

that development rests with the local site. For the NWDA consortium, this development, using the code base, has been manageable. The current state of interface development for the NWDA project can be reviewed at http://nwda.wsulibs.wsu.edu/project_info/.

Conclusion

In selecting an EAD search-and-retrieval system, one important question for the consortium was, Which software solution had the best prospects for migration in the future? Because of the inherent strengths of native XML technology in comparison to the other product categories listed in table 1, a native XML database appeared to be the best approach, and TextML provided the best combination of licensing costs, software capabilities, and support.

It is important to note that the distinctions between native XML databases and databases that support XML through extensions (XML-enabled databases) may become more difficult to discern over time, in part due to the existing expertise and investments in RDBMS technologies.¹⁶ Nevertheless, capabilities central to native XML, such as the use of an XML-based query language, are integral to the success of such hybrid systems.

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Using GIS to Measure In-Library Book-Use Behavior

Jingfeng Xia

This article is an attempt to develop Geographic Information Systems (GIS) technology into an analytical tool for examining the relationships between the height of the bookshelves and the behavior of library readers in utilizing books within a library. The tool would contain a database to store book-use information and some GIS maps to represent bookshelves. Upon analyzing the data stored in the database, different frequencies of book use across bookshelf layers are displayed on the maps. The tool would provide a wonderful means of visualization through which analysts can quickly realize the spatial distribution of books used in a library. This article reveals that readers tend to pull books out of the bookshelf layers that are easily reachable by human eyes and hands, and thus opens some issues for librarians to reconsider the management of library collections.

Several years ago, when working as a library assistant reshelving books in a university library, the author noted that the majority of books used inside the library were from the mid-range layers of bookshelves. That is, by proportion, few books pulled out by library readers were from the top or bottom layers. Books on the layers that were easily reachable by readers were frequently utilized. Such a book-use distribution pattern made the job of reshelving books easy, but created some inquiries: how could book locations influence the choices of readers in selecting books? If this was not an isolated observation, it must have exposed an interesting

phenomenon that librarians needed to pay attention to. Then, by finding out the reasons, librarians might become capable of guiding, to some extent, users' selectiveness on library books by deliberately arranging collections at designated heights on bookshelves.

A research study was designed to develop Geographical Information Systems (GIS) into an analytical tool to examine former casual observations by the author. The study was conducted in the MacKimmie Library at the University of Calgary. This paper highlights the results of the study that aimed at assessing the behavior of library readers in pulling out books from bookshelves. These books, when not checked out, are categorized as "pickup books" because they are usually discarded inside a library after use and then picked up by library assistants for reshelving. Like many other libraries, the MacKimmie Library does not encourage readers to reshelve books themselves.

ArcView, a GIS software, was selected to develop the tool for this study because GIS has the functions of dynamically analyzing and displaying spatial data. The research on library readers pulling out books involves the measurements of bookshelf heights, and thus deals with spatial coordinates. With the capability of presenting bookshelves in different views on maps, GIS is able to provide readers with an easy understanding of the analytical results in visual forms, which make any textual descriptions wordy. At the same time, some GIS products are available now in most academic libraries, thus giving developers convenient access to use.

Hypothesis

When library users decide to check books out of a library, these books are what they think of as useful. People are usually hesitant to carry home books that are of little or uncertain

use, not only because of the limit on the number of check-out books, but also because of the physical work required for carrying them. Moreover, some items, such as periodicals and multimedia materials, are either designated as "reference only" or have a very short loan period. It is reasonable to believe that users carefully select what they want from library collections and keep these books for handy use outside the library.

By contrast, in-library book use represents a different category of library readers' behavior. There are two general categories of in-library book use: readers bringing their own books into a library for use, and readers pulling out books from bookshelves inside a library. The former is commonly seen when students study textbooks for examinations (not the topic of this study), while the latter is a little more complex.¹

As library users approach bookshelves to extract books, they may or may not have a definite target. When coming with call numbers, people will deliberately draw the books they want for reading, photocopying, or referencing. However, there are times when users only wander in bookshelf aisles of desired collections, uncertain about singling out specific books. They may simply shelf-shop to randomly select whatever is interesting to them, or they may locate a subject of need and go to the storage position(s) to look for whatever books are there. No matter what these readers' intentions are, they roam among collections, pick books for quick use, and leave them inside the library after use, although some materials may also be checked out.

Because of such arbitrary selections from library collections, physical convenience sometimes influences library users in taking books from bookshelves—they may look around for books on bookshelf layers that are at a reachable height. The standard library bookshelf is higher than the average person's height and is structured to have five to eight layers. In

academic libraries, "wood shelving is available in three heights: 82 in. (2050 mm), with a bottom shelf and six adjustable shelves; 60 in. (1500 mm), with a bottom shelf and four adjustable shelves; and 42 in. (1050 mm), with a bottom shelf and two adjustable shelves."² For regular collections in most academic libraries, bookshelves are usually about eighty-two inches high and have seven layers. Books on the top layer are out of reach for many readers, requiring them to use a ladder to draw a book from it. Many users are hesitant to use ladders. Even worse, a reader will have to bend over or squat down to view the contents of books on the bottom layer of a bookshelf.

Hence, the hypothesis is that books used inside a library are primarily distributed among the mid-ranged layers of bookshelves. Specifically, if a bookshelf has seven layers, books placed on layers two through six are most frequently consulted. This is the subject of this research paper.

Background

A considerable number of studies have investigated the utilization of books that are checked out of a library. An estimate made in 1967 pointed out that over seven hundred research results pertained to this topic.³ However, the situation of books used inside a library has not been given enough attention. One of the reasons for this seeming neglect comes from the belief that the records of library books in circulation provide similar information as those of books used within libraries.⁴ This misunderstanding was lately criticized by other researchers who discovered the differences in use behavior between

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library readers taking books home and those using books inside libraries.⁵ Researchers have now recognized that correlations between the two sets of data are not as strong as they seemed to be.

Such recognition, unfortunately, has not resulted in more consequent work to explore the issue of in-library book use. This is probably due to the difficulties of collecting data or the lack of appropriate research methods.⁶ Also, the majority of relevant surveys were conducted several decades ago and focused primarily on exploring a good method of sampling in-library book use.⁷ Among these studies, Fussler and Simon preferred to carry out research by distributing questionnaires among library readers; Drott used random-sampling methods to statistically examine the importance of library-book use; and Jain, as well as Salverson, emphasized dividing the survey times into different investigation units when conducting research. Similarly, Morse pointed out the complexity of measuring library-book use at work, advocating an involvement of computerized operations in library-book management.

The sampling strategies and analytical methods implemented in past studies are still applicable to current research. Nonetheless, because many new technologies have come into view since then, it is quite likely that some new ways of obtaining and analyzing the data of in-library book use can now be developed. The new approaches must have the capability of providing not only accurate measurement of the data but also the means for easy manipulation. Their results must be able to enhance the understanding of user behavior in exploring the resources of existing collection inventories. One of the solutions is an analytical tool.

An analytical tool can control data collection and analysis by computerization. If the system is able to accumulate constantly updated records over time, it will remedy the problem

of poor sampling that many researchers have encountered, because analysis will then be done on all the data rather than with certain isolated samples. The development of modern technologies makes such data collection and storage possible and easier than ever before. One example of the technologies is the radio frequency identification (RFID) tag system that has been adopted by some public and academic libraries recently.⁸ This system stores a tag in each library item with the item's bibliographic information, and uses an antenna to keep track of the tag. By automatically communicating with data stored in the tags, the system can collect data on all library collections in a timely manner and export them into predesigned databases for easy management.

Data analysis and presentation comprise another part of the analytical mechanism. Researchers have to carefully evaluate existing technologies in order to select proper products or develop particular programs to integrate with RFID (if used) and the databases. It is fortunate that GIS technology is available with numerous functions for analyzing and demonstrating data, especially spatial data. Data visualization through GIS products has been very good, which gives them advantages over other analytical, statistical, or reporting products.

Combining RFID and GIS into one system would seem to be the perfect solution—the former can effectively carry out data collection and the latter can efficiently perform data analysis and presentation. However, while GIS products have been used in libraries in the United States for more than a decade, most academic libraries are hesitant to invest in RFID because of its high costs. GIS technology alone, however, can still provide sufficient functions to be developed into such an analytical tool.

Up to now, those libraries that have provided GIS services only use the software that assists in the utilization of geospatial data and map-

ping technologies for users.⁹ GIS is not exploited enough to aid the management of libraries themselves and the research of library collections. Some commercial GIS software, such as "LibraryDecision" by Civic-Technologies, has been recently marketed to support the analysis of library-user data for public libraries.¹⁰ However, it only works well on the data of conventional geographical nature, that is, the distribution and location of libraries and their users with the mapping of city blocks and streets. It does not apply to a library and its books, and especially not to the distribution of books used inside the library. Such products are also not applicable to academic libraries that do not always concentrate on the analysis of geographical areas of their users.

Even so, GIS has all the functions that such a proposed analytical tool demands. It is suitable for assisting in the research of in-library book use where library floor layouts or other facilities can be drawn into maps on multiple-dimensional views. At the same time, bookshelves with individual layers can be treated as an innovative form of map by GIS technology (see figure 1), making visible the relationship of book use to the height of the book shelf. As soon as the presentation mechanism is linked to databases, any updates on book use will be mirrored visually.

Method

This project is one of a series of projects for developing GIS into a tool to manage and analyze the usage characteristics of library books. The other projects include using GIS to measure book usability for the development of collection inventories; to assist in the management of library physical space and facilities; and to locate library items.¹¹ In order to make GIS workable for the subject of this paper, the focus was placed only on the exploration of correlations between bookshelf

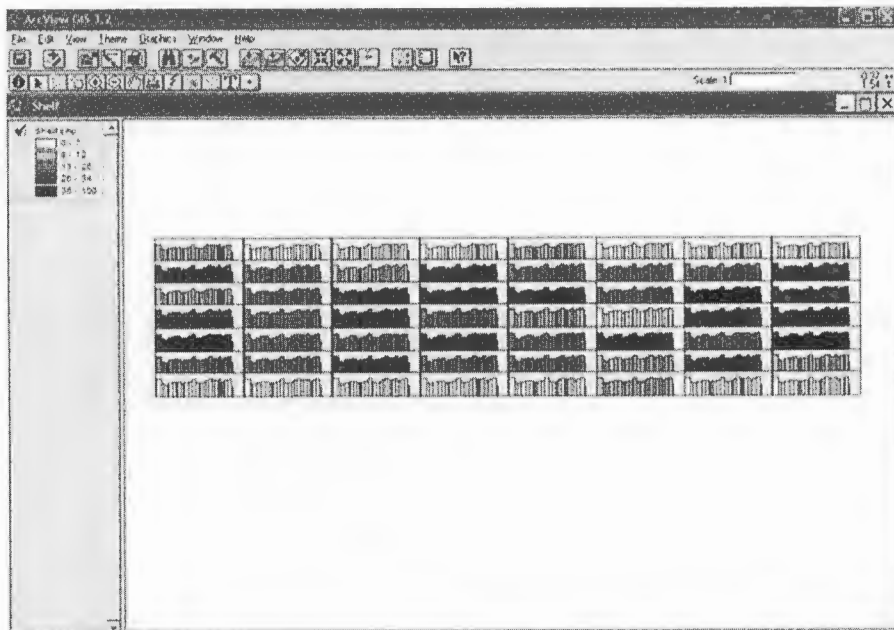


Figure 1. The front view of one bookshelf rack on the fifth floor of the University of Calgary MacKimmie Library. Eight bookshelves assemble the range. Here, different shades of color represents the numbers of books used on each individual layer. The display is only for demonstration and not to actual scale.

heights and book-use frequencies in an academic library environment.

There are two major steps to conducting this research: collecting data and developing a GIS analytical tool. Since MacKimmie Library did not invest in RFID at the time this research was undertaken, personal observations were made to record book-use data.¹² The development of the GIS tool involves creating a small database to store data and facilitate data analysis. It also requires creating several bookshelf and shelf-range maps to present analytical results in visualized forms. ArcView—the most popular GIS product in the world—was utilized for the development.

This paper presents only a portion of collection areas at MacKimmie Library. Part of the fifth floor, where some collections of humanities and social sciences are stored, was selected because this floor is among the busiest of the floors used by readers. It is filled with sixty-eight ranges of bookshelves containing books from call

numbers B to DU. The terms used in this paper include *bookshelf*, referring to one unit of furniture fitted with horizontal shelves to hold books; *rack*, which includes more than one bookshelf standing together in a line; and *range*, composed of two racks standing back-to-back. Bookshelves on the fifth floor are arranged to surround a group of facility rooms in the central area. Study corridors are set between bookshelves and the wall. Each bookshelf range consists of two bookshelf racks, each of which in turn has eight individual bookshelves. All of the bookshelves are about eighty-two inches high and have seven layers. The layers, except for the top ones that are open, are equal in height, width, and length.

Data Collection

Personal surveys were taken by the author to note down each call number of books that were not in their origi-

nal positions on the shelves, but instead were found discarded on the floor, tables, chairs, sofas, or on top or in front of other stocked books. Books on the shelving carts are also accounted for. The surveys were separately conducted three times a day—morning, afternoon, and evening—in order to catch as many books used in a day as possible. To avoid recording the same book more than once, no duplicate call numbers were accepted for any single day even though the same book was found in different locations on that day. On the other hand, the same call number could be entered into the records on the second day although it was recorded the day before and remained in the same place without being picked up by library assistants. (This duplicate recording was very rare because of the routine work of book pickup by library assistants.) A period of two weeks was designated for the survey in the first half of December 2002. The final examination week was planned because it represents a week of heavy book use, although previous research found that readers in this week tended to use library collections less than their own study materials.¹³ A supplementary survey that also lasted two weeks, including a final examination week, was conducted in the library in late spring 2004.

To simplify the research, some exceptions were established for data collection. Periodicals were excluded because they have a very short loan period (generally one day). Library users may prefer to read articles in journals within the library and thus will have a clear idea as to what materials to read.¹⁴ Books belonging to other floors of the library, or books belonging to the fifth floor but found outside the area were not included in the analysis. Furthermore, due to the nature and time limit of these observations, books pulled out of targeted bookshelves were not distinguished from books taken from bookshelves at random. This information can only become available through interviews

with library users, which can be another research project.

Each bookshelf layer was recorded with and signified by two call numbers: the start and end numbers of books. For example, the call numbers "BF1999 .K54" to "BH21 .B35 1965," representing books stored on a particular layer, were recorded to identify that layer. Because book shifting can happen from time to time, such recording of start and end call numbers for individual bookshelf layers only reflects the conditions when this research was undertaken and may need updates whenever changes occur.

Data Manipulation and Visualization

Using a bookshelf layer as the recording unit is essential for the analysis of the relationship between book use and bookshelf height. Each book used can be classified to fit in one unit according to the call number of the book. Therefore, building a database with a table for layers will be an important part in the development of such an analytical tool. The LAYERS table includes a data field as an identifier to stand for the sequence of each layer—1 for the top layer, 2 for the next layer down, and so on, in addition to storing the start and end call numbers of books for each layer. If more than one bookshelf in the library has seven layers, layer identifiers will iterate from bookshelf to bookshelf. Therefore, this table will also need an identifier for each individual bookshelf with which layers are associated.

The database will also contain such information as bookshelf ranges, bookshelf racks, and books, all of which are individual database tables that are joined with each other by relational keys. Among them, the RANGES table is simply characterized by its identifier, and is designed to represent two racks of book-

shelves that stand back to back. The BOOKSHELVES table is identified by the call numbers of the start and end books stored across individual bookshelves rather than on individual layers. Furthermore, the BOOKS table is primarily filled with the data of individual book call numbers as well as book pickup times and book discard locations.

GIS has limited ability for organizing database structure. If necessary, other database management systems, such as Microsoft Access, can be incorporated. Query codes are built to get summarized information for specific purposes, and the aggregated data are exported into GIS databases for further spatial analysis or convenient visual presentation. Data visualization can be shown at different levels—by layer, bookshelf, rack, and range. The first attempt at making a visual demonstration of this research is for the area of individual bookshelves at layer level (see figure 1). The following query will return necessary summarized information:

```
SELECT sum(b.call_no) AS
total_num, l.layer_id, l.shelf_id

FROM (BOOKS b INNER JOIN
LAYERS l ON b.some_id =
l.some_id)

WHERE b.call_no > l.start_no
and b.call_no < l.end_no

GROUP BY l.layer_id, l.shelf_id

ORDER BY l.shelf_id, l.layer_id.
```

At the same time, another attempt is made to demonstrate book numbers per layer, at bookshelf level, across multiple bookshelf ranges. This demonstration provides a better visualization in the GIS display so that an overall view of the height distributions of book usage over certain collection areas can be presented (see figures 2 and 3). To achieve such visualization, data must be compared in order to get information about which layer of a bookshelf

contains the most frequently used books and which holds those that are rarely visited. This demonstration indicates that any alternative selection of analytical-display units can be easily performed by making modifications on the query that works on aggregating data.

Technically, data visualization can be presented by using any GIS software, although ArcView is used here because it has been available in the systems of many academic libraries. Bookshelf ranges in MacKimmie Library's fifth floor were drawn into map features. In order to show them with a three-dimensional view, each of the seven layers was given a sequential number as its height value, and all bookshelves were treated as having the same height. These height values are treated as the z values in any three-dimensional analysis. Then, by associating the numbers of books from the database with the heights of layers on the map, ArcView is able to sketch the height distributions of in-library book use in new perspectives, dramatically improving the understanding of book use.

In order to implement the visualization of all layers across a bookshelf range, layers were drawn as map features (see figure 1). Layer heights and widths are in appropriate proportion. (Individual books on each layer are for demonstration only, and thus are not in the exact shape and number.) Figure 1 shows how a bookshelf rack has been presented as a GIS map, which is a totally new idea in the applications of GIS visualization.

The database and visualization mechanism constitute what is referred to in this paper as the analytical tool. One will find that the development is relatively easy and the tool is incredibly simple. However, it is a dynamic device. If expanded into other parts of the library collections, this tool will become an integrated system that is able to assist in the management of library book use and

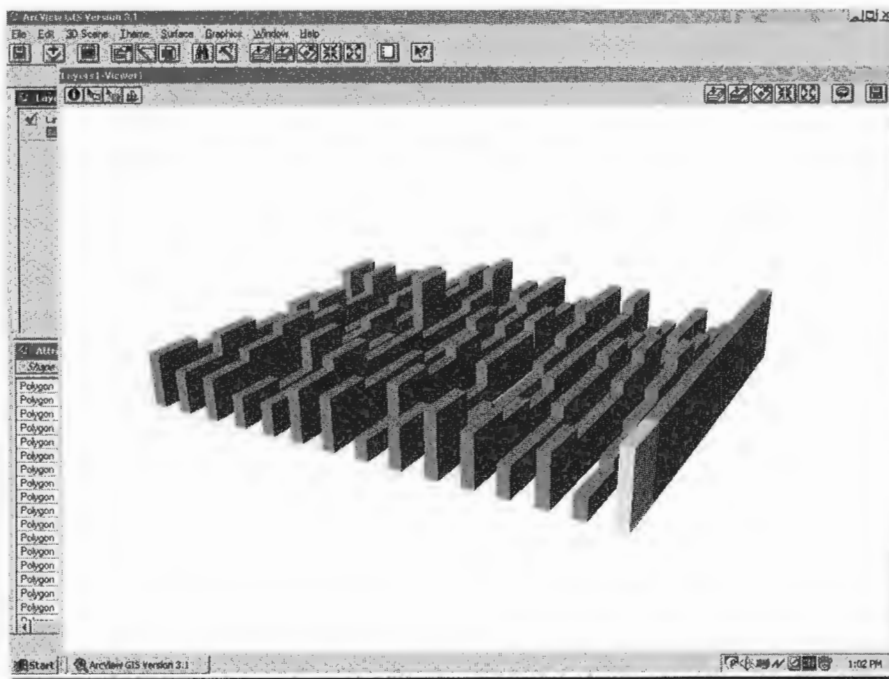


Figure 2. A three-dimensional view of bookshelf ranges on the fifth floor at the MacKimmie Library. The height of each bookshelf represents the corresponding height of the layer from which most books were removed. This display is not to actual scale.

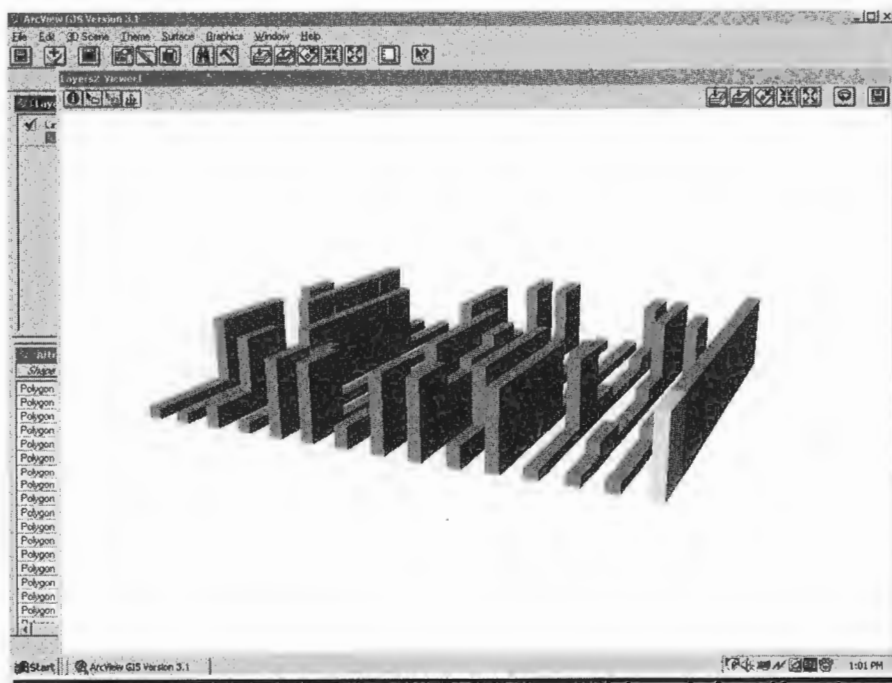


Figure 3. A three-dimensional view of bookshelf ranges on the fifth floor at MacKimmie Library. The height of each bookshelf represents the corresponding height of the layer from which the least books were removed. This display is not to actual scale.

collection development. What is required for routine operation of the system is to regularly update the database (by using RFID if possible, or by connecting to circulation databases) and analyze and display the updates on the GIS maps. The analyst has the flexibility of easily flipping the displays of the three-dimensional views by 360 degrees, zooming in on specific features on the maps, as well as making any feature transparent for even more sophisticated viewing. GIS's magic functionality makes the tool graphically elaborate.

Findings and Conclusions

The results have been visually exhibited on the GIS maps. For demonstration purposes, figures 1 through 3 display only one portion of collections on the fifth floor. Nonetheless, this small part of the illustrations has been able to show clear patterns of the usage pattern of library books. Figure 1 is the frontal view of a bookshelf rack that uses different levels of color density to present varied numbers of books used by readers on different layers. Shown as an example, it is clear from this picture that all top and bottom layers either are white or have lighter colors, because book-use numbers are very low on these layers, while colors on layers 2 to 6 are darker.

By extending the one-rack view to reveal several bookshelf ranges on the fifth floor, figures 2 and 3 present different perspectives. The height of each bookshelf in figure 2 represents the layer of the bookshelf, from which the most frequently browsed books are counted. Please note that the height of the nearest bookshelf range is at its highest (the top layer) for easy visual comparison. This graph shows that the majority of bookshelves here have a height suitable for regular readers to browse and retrieve books. A clear

pattern has therefore been revealed: most of the books used are on easily reached layers. In contrast to figure 2, figure 3 shows the least-used layer for each bookshelf. It is obvious that the heights are either the highest or the lowest, indicating the infrequent number of visits to layers 1 (the top) and 7 (the bottom). Hence, a strong correlation between the height of book locations on a bookshelf and the tendency of library users to pull out what they are interested in is visually portrayed. This occurrence has confirmed the hypothesis that books on the top and bottom layers of a bookshelf, by reason of their inconvenience to users, receive less attention than books on other layers. People seem to favor the items that are stored at a reachable distance when they glance through library collections without a definite destination.

The findings suggest that a library should conduct more surveys to see which books are truly useful for its users. The most useful items should be arranged on bookshelves with a height suitable for average-sized people. Many public libraries have already noticed the importance of regulating shelf layers for the convenience of readers, especially for elderly and young readers. However, academic libraries have not yet paid enough attention to this issue.

An alternate solution is to adjust the height of bookshelves in a library. Similar efforts have already been made by some libraries in an attempt to increase the space of the top and bottom bookshelf layers and place specific collections such as oversized books on them. For example, the Mars Hill College Library in North Carolina has purposely arranged little-used items on top layers.¹⁵ Nonetheless, such a structure is merely appropriate for certain types of library collections. To adopt a general rule for designing bookshelves for all collections in a library, one possibility is to take the entire library space into consideration

at the planning stage of library architecture and lower the heights of all bookshelves wherever applicable.

No matter what strategies a library takes to improve the usability of its books, the findings of this study make it obvious that librarians have the potential of guiding or directing the choices library users make from library collections by purposely positioning selected books. The strategy is similar to what grocery stores have successfully managed as the aisle display for business promotions. Although such a conclusion could bring controversy to library management, the research has at least introduced an issue for librarians to take into account when they make decisions on the management of library collections.

This study is an experiment in data manipulation and visual demonstration. Its results are only suggestive, due to the sample size and the lack of distinction between random extraction and deliberate selection of books for use within a library. Its value can be accentuated as soon as the analytical system gets expanded into the entire collection of a library and data accumulate over a period of time. Supplementary research on this topic could also embrace ethnographic investigations among library users to increase the library profession's understanding of usage patterns of in-library books.

This study was specifically for the purpose of measuring the behavior of library readers using in-library books with regard to bookshelf heights and spatial distributions of books. However, any library that is interested in investing in an analytical tool for its daily operations can make proper, yet simple, modifications on the tool without going to a great deal of expense. The ideas are attractive and practical. Future work could concentrate on integrating RFID's power of collecting and communicating data on the use of in-library books with GIS's strength of

analyzing and exhibiting spatial information into one big system.

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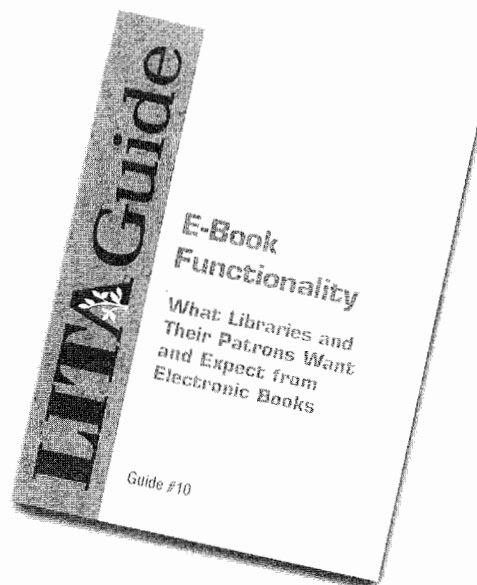
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Susan Gibbons, University of Rochester, Thomas A. Peters, University of Illinois, and Robin Bryan, Public Library of Charlotte and Mecklenburg County in North Carolina, have pulled together this E-Book Guide based upon the ongoing work of the E-Book Functionality Working Group of the E-Book Task Force of the American Library Association.



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