DIGITAL LIBRARY ACCESS FOR ILLITERATE USERS

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ABSTRACT

The problems that illiteracy poses in accessing information are gaining attention from the research community. Issues currently being explored include developing an understanding of the barriers to information acquisition experienced by different groups of illiterate information seekers; creating technology, such as software interfaces, that support illiterate users effectively; and tailoring content to increase its accessibility. We have taken a formative evaluation approach to developing and evaluating a digital library interface for illiterate users. We discuss modifications to the Greenstone platform, describe user studies and outline resulting design implications.

Keywords: digital libraries, user interfaces, illiteracy, formative evaluation

1. INTRODUCTION

An important role of libraries is to promote access to information. Digital libraries are especially good at this because they can transcend physical boundaries. Future digital libraries will be portable: they will be with you whenever you want them to be: in the home, in the plane, at the beach, in a Ugandan village, on the street when you want to play your friends that new song. They will be large, giving access to your personal book collection, your town's public library, your university library. Not only this, but they will ultimately be seamlessly integrated with national and international sources of information—inter-library loan at your fingertips.

By and large, however, libraries tend to promote access only to people who are literate—as we document in more detail below. Viewed from an international perspective (or even a national one), this disfranchises large segments of society. While it is understandable, perhaps, that in the realm of conventional books an inability to read will inevitably disbar one from access, this is far less true of digital multimedia documents.

To meet the new challenge, major technical innovations are needed. We must devise ways of organizing documents in all media, and provide imaginative facilities for browsing or searching through document collections. These new techniques should not appear as a stop-gap fix for second class digital library users, but rather should make information readily accessible by people who lack the everyday written language skills that are taken for granted in other systems.

In this paper we explore the rationale for investigating illiterate access and report on a study of a prototype interface for illiterate users. Section 2 reviews different perspectives on access to information sources by illiterate people from the point of view of users, technology and institutions. Section 3 describes the users who were involved in the design of the digital library interface for illiterate users, describes the implementation of the interface, and discusses user studies with the initial designs and final interface. Section 4 presents a collection and interface whose design was informed by the work presented in Sections 2 and 3, and the final section suggests future work.

2. ALTERNATIVE PERSPECTIVES ON ILLITERATE ACCESS

This section considers three perspectives on the access to information of illiterate users. We discuss how illiteracy affects different groups of users, how technology can be used and how libraries as institutions address the issue.

1

2.1 Users

The straightforward interpretation of literacy (as the ability to read and write) has been replaced by a more complex set of multiple literacies including computer literacy, media literacy, visual literacy etc. [1,2]. The 'reading and writing' interpretation is more accurately referred to as 'print literacy' [1]. However most people's print literacy is limited to a small number (often one) of languages. Literacy exists on a continuum, ranging from the highly skilled to the 'functionally illiterate' (those with such limited print literacy that they are unable, for example, to read a menu or a map) to the illiterate. A further relevant group is the aliterate, who can read but are disinclined to derive information from literary sources.

Users who have literacy problems extend beyond the conventional case of those who have missed out on their education. Digital libraries for children require different interfaces and different design practices to those for adults [3,4]. When children try to use adult systems they often find requirements for spelling, reading and other skills that are beyond their abilities [4]. Disabled users are another group that may find literacy-related problems in using information systems (e.g. [5]), as a disability may be a hindrance in gaining or expressing literacy skills.

Cram notes that 'there is another group, almost universally ignored by public libraries, and that is the newly illiterate' [3]. It is easy to overlook those such as migrants and those with brain injuries who move *from* literacy *to* illiteracy. Libraries have generally focused on providing (usually limited) foreign language materials and literacy education programs [5, 6].

The largest groups of illiterate (potential) users are found in developing countries and there is ample evidence of the problems of providing information to these people [7, 8, 9, 10, 11]. One reason put forward for the high rate of failure in these projects has been the importation of a 'Western' model of libraries that fails to tailor services to accommodate high levels of illiteracy [9]. An approach to this situation has been for librarians to take an active role in 'repackaging' existing information into formats that are more appropriate for the particular characteristics of the local population.

It can be argued that librarians have always played a part in packaging information for their users through organization and presentation but they rarely change the medium or language of the content. Information repackaging is an additional application of digital libraries in developing countries [12] and represents a challenge (in both functionality and usability) for developers. This group of users require an additional characteristic from software—the ability to create libraries usable by the illiterate; an additional complication for end-user collection construction [13].

2.2 Technology

The software issues in examining information access can be separated into two areas: *content* (the medium and presentation of information) and *access* (how searching and browsing are supported). Although the type of content can influence the access mechanisms (e.g. image thumbnails, "query by humming" to retrieve songs) this broad division is useful as it highlights a potential consequence of current interface design practice: namely, that useful non-text content can be rendered inaccessible by access mechanisms that require print literacy.

Content
Both traditional and digital libraries now commonly contain content that can be understood without print literacy skills. Images, video and audio recordings can all be stored and processed by computers in a variety of formats.

Audio has been a frequently used technological means of disseminating information to the illiterate in developing countries [8, 14]. Non-computerized methods such as audio cassettes are thought to be a good match for oral cultures [2, 10, 11]. Rahmena [11] envisions a purely audio library, arguing that cassette recorders are a more cost-effective and flexible approach to information dissemination than print-based methods. He observes that audio recordings are already made and distributed through informal networks. Other reported examples of a vibrant

audio information dissemination culture via cassettes include music in North India [15] and political speeches in Iran [14]. These examples illustrate that information can be successfully distributed, accessed and created via appropriate technology that does not require 'print literacy' skills. The existence of such emergent audio libraries should act as a goal for digital library research: to make our software as usable as cassette recorders but to generalize it across multimedia formats.

Access

The needs of illiterates are rarely taken into account in the design of computer interfaces—indeed, the field of usability has provided graphic illustrations of how interactions can be made difficult for even highly educated users. The human computer interaction literature is largely silent on the issue of access for illiterates, although there is recent recognition of the problem in the promotion of 'universal usability' [16]. On a global scale, the ambitious goal of universal usability has been stated as having '90% of all households as successful users of information and communications services at least once a week' [16].

Interfaces to digital libraries largely consist of text, icons and other artifacts of windowing systems (scroll bars, buttons, list boxes etc.). We suggest that it is likely that interface designers have assumed that all users who are 'computer literate' are also 'print literate'. Consequently a text-free, or low-text, interface hasn't been considered useful—particularly when most content is textual.

Evidence from India suggests that children can acquire certain computer-based skills without necessarily acquiring significant—or indeed, any—print literacy skills [17]. Street children learned, largely by experimentation, how to perform several tasks using a standard operating system and common applications. This suggests that it may be possible to construct an interface that is free from text and that such an interface could be used by illiterate users to access (text-free) content in a digital library. It is easy to imagine that research about access for illiterate users may have little relevance (or result in overly simple systems) for 'normal' users; however, we agree with Schneiderman that: "Accommodating a broader spectrum of usage situations forces researchers to consider a wider range of designs and often leads to innovations that benefit all users."[16]

2.3 Institutional Perspective

Libraries are generally for the literate—they focus on improving the literacy of users (e.g., [6]) rather than providing information in ways that are appropriate to users with low literacy.

Cram criticizes the standard institutional approach of focusing on literate resources and literate users:

> Librarians tend to divide people into users and nonusers, rather than users and potential users. Into the group of nonusers we put those who are never going to learn to read, and as a result that group tends to be very poorly served … [18]

She emphasizes that the existence of relevant resources/information sources is not the issue, rather it is the expectations/stereotypes of the librarians that constrain the mechanisms of provision.

Reed argues that illiterate users are increasingly seeking to use the services of public libraries and that librarians need to adapt their reference practices to such a "nontraditional" user group [19]. This adaptation may include intensive one-to-one interactions, help in interpreting material, providing appropriate alternative multimedia resources and sensitivity when using material from the children's collection with adult patrons.

2.4 Summary

We have outlined how existing practices and identifiable user needs provide motivation for investigating the issue of illiterate access. It appears that both librarians and interface designers have not considered in detail how their existing practices affect the access to information of

illiterate citizens. Further, we can find little evidence of previous studies of interfaces that are specifically aimed at serving the needs of illiterate users.

The technological advances that make digital libraries possible also facilitate the distribution of multimedia content that could be used by many types of illiterate users. In 1983 Harvey predicted that 'undoubtedly, methods can be designed which will bring sophisticated forms of computer power to illiterate people all over the world' [20]: in the remainder of this paper we describe our study of digital library interfaces for the illiterate.

3. DESIGNING A DIGITAL LIBRARY INTERFACE FOR ILLITERATE USERS

We adopted a formative evaluation approach [21] to developing a digital library interface suitable for illiterate users—that is, prospective users were involved in each stage of development, and feedback from these users/testers guided the creation and refinement of the implemented interface.

The initial stages of this research involved an assessment of the interests and usability requirements of two sample sets of potential users: patrons of UNESCO-sponsored telecenters, and a local group of students enrolled in English literacy and English as a Second Language (ESL) courses (Section 3.1). The process of designing a digital library interface for illiterate users then incorporated user feedback in three phases:

1. Initial user requirements were obtained from Telecenter responses and through observing testers as they interacted with the standard Greenstone digital library interface (Section 3.1).
2. Local testers evaluated three paper-based prototype designs (Section 3.3).
3. Local testers participated in a comparative usability test of a standard digital library interface and an interface tailored to illiterate users (Section 3.5).

3.1 Locating test users for requirements analysis and development

The first stage in requirements analysis for the digital library interface involved locating groups of potential users and exploring their usability requirements. We were able to administer a survey to UNESCO Telecenters that providing computing and informational services to our target users: illiterate people in developing countries. As it was impractical to involve these users in usability testing of our prototype interfaces, we located a local group of users/testers who shared some of the salient characteristics of our target users: local students enrolled in English literacy and ESL courses.

Telecenter Patrons

The Payson Center for International Development (Tulane University) distributed and administered a questionnaire to telecenters located in India, Mexico, and Costa Rica. These telecenters are supported by UNESCO, and were established to provide public access to information and communications technology for individual, social, and economic development. Telecenters help meet the goal of "universal access" by providing community-based access to this technology.

The questionnaire responses provided a profile of the level of technological expertise and the information interests of telecenter patrons. The telecenter users generally have some education and are considered literate in their communities, but may not find reading or writing to be a natural or easy process. Few are literate in English (the predominant language of the World Wide Web). The users have minimal prior exposure to the Web, and find Web navigation difficult—particularly with regards to using a mouse. Telecenter patrons report that they are not interested in gaining access to text-based information sources; the low appeal of text may be rooted in difficulties patrons experience with reading, or may reflect disappointment with the relevance of available material.

Local Testers

Ideally, users from our target group (semi-literate or illiterate people from developing countries) would have been involved in the development of our prototype system. This was not possible for practical reasons. Instead, a set of testers were recruited from a local English training center, as these students approximated as many of the characteristics of the target group as possible. They were primarily ESL students, who were literate in their native language but not in English. These students had obtained schooling in their own countries, and so had achieved a level of academic literacy that would not be part of the profile of our target users; however, they could provide insight on how someone illiterate in English might interact with an English-based digital library. Their previous experience with physical libraries and books provided them with a better mental model of searching and browsing than might be expected with our target users (although, interestingly, this skill transfer between physical and digital libraries failed to eventuate—see Section 3.5). The ESL students also had significant problems with oral English, and had a limited English vocabulary—again, a characteristic not shared by our target users, who would be assumed to have good oral facility in the language of the 'illiterate' digital library's documents.

A few of the students were native English speakers, but had slipped through the New Zealand educational system without learning to read and write. These latter testers more closely approximate the characteristics of the target group—that is, they had an oral but not a written facility with a single language.

For all student testers, the level of English literacy varied from being able to recognize a very few simple words but being unable to write a sentence, to being able to read a simple sentence and write their name or a very simple sentence.

Like the Telecenter users, the local testers had little or no prior experience with computers. Usually, this was confined to having been introduced to Microsoft Word. Most had no experience or knowledge of the Internet.

3.2 Initial user requirements

An initial set of user requirements were derived from the Telecenter questionnaire responses, a survey of the literature, and a set of observations of three local testers interacting with a collection of existing online digital libraries (http://www.nzdl.org):

- Target users have a high need for *ease of learning*, and *ease of remembrance*, due to their low levels of formal education, low (minimal or zero) computer experience, low frequency of use, and potential uncertainty or anxiety towards technology (Telecenter responses; local observations; [22,23]).
- Minimal or zero typing/reading skills suggests an interface with *no textual requirements* ([22,23]).
- No reading skill suggests that *icons and visual displays* (possibly with the use of speech synthesis) will be necessary (local observations; [22]).
- The potentially broad cultural and ethnic backgrounds of users suggested an interface that supports *internationalization* ([24]).
- Potential difference in language, ethnic, and cultural backgrounds of users suggests an interface that accommodates *localization* ([24]).
- Little exposure to technology and the context of life in a developing country suggests that the design should be *simple, easy to navigate, easy to use*, and *tolerant of errors* that will be inevitable in the process of exploration and learning. The design must be as self-explanatory (simple) as possible, and thus easy to learn and remember, by leading users through steps and by providing adequate on-line support (Telecenter responses; local observations).
- To promote learning and exploration, the design content should be *useful*, and the design should be *robust* (Telecenter responses; local user observations; [22, 23]).
- The digital library is likely to be accessed in a public space—a Telecenter, internet café, or other such public access site. The design must support users working in a possibly

distracting environment, with context information to remind users where they are when they get distracted (Telecenter responses).

- *Browsing*, rather than searching, should be the primary interaction strategy with the digital library, as browsing is simpler conceptually, and the exploration of a collection aids the user in constructing a mental model of the collection contents and organization. The design must support infrequent, inexperienced users performing a relatively complex task; specifically, a query/browse of a digital library with potentially millions of items (local observations).

3.1   Testing with Paper Prototypes

Paper prototypes were developed for three alternative designs for a browsing interface, and were tested with three local users. Interestingly, the low-fidelity nature of paper prototypes was more problematic in conveying an impression of a system than usual—this may have been because these users' difficulties with language were compounded by their relative unfamiliarity with computers. Both the concept of a 'collection' of documents and the idea of searching such a collection were found to cause problems for the users.

The following interface design guidelines were derived from tests with the paper prototypes:

- An interface that provides a side menu of the collections available is preferable (thus minimizing the use of the navigation buttons needed, and also minimizing the need to go back to the Home page).
- Audio support would be helpful for the content and for navigation within the interface.

3.2   Implementation

The guidelines presented in Sections 3.2 and 3.3 informed the development of a prototype digital library interface tailored for illiterate users. This prototype was developed under Greenstone (http://www.greenstone.org), a comprehensive environment for creating, maintaining, and providing access to collections of digital documents. Developed by the New Zealand Digital Library project, Greenstone is a freely available, open source digital product.

The theme of the prototype collection was 'images of Hamilton', the city in which most of the local testers reside. The digital library collection includes photos of Hamilton's attractions, community events, and the local area. This theme was chosen as being of potential interest to the test users, particularly as many were recent immigrants to New Zealand.

To facilitate browsing, the collection was divided into five categories: entertainment, events, people, places, and scenery. Each category is represented by an icon on the initial page of the digital library (Fig. 1). Clicking on an icon brings up a set of thumbnail images with that theme (Fig. 2); the full-sized photograph can then be viewed by selecting one of the thumbnails. Note that Greenstone supports browsing hierarchies that are arbitrarily deep and wide—a more complex document collection could be supported with a correspondingly complex browsing scheme.

The web interface of a Greenstone collection is controlled by a macro language that enables presentational changes to be made at run-time. The macros can be overridden on the basis of a particular collection, whether the display is text-only and on the chosen language of the display. These capabilities were used extensively to create the appearance of the Hamilton collection.

The initial user requirements (Section 3.2) indicated that audio capabilities would improve digital library usability for illiterate users. Two types of audio were added to the digital library: audio 'mouseover' help and audio descriptions of the image documents. The audio help is available for navigation buttons that move users up and down the browsing hierarchy, and is context-sensitive—e.g., "click here to go back to the Hamilton City homepage", rather than simply "click here to go up one level". The audio descriptions of the image documents were intended to

complement the images by providing additional information or background details for the image; this content audio also played on mouseover of the document image.
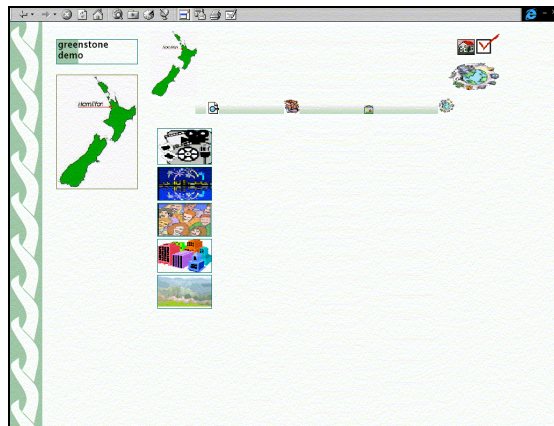
Figure 1. Initial (browsing) page of the Hamilton City digital library.
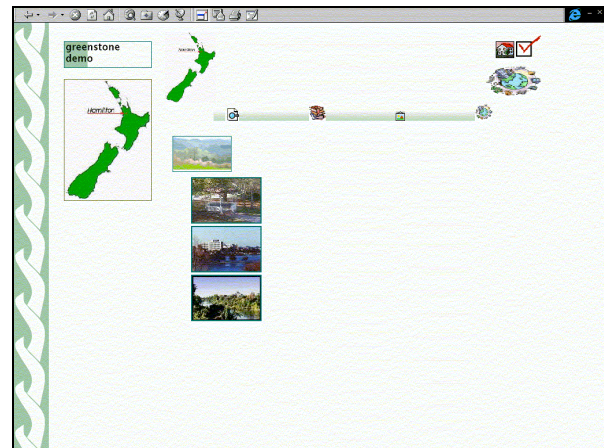
Figure 2. Thumbnail images in the 'Scenery' category.

Two possibilities exist for incorporating audio into Greenstone: using speech synthesis software to automatically generate audio from text tags or text documents associated with images; or storing pre-recorded audio files. The former alternative is attractive in that it could require far less memory, since the speech synthesis could be accomplished on the fly. However, synthesized speech can have poorer quality in pronunciation than natural speech [25, 26], and synthesizers are not available for many languages and dialects (and, of course, not all languages have a written form). Further, the synthesizer would have had to run on the client side—greatly increasing the effort and expertise required to set up a computer to successfully use the digital library. For these reasons, the second alternative—incorporating pre-recorded, natural speech audio files in the digital library interface—was chosen for implementation. The standard Greenstone web interface was customized (using JavaScript) to play a specific audio clip when the cursor was located over a particular image or interface icon.

3.3 Usability Testing of the Implemented Digital Library Interface

Five local users participated in this round of testing. Each was observed interacting with both the Hamilton City Collection and with text-based collections implemented under the standard Greenstone interface. These observations focused on obtaining qualitative responses from the testers as to the relative perspicuity of the two types of digital library interface. None of these testers had had prior experience with Web browsing or searching and all required initial training on the use of navigation buttons (Home, Back, and Forward).

Given these users' lack of experience with the Web and its browsing structures, it is not surprising that the users found the audio mouseover help to be useful, and the context-sensitive navigation messages provided appropriate support for navigation. However, it quickly became apparent that additional 'process' support would have been helpful for these users—for example, contextual information such as what to do next or how to get started in browsing. The idea of browsing in a hierarchy was not intuitive to the users; they had had little experience with hierarchically arranged information, and consequently required time to experiment with the system and build a mental model of the contents of the collection and the way the images were categorized. Difficulties with hierarchies have also been reported with novice web users in South Africa where a recent study 'suggests that there are clear cultural dimensions to the interpretation of common visual navigational conventions on the web' [2].

Interestingly, for our users prior familiarity with browsing physical books and libraries did not help them in developing a mental model of the digital library. When asked to describe a physical library and what they did there, and then to relate these activities to their interactions with the

digital libraries they encountered in this usability test, they had difficulties describing any concrete relationship between the two. These observations indicate that training in how to use a digital library would likely be useful for illiterate users—perhaps not a surprising conclusion, given the large number of 'how to use a library' training sessions offered to university undergraduates!

Browsing as the primary access mode for documents in the digital library incurs a high overhead in human memory: to successfully locate a new and relevant document the user must have a better understanding of the structure of the library than would be the case in a 'normal' digital library providing keyword search as the main access mode. Additionally, to successfully retrieve a previously located document, the user must remember or reconstruct the path to that document through the browsing hierarchy. Recent experience with another digital library that relied heavily on browsing—a collection of conversational expressions for use by a non-verbal user [27]—indicates that the effectiveness of browsing breaks down when the complexity of the collection's organizational structure begins to tax the user's memory.

Our initial dream, then, of a browsing hierarchy that supports access to "potentially millions of items" (Section 3.2) appears improbable. Instead, digital library developers should concentrate on isolating smaller collections of documents, and carefully tailoring the collection size and browsing structure complexity to minimize human memory overheads.

4. CREATING A DIGITAL LIBRARY TEST COLLECTION

The lessons learned from the literature review, user studies, and formative evaluation exercise described in Sections 2 and 3 informed the development of a test collection for our digital library design. The test collection is based on the contents of *First Aid in Pictures* [28], an icon-based wordless book designed to provide first aid advice to illiterate people in emergency conditions. The book has been used extensively in war zones and in the wake of natural disasters.

The skeleton image on the left of Figure 3 provides the search mechanism for the collection; the user clicks on the spot that has been injured, and the user is then presented with a list of icons depicting the various injuries of that body part (breaks, cuts, gunshot wounds, etc.). The user can then browse the icons to find the appropriate treatment. The four icons on the right of Figure 3 depict general physical illnesses or injuries: from top to bottom, burns, heat stroke, sunburn, and hypothermia. Clicking on one of these icons leads directly to first aid instructions for that condition. Browsing (Figure 4) is supported through a scrollable list of all icons present in the book (primarily injury sites and body parts), sorted by frequency of occurrence in the collection. Figure 5 presents a sample page of content, for dealing with a broken arm. For the semi-literate or literate user, explanatory text can be generated by clicking at the bottom of each page. This text (currently in English) can also be spoken by a voice synthesizer.

Our next steps are: to perform usability experiments with this collection, to determine the usability of this approach to searching and browsing; to distribute the collection for further feedback, to support iterative refinement of the design; and to extend this approach to other health-based digital library collections (for example, for AIDS prevention or diabetes control).

CONCLUSION

This paper describes the development and usability testing of a digital library interface tailored to illiterate users. An extensive review of the literature indicates that such an interface would indeed be useful to identifiable groups of potential users, particularly in developing countries.

We have shown, through the development and testing of this interface, that it is indeed feasible to construct an interface tailored to the needs of illiterate users. We found that short audio clips can be used to replace textual labels although the presentation of information hierarchies requires careful design. Further work should investigate the scalability of the approach described here and generalize the testing to other user groups and other forms of multimedia content.
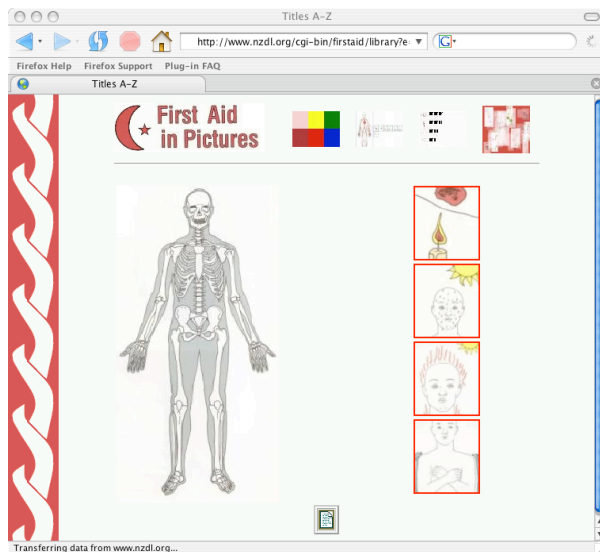
Figure 3. Searching (left, skeleton icon) and general conditions (right icons) page of the First Aid in Pictures Collection.
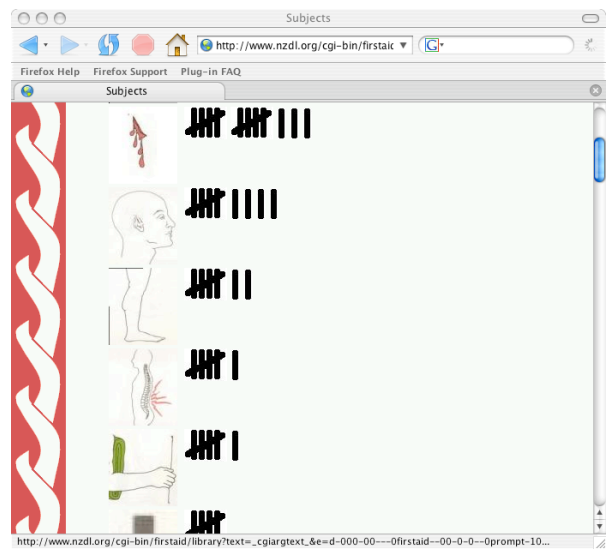
Figure 4. Browsing structure; icons sorted by frequency in the collection.
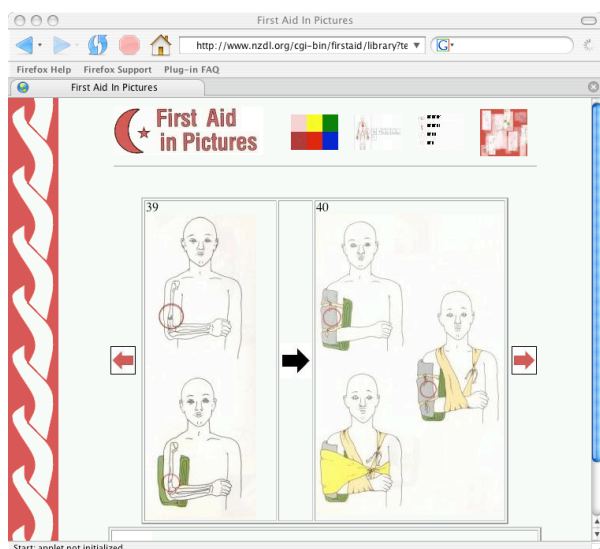
Figure 5. Sample content page from First Aid in Pictures (dealing with a broken arm).

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