/listening. Between 10–15 minutes, Groups 2 and 3 were engaged in writing. The boys in Group 1 were trying to settle down to do their work (in fact they were playing between 10-15 minutes instead of doing some kind of pre-writing). Writing became the main activity in all three groups between 20–25 minutes. Note that though the teacher was called away for the period between 20–35 minutes, the boys continued working on their drafts. The Group 2 boys, for example, seemed to be doing well, exchanging drafts, giving feedback to each other.

2.2.3 From observation to refinement

One of the major challenges confronting those who believe ethnography has something to offer system design is how to bring descriptions and analysis of work practices to bear on the design of new technologies [15]. Shapiro [19] says that ethnographers should embrace the problems of design, and try to link observations to design implications. Although some studies have been conducted to address this challenge [e.g., 21; etc.], the transition from ethnographic study to design remains complex and difficult. There is no simple relation between the findings of ethnographic study and design specifications [15].

How does one structure the results of an observational study in a way that might bridge the gap between the study of children's natural collaborative writing behaviors and the design of a dynamic collaborative environment within the children's DL? How could collaborative writing be done if it were to be done remotely, over a network? What would happen if the physical artefacts are replaced by the computer? Of course one needs to be aware that in remote collaboration, a shared workspace is not a shared physical space, but one made possible by the computer system and communication technology.



This video segment shows the boys in Group 1 during the period 10-15 min.

Lucas and Ravi were engaged in a discussion, so is given a ☺ Symbol. Bhavin was listening, indicated by ☼ .

Alex seemed uninterested and he was playing with his pen, and this is indicated by ⧖ .

Figure 5. Video segment of Group 1's activities during period: 10-15 minutes

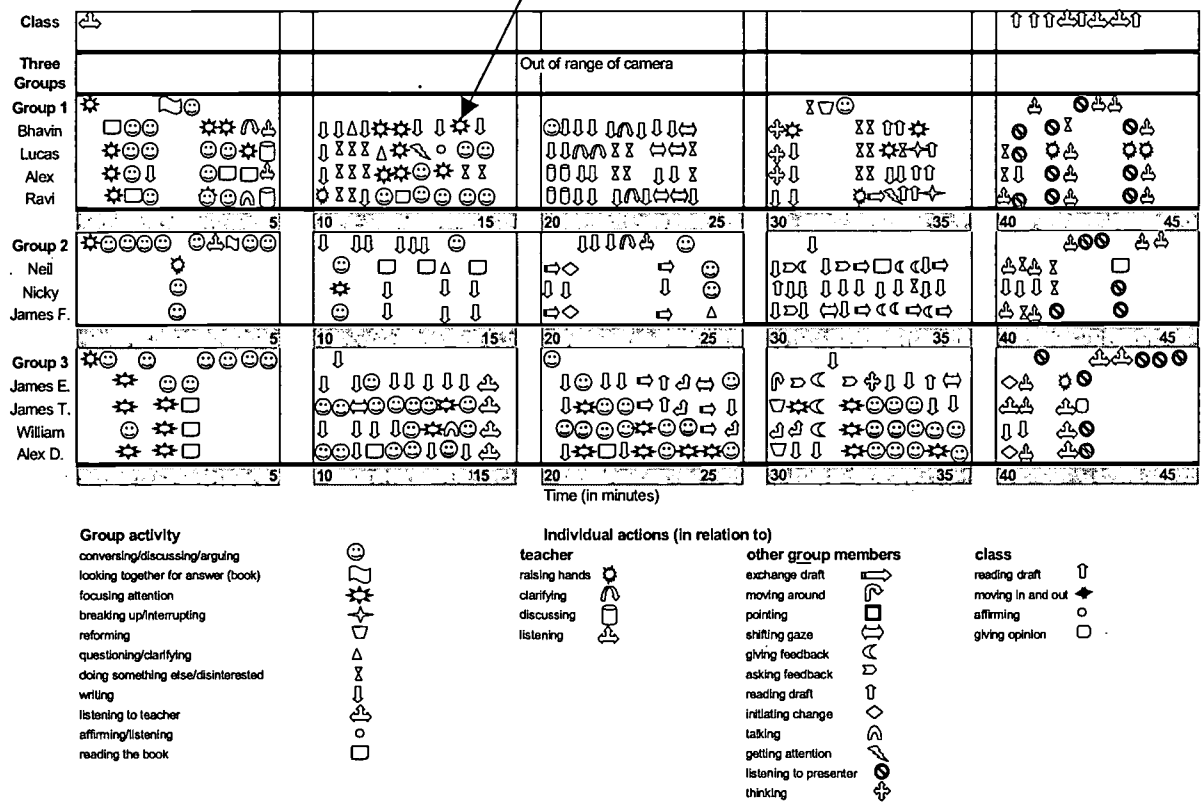


Figure 6. Overview of 45-minute session - children engaging in collaborative writing for periods: 0-5 min; 10-15 min; 20-25 min; 30-35 min and 40 -45 min

Table 2 maps initial requirements and results of observational study to affirmation/suggestion for improved design.

Column A indicates what Class 99/00 boys wanted in the DL; qualities desired in the DL and dynamic features to allow for user-initiated activities (e.g., submitting to the DL, etc.) and social environment to promote collaboration and feedback (e.g., chatting with friends, etc.). Column B bullet lists the writing behaviors of Class 00/01 boys observed in our observational study. The actions are put into four different stages in collaborative writing: starting and pre-writing; writing; reviewing and reporting. In each of these stages, we observed certain behaviors. Column C draws up a list of proposed new features suggested by Class 99/00 boys and reinforced in our observational study on Class 00/01 boys.

The classroom collaborative writing task (Column B) shows differences with the original expectations of the Class 99/00 boys (Column A). During the writing class, exploitation of some qualities Class 99/00 boys desired, for example, games and reading of other stories, was minimal in the classroom, paper-based environment. On the other hand, dynamic activities such as discussions were engaged more often as observed involving Class 00/01 boys, validating the suggested dynamic features in the children's DL. This profile of use, thus, leads to a significant emphasis of the dynamic features (Items 5-7, Column A) in the re-design of the children's DL (Column C).

Table 2. From initial requirements (see section 1.2) to results of observational study (see section 2.2) to refinement of initial design

Column A: What boys wanted	**Column B: Observational study**	**Column C: Proposed new features (suggested in Column A, reinforced in Column B)**	**Column D: Comments**
▪ **Qualities** 1. Be like "traditional" library 2. Be more game-like 3. Be efficient in searching for relevant materials 4. Offer children with fun features to search for relevant books, etc. ▪ **Dynamic features** 5. Offer children with opportunities to submit to the DL. 6. Give recognition of good stories submitted by listing the top 10 books/authors. 7. Provide opportunities to chat with and to get feedback from other readers.	▪ **Starting and pre-writing** a) Some kind of external stimulus (e.g., teacher) was required before students started working on their assignments. b) Reference was made to the book recommended by the teacher. c) Some boys tried to attract attention by using hands, fingers and voice. d) Some boys were unable to join in the discussion (possibly due to shyness). e) A couple of the boys looked confused. f) Lots of activities on Conversing/discussing/arguing with focusing/listening. ▪ **Writing** g) A couple of boys needed other boys to help them with spelling. h) Cancellation of the whole or bits of document by some boys. ▪ **Reviewing** i) Drafts were passed around. j) Some boys were talking to boys in other groups. ▪ **Reporting** k) Boys were eager to read drafts in front of class.	i. Provide spell checking *(3, g)*. ii. Have editing and deleting facilities *(5, h)*. iii. Features where the users can contribute. Ranking feature where users can contribute by reading and providing some kind of feedback to the document *(5, k)*. iv. Have personal writing space *(5, j)*. v. Flags to show that there are new reviews in the bulletin board or new essays in the DL *(6, i)*. vi. Post drafts in bulletin board *(6, k)*. vii. Read related essays written by other students not belonged to assigned groups *(7, f)*. viii. Links to related topic of discussion *(7, b)*. ix. Facility to post questions to teacher *(7, a/c/d/e)*. x. Ability for group members to contribute to the review session *(7, j)*. xi. Teacher area and teacher-guided discussion *(7, a)*.	Not yet implemented. Yes, already implemented. Not yet implemented. Yes, already implemented. No, not in initial design (see Figure 7 for new feature added in the improved version).

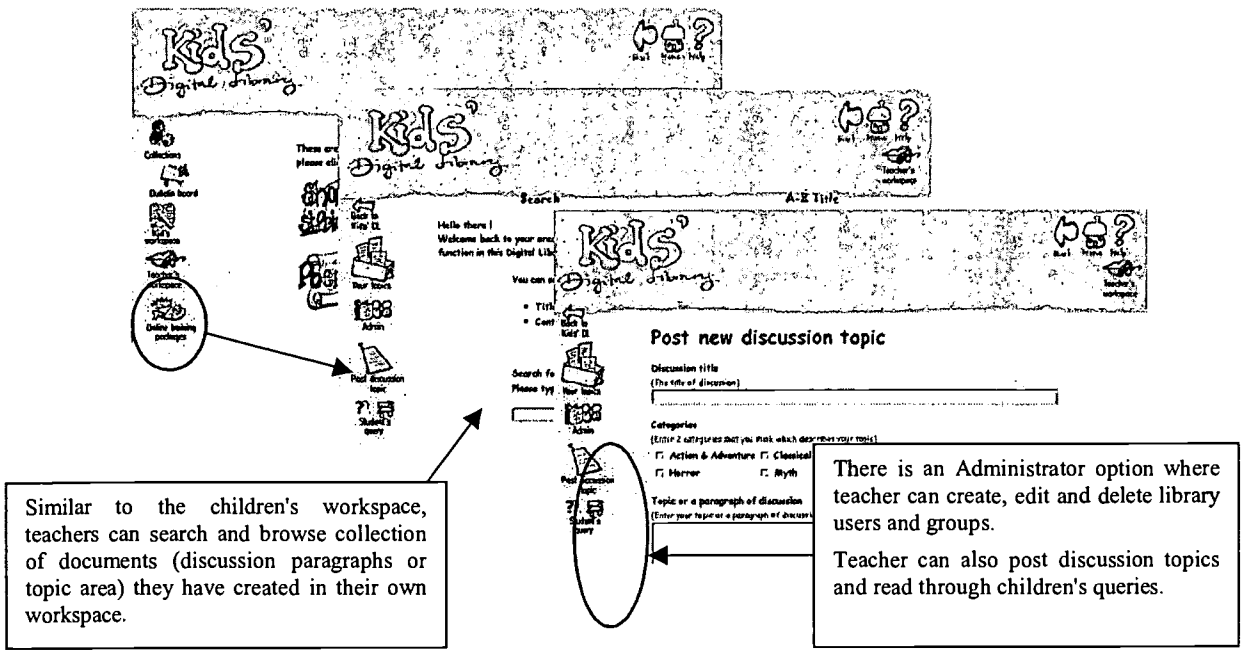


Figure 7. New feature - teacher workspace

What Class 99/00 boys wanted are generally reinforced by the behaviors of Class 00/01 boys. The following are features we have already implemented in our initial DL prototype:

- Links to related topic of discussion;
- Flags to show new reviews posted in the bulletin board;
- Features to contribute essays, rank essays, give reviews and give feedback;
- Bulletin board in which drafts, questions and answers can be posted;
- Features to edit and delete; and
- Personal work space for writing;

From the observational study, we identified three new features when observing the natural collaborative writing behaviors of Class 00/01 boys:

- *Teacher area and teacher-guided discussion.* The teacher was the "stimulus" to get the boys to start thinking and writing. The discussion at the end was helpful in rounding up the activity. Throughout the lesson (when the teacher was in class), individuals and groups would be asking the teacher questions, clarifying task, etc. We have now implemented a teacher area where the students can pose questions and engage in discussions initiated by the teacher (see Figure 7).
- *Ability to select own friends.* Some of the children preferred to work with their own group of friends and not with those assigned by the teacher. A couple of boys walked across the room to look for friends to read their writing and give them feedback. At the moment, the children's DL has not included the facility to allow the children to add their circle of friends whom they want to get feedback from. We are in the process of incorporating this feature.
- *Spell checker.* This feature was also identified when we asked Class 99/00 boys, and this was reinforced by a couple of boys needing help with spelling. We are also in the process of implementing this feature.

DISCUSSION

The goal of integrity is that a DL represents the collection that "should" be there. In dynamic library, especially one with children as authors, one wants to encourage creativity, diversity and the unexpected: but this should be aimed at the content rather than the integrity of the system itself!

Our project highlights these issues summarized as follows:

- Conventional reliability, integrity and security issues. The software the DL is built on must be reliable, it must provide an adequate security system that the teacher can handle, and which the students cannot easily circumvent. All this is possible with NT, Macintosh and Unix based systems, and these can be set up to guarantee that students do not mix up their submissions to the DL. Doing better than proprietary systems would be a research project in its own right!
- If students can submit materials that contain active components, these components may be accidentally or maliciously damaging. Even Microsoft Word documents can contain executable code, and the effect of other users reading it can initiate virus infections. It is therefore desirable to restrict dynamic content to basic HTML or to other easily-restricted formats.
- Systems with very little security can be surprisingly successful. In a school environment, mutual trust might easily be built up *within* a classroom, and this could be supported by the DL having restricted physical/firewall access or permitting access from designated ports or IP

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numbers (i.e., particular machines rather than particular users). However in our project we found that the school's firewall (which is designed to stop external security breaches) made it impossible for us to maintain the DL server, which was located physically inside the school premises!

- Examples of successful open systems include Wiki (`http://wiki.org/wiki.cgi?WikiWay`) and early versions of Unix. Wiki [10] can be understood as an open dynamic DL with absolutely no restrictions on what users can do to content. (It provides automatic indexing and cross-referencing of content, though typically delayed by a few days.) Users can change or create any content, whether or not they authored it, and Wiki distinctively makes it extraordinarily easy (and, indeed, tempting) to do this. The result is that constructive social conventions emerge, and users rewrite and edit content to make it better. Wiki systems are typically strongly subject-based; a generic Wiki system (e.g., the equivalent of a public rather than a research library) would, in our opinion, be unlikely to succeed. Wiki systems achieve their success by having a distinctive *brand*: just like substantial real libraries which, without trying, instill a sense of awe or peace in their users! The Wiki brand is enforced by a distinctive markup language (equivalent to a very small subset of HTML) which might be said to restrict user's freedom of expression, and hence encourages conformity.
- In the early (1970s) days of Unix, Queen Mary College (QMC, London) and Melbourne (Australia) had different philosophies of student access. QMC had open access to source code: the result was that students found system bugs and helped staff fix them. In Melbourne, a stricter system was in force, with source code off-line, and students were implicitly seen as a threat to security. As a result of the lack of cooperation, when student problems arose, they were quite serious. In comparison, QMC had no student problems, and in fact found them helpful.
- The moral is that if it is technically possible to do so, students should be actively involved in all aspects of the DL, and encouraged to take responsibility for it. Obviously, our experimental approach used the students as co-workers with us in developing the user interface and other features. This gave the students a sense of self-worth and, crucially, of investment in the system itself, and hence made the DL a positive experience for all involved. It is possible that future dynamic children's DLs which "big bang" with a working system will be susceptible to different, possibly destructive, attitudes from students.

Some constraints of the implementation technologies available affected the facilities that could be provided.

The movement of a document between collections means that the source and destination collections both need to be re-indexed for searching. For very small collections, this takes a matter of seconds. However, even modestly sized collections can start to take more substantial amounts of time with some algorithms. As with almost all algorithms, there is a trade-off between pre-processing and run-time costs. The MG search engine behind Greenstone provides a high-quality level of compression and fast recall times, but at the cost of processing time when indexes are rebuilt. Similarly, MG does not provide incremental indexing which would substantially reduce the time cost of rebuilding the index.

Moving a single document between two small indexes would probably not itself cause a problem. However, the pattern of use within a school environment is for a high density of use within a small period (less than one hour), so many indexes can be rebuilt at once, alongside high densities of saving and editing activity.

Most of the user actions which would lead to re-indexing are focussed during class time, concurrent with editing and other creative tasks. As seen from our observational study, much of the review and other user-to-user interactions that occur within the classroom happen outside the core DL system. In order to provide good response times to the users during this peak time of use, we have scheduled the rebuilding of indexes to follow each class in a predictable manner. Texts then appear in a timely manner to support later review outside of the class.

The DL has provided an active environment where a user (in this case, a reader) can participate in the environment by giving feedback to the author. In our previous design, we have included authors' email addresses for readers to contact. From our evaluations, the children testers were not in favour of having their email addresses listed to avoid them from getting "junk" mails. For security reasons, we were advised by ethic experts not to display personal information mainly full names and addresses together with their photos. However, in order to provide an active environment and feedback to the authors, we allow the reader to send feedback using a rating system. The rating system was created by adopting our own DocMan [4] tool with a minimal degree of alteration (to be able to access certain metadata in the Greenstone system).

3. CONCLUSIONS & ON-GOING WORK

Ethnographically-based design projects are still few in number and primarily exploratory in nature. They are just beginning to provide concrete examples of the value of bringing knowledge about specific work practices to the designed artifacts, and of the requirements for creating an environment wherein the worlds of design and work analysis can come together [15].

We structured the results of our observational study to bridge the gap between the study of children's natural collaborative writing behaviors and the design of a dynamic collaborative environment within the children's DL, as if it were to be done over distance.

This is on-going work for us. The initial work has created a useful DL for children, which has novel features *with a rationale for those features*. Certainly, more can be done: careful analysis of data; refinement of taxonomy of embodied actions and greater understanding of how actions can be interpreted to support design. If we had had a mixed school, and the gender issues were really relevant, we would have to have done more complex structured experiments, with controls and what not. Instead, we have been clear we used males, and therefore raised sharp questions that others working with females or mixed groups might like to explore as specifically gender issues, rather than DL issues. One might make similar comments about the age range, the income group, and so forth. These are all large and relevant issues for the success of DLs in the world. What matters — in our view — is that we can create a useful DL for a well-defined part of the real population of users.

The pilot work suggests many exciting avenues to research in greater depth. It will be interesting to repeat work with other age groups and control for other factors such as web skills and gender. We will be carrying out longer-term observational studies to study the impact DLs have on collaborative writing.

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