Heat Map Visualizations of Seating Patterns in an Academic Library

Michael Khoo[1], Lily Rozaklis[2], Catherine Hall[1], Diana Kusunoki[1] and Michael Rehrig[1]
[1] Drexel University
[2] The City University of New York

Abstract
Library seating surveys record the use of seats in a library. They estimate library usage and are used to plan library spaces for future use. This paper describes a seating survey in an academic library, which aggregated data from 112 seat counts to generate heat maps to visualize occupancy. Triangulation of the seating survey data with another survey on users' perceptions of space in the library, revealed an interesting contrast between highly-occupied areas that were perceived as quiet, and less occupied areas perceived as crowded and noisy. Discussion of this finding is framed in terms of Bennett's (2009) model of a technology-driven paradigm shift in academic libraries from places for solo work to places for group learning.
Keywords: evaluation, heat map, libraries, seating, survey
Citation: Khoo, M., Rozaklis, L., Hall, C., Kusunoki, D., & Rehrig, M. (2014). Heat Map Visualizations of Seating Patterns in an Academic Library. In *iConference 2014 Proceedings* (p. 612–620). doi:10.9776/14274

Acknowledgements: The authors thank the Dean and staff of the Library for their encouragement and cooperation with the survey team.
Contact: mjkhoo@gmail.com, lrozakli@gmail.com, ceh48@drexel.edu, diana.kusunoki@gmail.com, mjrehrig@gmail.com

1 Introduction

Evaluating users' behavior is an important part of library management. One useful evaluation method is the seating survey, which records the number and position of occupied seats in a library. Seating surveys provide insight into patron needs, library usage, and under-used and over-crowded areas (Loder, 2000). They can also provide insight into specific behaviors. For example, students entering a library room will seat themselves away from other students (Fishman & Walitt, 1972); students require a spaces ranging from carrels for quiet study to tables and collaborative spaces to study with other students (Loder, 2008, 2010); and seating preference is shaped by users' mental models of a library and their knowledge of how to move within a library in order to find preferred environments (c.f. Mandel, 2010; Van Beynen, 2010).

The research described in this paper is informed by Bennett's (2009) model of three library architecture paradigms, which describes the relationships between information technologies, user practices, and library space. An historical user-centered paradigm is associated with early printing and movable type, in which libraries supported users to use a small number of scarce and expensive books. A later book-centered paradigm, originating in nineteenth century industrialized paper production and printing, led to expansive stacks of physical volumes in academic libraries, about which study areas are arranged. Computer technologies are now supporting an emerging learning-centered paradigm, in which users engage in solo and group learning with electronic resources. In this third paradigm, book stacks are less visible, and spaces for learning and collaboration are moving to the center of library space, for instance in the form of the information commons (Beagle, 2000). While a learning-centered paradigm is emerging in academic libraries, the physical fabric of many libraries dates from the twentieth century and supports the book-centered paradigm. Understanding how to identify and support a new paradigm of academic library use within existing building spaces is not a straightforward exercise (Nitecki, 2010).

To address this issue, the seating survey described in this paper presents initial results from a heat map visualization of seating patterns in an academic library. Heat maps are data visualizations that can

display the relationships between two sets of data in terms of color, often a spectrum, with lower values represented by blue and higher values by red. Heat maps are used to visualize matrix information in the biological sciences (Wilkinson & Friendly, 2009). They can also be used to map data values onto spatial values, such as road traffic injuries (Hilton et al., 2011), or the gaze of Web site users (Spakov & Miniotas, 2007; Tullis, 2007). In this study, data from 112 seating surveys were used to generate heat maps of occupancy in an academic library ('the Library'). The survey took place in the context of ongoing work aimed at understanding whether the Library supports patrons to accomplish their goals, and what innovations patrons would like to see. A team of faculty, Ph.D. students, and a Library employee developed this survey. The instruments were refined over a number of iterations. The survey administrators were provided with IRB training.

2 Methods

The Library was constructed in the 1980s to serve a mid-sized university ('the University') in the United States. The basement includes several large open plan study areas with movable tables, desks and chairs, journals housed in compact storage, classrooms, computer labs, and some small study rooms. The entrance level has turnstiles, circulation and reference desks, public computers, DVDs, access to an adjacent fast food café, and various tables and chairs. The second floor houses the main stacks, study rooms, different forms of seating and tables, and rows of carrels. (A third floor houses a law school library but this is not generally accessible to Library patrons). The entrance, second, and third floors are arranged around and connected spatially through a large asymmetrical atrium that lets in light through a glass roof. Overall, the Library provides for both individual and group study with chairs, tables, carrels, and study rooms. Computer terminals and wireless networks provide Internet access, and students can also loan laptops.

The survey divided each floor of the Library into a series of zones, defined as spaces that felt coherent in terms of furniture, activity, etc. (Figure 1). Overall, seventy-six zones were identified. Zones ranged in size from two small tables and four chairs, to an open area inside the library entrance, with seven tables, thirty-five assorted chairs, and other furniture. A symbol key was developed to describe the furniture within a zone (Figure 2). The zones on each floor were given numerical identifiers that supported a sequential 'sweep' of the Library (Figure 3) (c.f. Given and Leckie, 2003). A number of pilot surveys were carried out, before the survey instrument was administered by a Library staff member, who walked the Library and recorded all seated users. A walk-through typically took about 45 minutes. A total of 112 surveys were carried out. The resulting seat counts were entered into a spreadsheet.

The average occupancy of each of zone was calculated as a percentage as follows:

$$\frac{\text{average recorded occupancy}}{\text{maximum potential occupancy}} \text{ x } 100 = \text{average occupancy rate}$$

Thus, a zone with five seats and an average occupancy of 1.5 users, was recorded as having an average occupancy rate of 30%. The percentage values were then converted to an RGB color value, ranging from red (255, 0, 0), representing 100% occupancy, to blue (0, 0, 255), representing 0% occupancy. For instance, an occupancy rate of 30% generates a rounded RGB value of (77, 0, 179). RGB values were calculated for each of the seventy-six zones in the Libary, and a plan of each floor was overlaid with colored shapes for each zone based on the RGB values. The result was a series of heat maps of Library occupancy (see Figures 4, 5, and 6).

3 Results

The heat maps provided a visual synopsis of overall occupancy patterns in the Library. Frequently occupied zones appeared as islands of orange or red in otherwise blue and green settings. The initial visualization made it easy to identify areas in the Library that were more or less crowded than others. For instance, the

hexagonal workstations on the entrance level appeared as highly occupied (Figure 5), as did the carrels on the second floor (Figure 6), while the basement appeared to have a relatively low occupancy (Figure 4). These findings correlated with other occupancy studies carried out in the Library.

These results were generally expected. When the heat maps were correlated with a face-to-face survey, which had interviewed ninety-eight users about their perceptions of the Library as a place to study (Khoo et al., 2013), some of the findings were confirmed. In one example, a zone with high occupancy in Figure 4 is that of the Reference Hub on the entrance level, which has six hexagonal workstations, each with six computer carrels. The Hub is used for quick work, checking email, accessing the Web, etc., and the space survey often recorded users standing around seated users of the workstations. Face-to-face survey responses understandably described this area as "*Normally filled with students*," and "*Convenient to access, but often loud and crowded. Hard to find a computer.*" Contrary to initial expectations, however, there was sometimes no direct correlation between occupancy and perceptions of noise. One area with high occupancy was the second floor carrels, along the walls of the library between the stacks and the windows, with power outlets built into their frames (Figure 3). These were also perceived as frequently occupied, but quiet; comments included "*Some of the quietest and most relaxing spots*," "*Nice place for quiet study and get books to read*," and "*Use when CANNOT be distracted. This is my hiding area.*" Conversely, there were areas in the Library which were less occupied, but which were also perceived to be noisy and crowded. One example here is that of the basement, an area that includes several open areas with multiple tables and chairs (Figure 4). According to the heat map, many parts of the basement had average occupancy rates of 20-40%. However, when triangulated with the face-to-face survey data, a different picture emerges, that of a more crowded area. The group study areas in particular, while popular with some students, also drew negative comments from others: "*Too many people*", "Don't use because of congestion", and "*Avoid. Noisy. Kids playing around*" were typical comments about this space. These later findings suggest the need for further research.

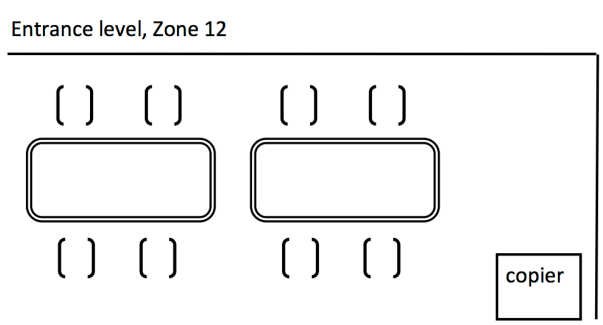

Figure 1: An example of a zone plan, showing a two tables with chairs, and a photocopier.

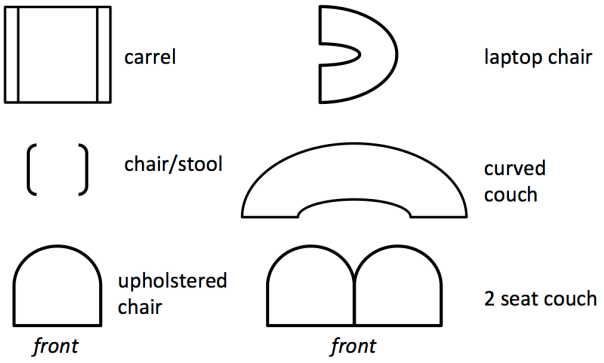

Figure 2: Coding key with different seating types.

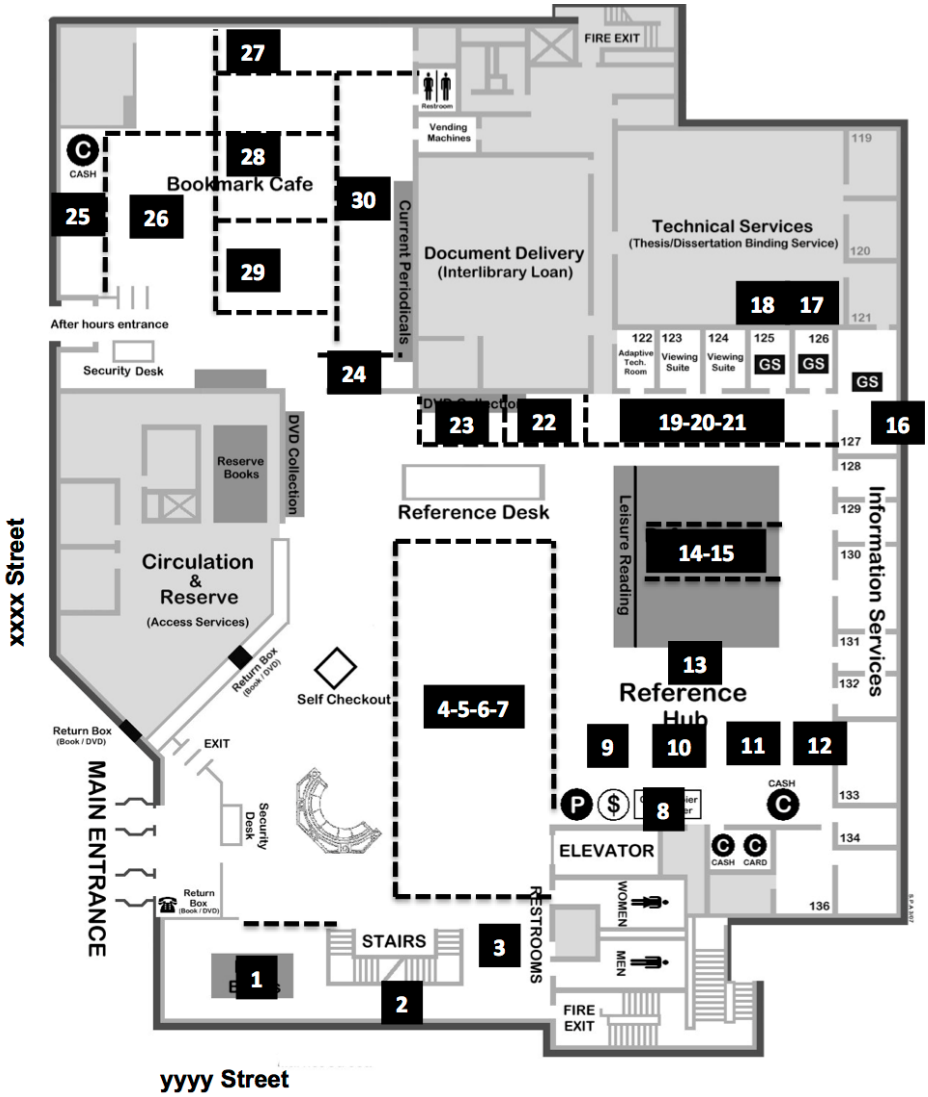

Figure 3: Example floor plan, with zones arranged in order. In this case, the 'sweep' would follow a roughly anti-clockwise direction from the front entrance.

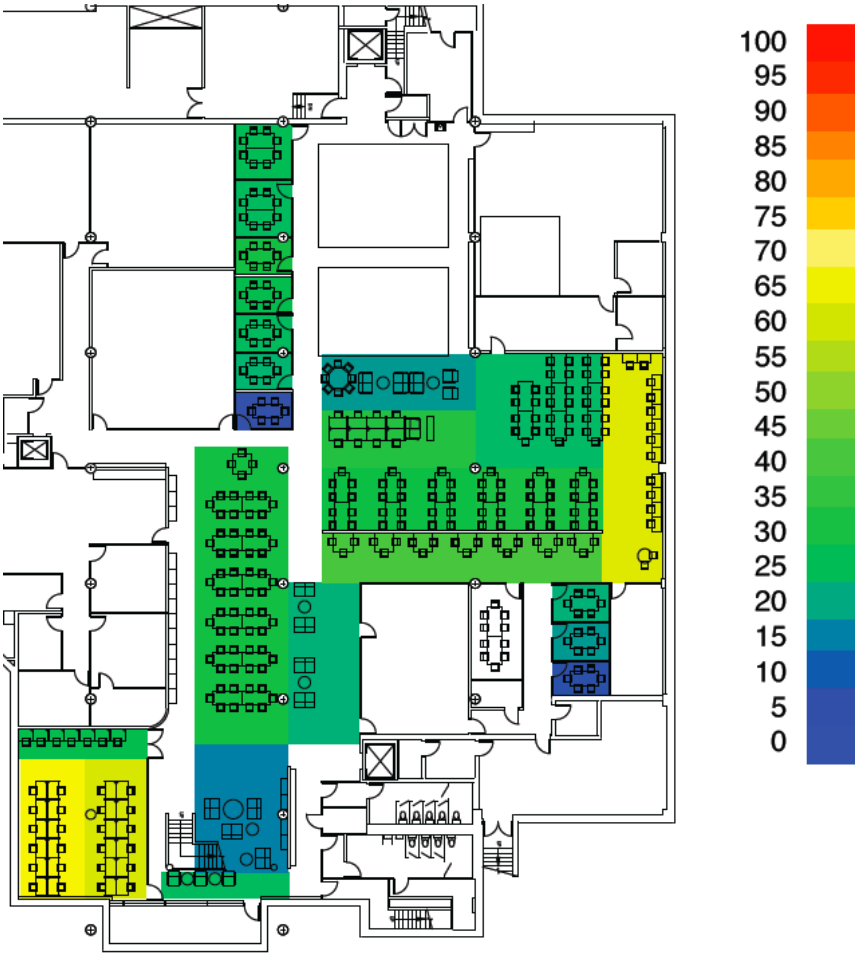

Figure 4: Prototype heat map for the basement level. Relatively high occupancy areas are in red, relatively low occupancy areas in green/blue.

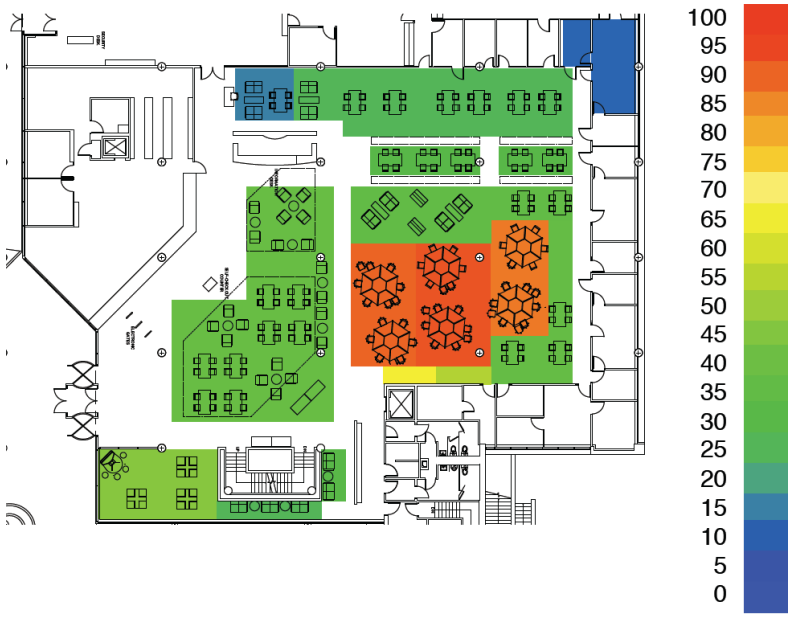

Figure 5: Prototype heat map for the entrance level of the Library. Relatively high occupancy areas are in red, relatively low occupancy areas in green/blue.

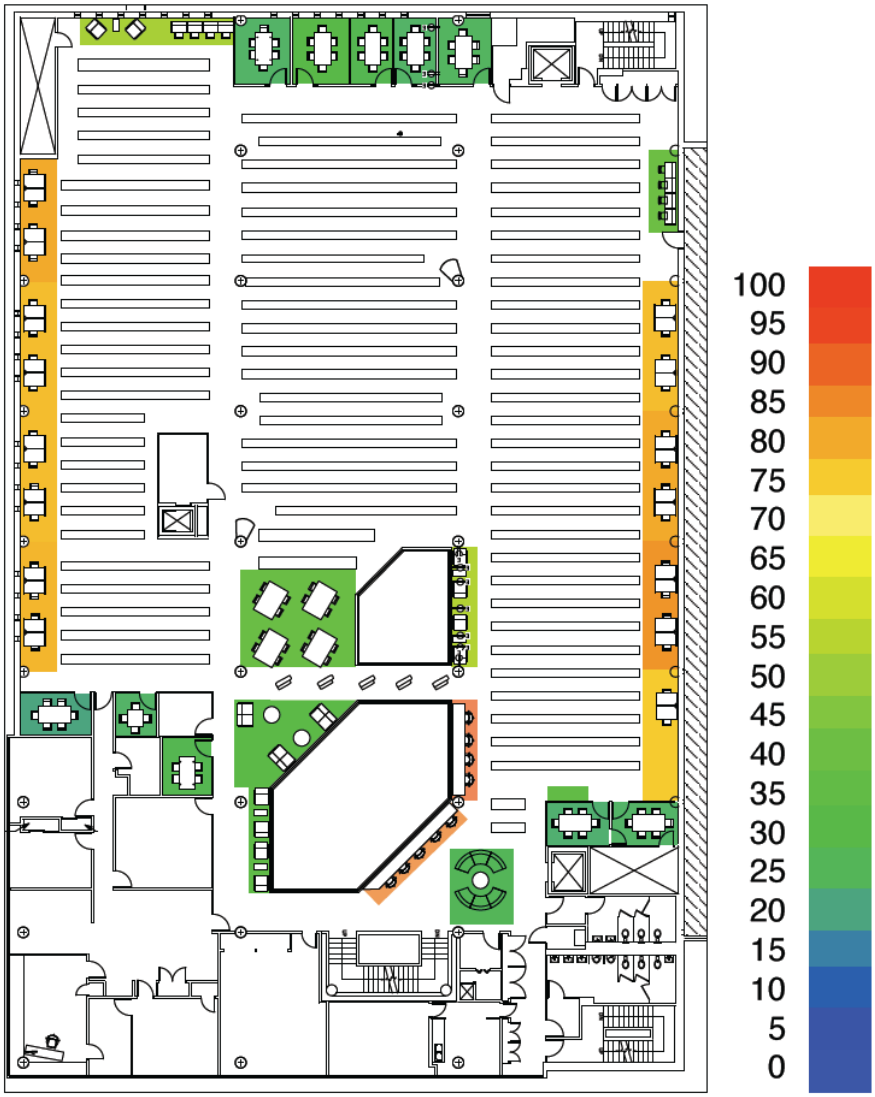

Figure 6: Prototype heat map for the second level of the Library. Relatively high occupancy areas are in red, relatively low occupancy areas in green/blue.

4 Discussion

At the start of the surveys, it was expected that the more occupied spaces from the seating survey would be described as busy in the face-to-face survey, and less occupied spaces would be described as quiet. However, the data sometimes showed the reverse, with some highly occupied areas perceived as quiet, and other less occupied areas perceived as crowded and noisy.

This finding prompted reflection on how users perceive occupancy in different seating contexts. For instance, the second floor carrels were often fully occupied, but perceived to be quiet. A carrel has clear boundaries, and it is easy to see (and to record) whether it is fully occupied or not. In Bennett's terms, carrels are a 'second paradigm' form of library space, dedicated to quiet solo work, and arranged around physical books. Conversely, in the basement, while the occupancy of the seats and tables used for group work was recorded at approximately 25%-40% – which is about half the occupancy rate of the second floor carrels – Library users also regarded this area as much more crowded, noisy, and busy. How can an area with a 25%-40% occupancy rate be perceived as busy? Gibbons and Foster (2007) note that in the case of table space for group work, an eight-seat table is considered full by students if there are four or five students

sitting there, with laptops, notebooks, textbooks, cell phones, beverages, and other paraphernalia. A group study area containing large tables and one hundred chairs might therefore be perceived by users to be 'full' when only approximately 50% of the seats at each table (and 50 seats overall) are occupied. This suggests that practical occupancy limits for open plan group study spaces could be significantly lower than the theoretical maximum seating. As a thought experiment, if the group work areas in the basement are perceived by users to be fully occupied when only 50% of seats are actually taken, then the perceived average occupancy rate would doubled from 25-40% to 50-80%, and would be colored green/yellow/orange rather than blue/green in Figure 4).

It could be argued that these results are peculiar to the library that was studied. To begin thinking about how the results might be generalizable, it is useful to return Bennett's (2009) model of three library space paradigms. In the survey data, and particularly the triangulated data, there is evidence of both second and third paradigm spaces in the Library. In second paradigm terms, there are (quiet) solo carrels placed around the stacks on the second floor; and in third paradigm terms, there are (noisy) group study spaces in the open plan basement. In each space, the dynamics between the occupancy levels and users' sense of place varied in complex ways.

What is generalizable from this research so far is not so much the claims regarding specific dimensions of users' interactions with carrels, group spaces, and so on – although from anecdotal feedback to an earlier version of this paper, it might be assumed that similar phenomena would be observed in other library settings – but (a) that a general historical model of library architectonics is a useful one to approach library planning, and (b) that there is therefore a need for more fine-grained and distinct occupancy models that can probe the interactions between technology, pedagogy, and solo and group student work. This suggests in turn the need for a rethinking of some models and methods for assessing and managing library buildings. The relationship between what appears to have been a relatively straightforward positive correlation between density of occupation, and affective dimensions of place such as noise and crowdedness, are challenged by the research findings, and suggest the need for libraries to think about these phenomena and the relationships between them in new ways. Particularly, the results suggest that a number of library metrics models might be specific to second paradigm buildings and spaces, and therefore that new third paradigm models need to be developed. While there is plenty of anecdotal evidence for many dimensions of such change, gaining a systematic understanding the sociotechnical nuances involved – for instance understanding how students use reconfigurable group spaces to support technology use in groups, and judge whether a space is 'full' or not – remains a an ongoing task.

5 Conclusion

This paper has introduced a heat map method for visualizing library seating occupancy. The method proved useful in visualizing the busy and quiet areas of the library. When combined with other face-to-face survey data gathered by the Library, a complex dynamic was identified between occupancy levels, and perceptions of noise, quiet, and occupancy. There is a need to assess in more detail how changes in technology use by students are impacting library space planning and management. These questions will be explored in future work.

6 References

Applegate, R. (2009). The library is for studying: Student preferences for study space. *The Journal of Academic Librarianship*, 35, 341–346.

Beagle, D. (1999). Conceptualising an Information Commons. *The Journal of Academic Librarianship, 25*(2), 82–89.

Bennett, S. (2009). Libraries and Learning: A History of Paradigm Change. *portal: Libraries and the Academy 9*(2), 181–97.

Briden, J., & Marshall, A. (2010). Snapshots of laptop use in an academic library. *Library Hi Tech, 28*(3), 447–453.

Fishman, D., & Walitt, R. (1972). Seating and Area Preferences in a College Reserve Room. *College and Research Libraries, 33*, 284-297.

Gibbons, S., and Foster, N. F. (2007). Library Design and Ethnography. In: Foster, N. F., & Gibbons, S. (Eds.), *Studying students: The undergraduate research project at the University of Rochester.* Chicago: ALA.

Given, L. M., & Leckie, G. J. (2003). "Sweeping" the library: Mapping the social activity space of the public library. L*ibrary & Information Science Research, 25*, 365–385.

Hilton, B. N., Horan, T. A., Burkhard, R., & Schooley, B. (2011). SafeRoadMaps: Communication of location and density of traffic fatalities through spatial visualization and heat map analysis. *Information Visualization 10*(1), 82–96.

Hobbs, K., & Klare, D. (2010). User driven design: Using ethnographic techniques to plan student study space. *Technical Services Quarterly, 27*, 347–363.

Khoo, M., Rozaklis, R., Hall, C., & Kusunoki, D. (2013). Identifying the 'Go-To Spots': Using Map Surveys to Elicit Perceptions of Space and Place in an Academic Library. 2013 ASIST Annual Meeting, Montreal, QC, November 1-5, 2013.

Loder, M. W. (2008). Seating Patterns and Improvements in a Small College Library. *College and Undergraduate Libraries, 7*(2), 83-94.

Loder, M. W. (2010). Libraries with a Future: How Are Academic Library Usage and Green Demands Changing Building Designs? *College and Research Libraries 71*(4), 348-360.

Mandel, L. H. (2010). Toward an understanding of library patron wayfinding: Observing patrons' entry routes in a public library. *Library & Information Science Research, 32*, 116–130.

Nitecki, D. A. (2011). Space Assessment as a Venue for Defining the Academic Library. *The Library Quarterly, 81*(1), 27-59.

Organ, M., & Jantti, M. (1997). Academic Library Seating: A Survey of Usage, with Implications for Space Utilisation. *Australian Academic and Research Libraries, 28*, 205-216.

Spakov, O., & Miniotas D. (2007).Visualization of Eye Gaze Data using Heat Maps. *Electronics and Electrical Engineering, 2*(74).

Tullis, T. S. (2007). Older Adults and the Web: Lessons Learned from Eye-Tracking. In: C. Stephanidis (Ed.): *Universal Access in HCI, Part I*, HCII 2007, Springer Lecture Notes in Computer Science, 4554, 1030–1039.

Van Beynen, K., Pettijohn, P., & Carrel, M. (2010). Using pedestrian choice research to facilitate resource engagement in a midsized academic library. *The Journal of Academic Librarianship, 36*, 412–419.

Wilkinson, L., & Friendly, M. (2009). The History of the Cluster Heat Map. *The American Statistician, 63*(2), 179-184.

7 Table of Figures