Evidence Based Library and Information Practice

Research Article

Library Usage Study, the How and What: A Survey of Space Usage at a Mid-Sized Research Library

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Received: 9 Feb. 2022 **Accepted**: 10 Oct. 2022

DOI: 10.18438/eblip30103

Abstract

Objective – The research was conducted to understand better how and what spaces are used in a mid-size academic library. Also, the authors were interested in their users' spatial likes and dislikes and why they gravitated to or avoided specific spaces or floors. The authors also found an opportunity to examine recent renovations that added a connector bridge to a first-year student dorm and the subsequent increase in foot traffic to evaluate its success in meeting users' needs for varied and productive study spaces across the building.

Methods – The study used a survey to gauge user satisfaction with the library's space and environment for research, study, and collaborative work. The authors hand-distributed a survey with five multiple-choice and three open-response questions to users over three days (Monday-Wednesday) between 10 am - 4 pm, the busiest days and times in a typical week. The collected surveys were sorted and coded in an Excel spreadsheet and uploaded and analyzed in JMP Pro.

Results – The 298 completed responses came from undergraduate students (n=281) who visited the first floor, identified as a collaborative study space (n=144). Respondents showed that they visit the library daily (58%, n=173) and weekly (34%, n=104). Most of the survey participants (98%, n=293) indicated that they pursued academic work in quiet spaces they occupied (75%, n=224). Interestingly enough, the noisiest and quietest floors are the areas most avoided, the first floor-collaborative, noisiest space (54%, n=161) and the third floor-designated as quiet space (18%, n=55). The final survey question invited the respondents to "sound off," with 135 responding; 107 (79%) of them opined on improvements to existing study spaces within the library.

Conclusion – This research demonstrated that students value the library as a place to study but are critical of excessive noise and overcrowding in the designated collaborative study areas. Academic libraries should consider balance when designing library study spaces. Librarians and space designers should strive to strike an appropriate balance between seating quality and quantity, acceptable noise levels in designated collaborative and quiet study spaces, and the impacts of environmental factors such as printers, food services, exhibits, art displays, restrooms, and walkways through library study spaces within the library.

Introduction

The University Library provides information, services, and support to the university's 12,327 students, with about half living on campus. Undergraduates make up 10,700 of the student body, and graduate programs bring in 1,627 graduate students. The Medical Library, which is not a part of this research study, serves a small and robust medical school and research centre. The university is a public land grant university located in the Northeastern United States. The vast majority of the students attend full-time and are under 25 years old. The library building also houses non-library entities such as the instructional support services, a writing centre, classroom technology services, student accessibility services, and a coffee and snack bar with seating.

The four-floor building is used heavily throughout the academic year, with peak daily gate counts exceeding 9,000 during the 2018 and 2019 academic years. The library uses the Traf-Sys People Counting Systems to count entries and exits. When the pandemic reduced building capacity, we upgraded to their SafeCount system to monitor live occupancy.

Problem Statement

Since 2016, circulation staff conducts an annual density count during the first or second week in November to determine where library users congregate. Six years' worth of data leads us to this study to determine who, what, and why individuals use library spaces. In the interim, the university built a new residence hall for first-year students adjacent to the library with a connecting bridge and renovated space

in the library. The addition and renovation created a second entrance and exit to the library and relocated a service point from the lower level. The renovations included a more spacious Center for Multimedia Development and a reconfigured gallery for multi-cultural art. The reconfigured spaces altered traffic flow and increased seating capacity on the first floor.

Like many multi-level academic libraries, the first floor of the library hosts a collaborative social learning environment including a blend of group seating and soft chairs, printers, computing stations, three public service points, one group study room, and a coffee and snack bar. When the study was conducted, the library was open seven days each week during the academic year with the library opening at 8 am and closing at 12 am on most weekdays. Total seating on the first floor was 325 and head-count data revealed that seating was often full or overflowing during peak day-time hours, with 352 counted. The second floor is a designated quiet study floor with 358 total seats including large multiple seat desks, soft seating, and individual study carrels. Also included on the second floor are six sound-proof group study rooms, a large silent study room, book and journal stacks, current periodicals, and computer workstations. Head-count data reveal that peak usage occurs during day-time hours, with 258 filled seats for a peak count. The third floor is designated for quiet study and is nearly silent with little foot traffic. The third floor contains 403 total seats, book stacks throughout the centre of the floor, one group study room, and a suite of administrative offices. Seating consists of a few large multi-seat tables, individual study carrels, and is heavily dominated by simple single-seat desks, which are placed side-by-side along the perimeter of the floor. Head-count data reveal more seating than demand, with a peak head-count of 124 seats filled during peak operating hours. Wi-Fi is excellent throughout the building.

Since the construction of the connector bridge and the subsequent increase in foot traffic, no formal evaluation of the library space has been conducted. While we have population density studies that tell us the number of users distributed throughout the various areas in the building, we had no qualitative data from our users. Previous LibQual studies provide excellent general information about the library. Still, they do not give enough detail to pinpoint the aspects our users like and dislike about the spaces in the building. Anecdotes from librarians and staff painted a dismal picture of the first floor's overcrowded, chaotic, and boisterous environment. Opinions from librarians and staff were firmly in favour of creating a strict noise policy to facilitate a quieter and less crowded first floor, but we needed to hear directly from the students who use the spaces throughout the building to determine if they share the same assessment of the library spaces as our librarians and staff.

To determine new space configurations and policies that work for our users, we needed to hear what they see as good and bad aspects of the library's study environment. We decided to conduct a qualitative study with several guiding research questions:

1) Which spaces do users avoid? Why?
2) Which spaces are users drawn to? Why?
3) What activities do users engage in their chosen space?
4) Do these spaces work well for library users? What can be improved?

Literature Review

Over the past three decades, the academic library has evolved from the traditional library, a mausoleum of knowledge and tranquil study, to the technology-enhanced and highly collaborative learning commons model. Many academic libraries have provided library space to non-library entities (Lux et al., 2016). They have emphasized the creation of a technology-rich environment and social learning spaces

(Bostick & Irwin, 2014). Throughout the early 2000's, academic libraries redesigned their spaces to incorporate technology, group study spaces, areas for socializing and informal study, and eating (Freeman, 2005; Jamieson, 2006).

These trends in social study spaces and non-library services relocating to the library are not universally accepted. For example, James (2013) documented a conflict that emerged when faculty who were displeased with the learning commons established at East Carolina University voiced their concerns about the future of the library. Gayton (2008) argued that library users value the traditional communal academic library model and that the developing social library model threatens the communal spirit and harms the experience. With these significant changes in academic libraries, we have seen many opportunities for research and debate.

Research and user feedback studies demonstrated that library redesign efforts were viewed positively by library users (Jamieson, 2006) and that libraries have experienced increased use of physical spaces following a redesign (Shill & Tonner, 2004). Spatial preferences and the attributes that determine users' spatial choices are important factors in determining the overall quality of library study spaces. Cha and Kim (2015) discovered that attributes such as abundance of space, noise level, crowding, comfortable furnishing, and cleanliness were primary factors in users' spatial choices. Lux et al. (2016) found that library users overwhelmingly use library spaces for study and that individual study spaces are very much in demand. Similarly, Applegate (2009) found that the library is primarily used as a study space and suggested a blend of study environments to accommodate a wide range of student needs. Noise levels play a factor in the quality of library spaces. Pierard and Baca (2019) found that a moderate noise level is ideal for collaborative study areas and Stemmer and Strawser (2019) observed that students highly value quiet study spaces. Research regarding user preferences and their views on the quality of library spaces provides valuable insights for successful remodeling and spatial design efforts. This study adds to the current body of research by examining user activities, preferences, and dislikes for spatial choice and study environment.

The groundbreaking ethnographic study by Foster and Gibbons (2007) at the University of Rochester Library inspired many ethnographic studies in academic and public libraries across the United States. The Ethnographic Research in Illinois Academic Libraries project involved five Illinois academic libraries. It used interviews, photo journals, and mapping diaries to better understand students' work behaviours in the libraries and applied those findings to library design initiatives (Asher et al., 2010). Pierard and Lee (2011) used ethnographic methods such as photographic observation, photo diaries, and flipcharts in conjunction with a traditional user survey to learn how library spaces were being used and what users considered to be an ideal library space. The researchers used their findings to change public spaces while staying within a modest budget. Bedwell and Banks (2013) made important discoveries in how the library environment impacted student behaviour and study patterns when they employed students from a Sociology and Social Anthropology class to observe how students use space in the Dalhousie University Library. These studies have all been instrumental in understanding what users are doing in library spaces and how they use them.

Long-range multiyear studies such as those conducted by Gerke and Teeter (2017) and Harrop and Turpin (2013) effectively employed mixed methods to measure user interactions in their physical library spaces. Lux et al. (2016) combined an exit survey with observation and noted that focus groups might have added more depth to their study. Hillman et al. (2017) conducted a comprehensive mixed methods study involving librarians, students, and sociology faculty to conduct seating sweeps to map patron activity, conduct student-led focus groups, and implement a survey based on the findings of the seating

sweeps and focus groups. At the University of Iowa, Thomas et al. (2015) paired an online survey with observational headcounts to assess the purpose and demographics of their learning commons use. At Penn State, Lynn (2011) conducted a needs assessment in advance of a building renovation using an online survey tool and student and faculty focus groups.

Not all studies need to be labour intensive or complex to give quality data. Short and simple studies have yielded excellent data for many academic libraries. Bailin (2011) conducted short interviews with students to better understand their space needs, how the library was meeting those needs, and to evaluate the success of the library remodel. Stemmer and Strawser (2019) implemented a survey to gauge the needs and desires of students in advance of a library renovation project and used the data to inform the remodeling process. Cha and Kim (2015) and Gardner and Eng (2005) also had success collecting useful qualitative and quantitative data on library space attributes users value and need with paper-based surveys. Hedge et al. (2018) collected insightful data on patron activities, elements of an ideal study space, and preferences for environmental factors such as noise and lighting in the library, using an online survey instrument. The effectiveness of these simple study methodologies coupled with a lack of time and resources to plan and execute a more exhaustive study led us to employ a simple survey to harvest user feedback.

Methods

During three consecutive days for the week of October 7, 2019, a survey was conducted to gather information about the current space usage of the library. The authors designed an eight-item survey instrument based on the study's goals. It consists of five multiple-choice questions and three open response questions. The complete survey is found in the appendix. Institutional Review Board exemption for the study was received in August 2019. Survey collection began on Monday, October 7, 2019. It ended Wednesday, October 9, 2019. From 10 am to 4 pm during those days, the authors hand distributed the surveys, attempting to distribute at least 50 surveys per pre-identified zone. We selected dates in early October because it was roughly five weeks into the sixteen-week semester. This is a period of time when library business is steadily busy but not a period, like final exam or mid-term periods, in which library use is unusually high. Time and resources did not allow for survey distribution during evening and weekend hours, and we therefore selected the 10 am – 4 pm time period to distribute surveys because it was the busiest time of day and would yield the most survey results.

On Monday, October 7, 2019, the authors distributed at least 350 surveys to library users on the first floor in seven identified zones. On Tuesday, October 8, 2019, 300 surveys were handed out on the second floor, covering six zones. Finally, on Wednesday, October 9, 2019, 150 surveys were distributed on the third floor in three zones. Some spaces were so quiet that the authors left surveys on tables with printed instructions. Survey participants were instructed to deposit completed surveys in locked ballot boxes placed strategically throughout the library. Each survey was identified with a floor and zone designation in the footer of the survey document. The completed surveys were sorted and coded in an Excel spreadsheet. The spreadsheet data were uploaded to JMP Pro for analysis.

Results

Demographic of Participants

Responses came primarily from undergraduate students (n=281). Graduate students (n=12), community users (n=3), faculty (n=1), and staff (n=1) were all underrepresented in relation to their numbers across

campus. However, data from past LibQual studies as well as anecdotal evidence suggest that undergraduates are indeed the dominant user group of the library.

Responses were spread across all areas of the library. Library users from all three main floors participated in the survey. Table 1 shows the floors with the most respondents. Overall, we were pleased to see participants from a wide range of floors and seating areas.

Table 1
Number of Participants

Floor Surveyed	Participants
1 (collaborative)	144
2 (quiet)	74
3 (quiet)	80
Total	298

Visit Frequency

After demographic data questions, the survey asked participants how frequently they use the library area/space they are in. Participants tended to use the area/space they occupied with regular frequency, with 58% (n=173) responding that they visit the library area/space daily and 34% (n=104) responding that they use the library area/space on a weekly basis. A small minority of participants responded that they use the library area/space infrequently, with only 15 participants responding that they visit the area/space monthly or less than monthly, and six responded with "other."

Visit frequency was similar for participants across all three floors. Participants who responded that they visit the area/space daily were proportionately represented across the collaborative study first floor (58%), quiet study second floor (55%), and quiet study third floor (60%). Weekly users saw a similar, equal distribution across the first (34%), second (38%), and third (34%) floors. Table 2 shows participant visit frequency broken down by the floor they were surveyed on.

Table 2
Visit Frequency

Floor Surveyed	Daily	Weekly	Monthly	Less than Monthly	Other	Questionnaire Responses
1 (collaborative)	84	49	4	4	3	144
2 (quiet)	41	28	2	1	2	74
3 (quiet)	48	27	3	1	1	80
Total	173 (58%)	104 (34%)	9 (3%)	6 (2%)	6 (2%)	298

The high rate of visit frequency demonstrates that the library attracts and retains a loyal following and that participants tend to return to the spaces they use. While these data alone do not point directly to a satisfied user base, they do demonstrate that the library offers resources and/or services sought by undergraduate students.

What Users Are Doing in the Library

One of the driving research goals of this study is determining what library users are doing while they spend time in the library. The survey presented a simple multiple response questions "What are you doing in this space?" Participants were given several response options, including an open response, from which they were invited to select all responses that apply.

Most of the participants (98%, n=293) responded that they were pursuing academic work while in the library. Personal work is the next most popular activity with 37% (n=109) of participants selecting this option. Surprisingly, almost a quarter of all participants (23%, n=69) responded that they were socializing while in the library. Leisure reading (7%, n=22) and the open response option (5%, n=16) were the least frequently selected options.

The high number of participants engaging in social activities makes more sense when looking at the data broken down by floor. Participants surveyed on the first floor, which encourages collaborative study and sees significant foot traffic, all but owned the social activities with 34% (n=49) of first-floor participants responding that they engage in social activities while in the library. Participants on the second floor, which is a designated quiet floor, responded with a surprising 19% (n=14) indicating they indulged in social engagement. Only 7.5% (n=6) of participants surveyed from the third floor claimed they engaged in social activities while in the library.

Table 3
Participant Activity

Floor Surveyed	Academic Work	Personal Work	Social	Leisure Reading	Other	Questionnaire Responses
1 (collaborative)	142	50	49	10	10	144
2 (quiet)	71	29	14	3	2	74
3 (quiet)	80	30	6	9	4	80
Total	293 (98%)	109 (37%)	69 (23%)	22 (7%)	16 (5%)	298

Why Users Choose the Space They Occupy

Our next question asked participants why they chose to use the space they occupied. The survey asked participants "Why do you use this space/area?" and allowed participants to select multiple responses including an open-ended "other" option.

Many participants (75%, n=224) selected "quiet" as the reason for selecting the space they occupied. Other popular selections included "furniture" (49%, n=146) and "outlets" (42%, n=125), with "lighting" (27%,

n=81), "Fewer noise restrictions" (25%, n=76), "other" (21%, n=64), and "access to technology" (20%, n=61) as less popular yet compelling and statistically significant reasons.

Broken down by floor, the distribution of responses is somewhat different. Participants (n=144) on the collaborative and often noisy first floor selected "furniture" (56%, n=81) most frequently and, quite surprisingly, they chose "quiet" (55%, n=79) with almost the same frequency. All other reasons for using spaces on the first floor were selected at similar, statistically significant frequencies: "outlets" (35%, n=50), "fewer noise restrictions" (32%, n=46), "access to technology" (30%, n=43), and "other" (29%, n=42).

Table 4
Why Participants Choose the Space They Occupy

Floor Surveyed	Quiet	Furniture	Outlets	Lighting	Fewer Noise Restrictions	Other	Access to Technology	Questionnaire Responses
1 (collaborative)	79	81	50	39	46	42	43	144
2 (quiet)	69	37	44	24	14	9	11	74
3 (quiet)	76	28	31	18	16	13	7	80
Total	224 (75%)	146 (49%)	125 (42%)	81 (27%)	76 (25%)	64 (21%)	61 (20%)	298

Participants on the second floor (n=74), which is a designated quiet floor, selected "quiet" (93%, n=69) with overwhelming frequency. "Outlets" (59%, n=44), "furniture" (50%, n=37), and "lighting" (32%, n=24) were also strong attributes that attracted participants to second-floor spaces. Not surprisingly, with the second floor offering a small number of computer terminals without printers or specialized technology, responses such as "fewer noise restrictions" (19%, n=14), "access to technology" (15%, n=11), and "other" (12%, n=9) were not significant factors for most second-floor participants.

Third-floor participants (n=80) sought "quiet" (95%, n=76) above all else. "Outlets (39%, n=31) and "furniture" (35%, n=28) were also important reasons participants chose third-floor spaces. "Lighting" (n=18), "fewer noise restrictions" (n=16), and "access to technology" (n=7) were not factors for most participants.

User Needs

Our results showed that participants come to the library for a variety of needs. Quiet study (84%, n=250), printing (66%, n=197), and collaborative study (46%, n=136) were the needs most frequently selected by participants. Standard technologies such as computers (19%, n=58) and scanning (12%, n=35) were selected with modest frequency, while more specialized technologies such as the 3D printer (2%, n=5) and microform scanners (1%, n=3) were in exceptionally low demand. Participants cited other needs such as additional electrical/USB outlets (2%, n=7) and more comfortable seating (2%, n=5) in the open-ended comment section.

The first floor of the library is the central printing hub for all of campus and, as we expected, printing (72%, n=104) was the most frequently selected need by first-floor participants. However, we were surprised to see that participants surveyed on the collaborative and often noisy first floor selected quiet (70%, n=101) with remarkably high frequency, even more so than collaborative study (58%, n=83). One possible explanation is that the survey was taken at a time of year when collaborative projects are not frequently worked on. It is also possible that participants on the first floor think of quiet in relative terms, as one participant remarked "It [the library] is quieter than my dorm." It is also possible that the first floor is quiet enough for most students during certain times of the day and of the year. Other than printing, participants saw modest interest in technological offerings such as scanning (14%, n=20), computers (26%, n=37), 3D printing (2%, n=5), and microform scanners (1%, n=3).

Participants on the second floor overwhelmingly selected quiet (95%, n=70) as a need. Collaborative study was selected at a moderately high rate (38%, n=28). Printing (59%, n=44) dominated technological needs, while computers (21%, n=16) and scanning (12%, n=9) were modestly selected. All other options were selected infrequently.

All respondents on the third floor selected quiet (99%, n=79) as a need. Like the first and second floors, printing was selected with strong frequency (61%, n=49) by third-floor participants. Collaborative study (31%, n=25) was the next most frequently selected need. Scanning, computers, microform readers, and 3D printing were selected with little frequency.

Table 5
Participant Needs

Floor Surveyed	Quiet	Printing	Collaborative Study	Computers	Scanning	Other	Microform Scanner	3D Printing	Questionnaire Responses
1	101	104	83	37	20	17	2	4	144
2	70	44	28	16	9	7	1	1	74
3	79	49	25	5	6	5	0	0	80
Total	250 (84%)	197 (66%)	136 (46%)	58 (19%)	35 (12%)	29 (10%)	3 (1%)	5 (2%)	298

The next question, which was designed as a follow up to the multiple response Question 5, asked participants "Are we meeting those needs?" with an open-ended response option. There was also room for participants to add commentary to their response. Of the 298 total participants, 251 (84%) answered "yes," the library is meeting their needs. Only four (1.3%) participants responded with "no" and 43 (14%) neither responded yes nor no. Most of the comments centered around improved study space needs (n=74) such as more or larger tables, more collaborative study space, more seating, more outlets, comfortable seating, better lighting, and complaints about crowding and noise. We saw complaints (n=25) about printing, which is understandable given a rash of mechanical failures we dealt with due to worn out machinery during the survey.

Areas Avoided

The collaborative first floor is the most avoided floor with 54% (161 of 298) of all participants identifying the first floor, or specific areas within the first floor, as an area they avoid at some point. First-floor areas such as the coffee and snack bar (n=11), front lobby (n=7), and reference computer area (n=11) were pointed out as places avoided by participants. Surprisingly, 39.6% (57 of 144) of participants surveyed from the first floor avoid the first floor at some point. The most frequently cited reason participants avoid the first floor is that the space is too loud (66%) and crowded (28%).

The quiet third floor is the next most avoided space with 18% (n=55) of participants noting that they avoid that floor. Most of those who avoid the third floor do so because they find it is too quiet (78%, n=43) for their liking. Other reasons participants avoid the third floor do not show up with much frequency and are therefore statistically insignificant. All the participants who avoid the third floor were either surveyed from the first floor (n=43) or the second floor (n=12) and none of the participants who were surveyed on the third floor avoided the third floor.

The second floor is the least avoided area with only 9% (n=27) of participants claiming that they avoid the area. Most of the survey takers who avoid the second floor were surveyed from the first floor (n=19) and claimed that they avoid the floor (n=12) because it is too quiet. Only one participant surveyed on the second floor and seven surveyed from the third floor avoid the second floor.

Table 6
Areas Avoided

Floor Surveyed	Avoid Floor 1 (collaborative)	Avoid Floor 2 (quiet)	Avoid Floor 3 (quiet)	Avoid Ground Floor	Questionnaire Responses
1	57	19	43	5	144
2	42	1	12	1	74
3	62	7	0	4	80
Total	161 (54%)	27 (9%)	55 (18%)	10 (3%)	298

Sound Off

The final survey question invited participants to "sound off" in an open-ended response about anything they wish. Of the 135 responses, 107 (79%) opined on improvements that can be made to existing study spaces within the library. Demands for more spaces and furnishing types such as more tables (n=23), more soft seating (n=10), more seating in general (n=14), more collaborative study space (n=5), and more private study space (n=8) were made clear by participants. Participants also asked for improvements to the quality of study spaces such as better lighting and more natural light (n=12), more electrical outlets (n=16), a more updated look (n=7), and better temperature regulation (n=5). Participants did not mention many grievances about noise (n=6) or crowding (n=9), and complaints regarding printing (n=7) seem to have been exhausted in previous sections.

Discussion

The study sought to determine why and how users are using study spaces in the library and whether the spaces they are using are satisfying their needs.

Noise Level and Crowding on the Collaborative Study Floor

The first floor is the largest open space in the library and serves as the only open study space that encourages collaborative study without noise restrictions. Anecdotal observations from librarians and staff that first-floor users are using the first floor as a recreational area are largely untrue. Our study revealed that nearly all of the first-floor participants were engaged in academic work and that these users value both quiet and collaborative study. Indeed, some of the first-floor participants did reveal that they are there to socialize in addition to pursuing their studies, but very few indicated that they were there strictly for socializing. While the perception that first-floor users are primarily interested in socializing is patently wrong, complaints from librarians that noise is an issue on the first floor are strongly supported by the participants who were surveyed on the first floor. Participants surveyed from all floors, including the collaborative and noisy first floor, find the first floor too loud for their liking. Crowding was another problem that was widely identified by first-floor participants and indeed, many library staff from the first-floor service points have identified crowding as a consistent problem in the first-floor lobby, walkway, and study areas. Research by Stemmer and Strawser (2019) and Vondracek (2007) found similar patterns at their libraries, with significant numbers of respondents indicating that the learning commons were too loud, crowded, and distracting for productive work.

The first floor provides much-needed and wanted collaborative study space for students. To improve the user experience, crowding and excessive noise must be addressed. Research conducted by Pierard and Baca (2019) and Mehta et al. (2012) suggests that a moderate ambient noise level, about 70 dB, is ideal for collaborative learning spaces. With this in mind, we recommend studying the noise levels on the first floor with a decibel meter to gain an accurate assessment of when and where noise may be problematic.

We do not see a single approach as being effective in mitigating excessive noise on the first floor. Indeed, research has demonstrated that a multiple approach strategy is most effective in mitigating excessive noise levels. These approaches include expectation-setting, self-monitoring through noise monitoring displays such as NoiseSign, gentle and consistent staff intervention, the development of positive marketing campaigns to help users find appropriate study spaces in and outside of the library, and addressing building and seating design problems that enable excessive noise and crowding (Pierard & Baca, 2019).

Creating barriers or physical delineations between study areas and the hectic and highly social lobby and thruway areas would be a good first step. Many of the desks on the first floor are crammed together and the computer pods in the reference section frequently see groups of students on top of one another. Freeing up space on the first floor to create higher quality collaborative study areas with reasonable space between group tables might also be helpful in reducing overcrowding. Pierard and Baca (2019) noted that such rearrangement of furnishings and redesign can be successful in solving noise problems with design rather than policy.

Participants on the designated quiet study second and third floors were satisfied with the level of noise on their respective floors. There were only a few complaints about noise occasionally becoming an issue on these floors. While crowding was not frequently cited as a major issue for these floors, some users did

claim that the second floor is often too crowded. Observations from circulation staff and population density data bolster the crowding claim, especially in the middle and end of each semester. In related studies, Applegate (2009) found that students involved in quiet individual study prefer not to sit next to one another, that a seat or more apart is ideal for focused study. Stemmer and Strawser (2019) found that students desire more room and more quiet study space. The user experience might be enhanced by creating more space for users to spread out and have a bit more self-space. While adding more seats might be tempting, with the limited available seating on the quiet floors in the library, we should focus more on the quality of the individual study spaces by creating larger, more spacious work areas with more room between adjacent tables, desks, and carrels. And while users tend to self-enforce noise on these quiet floors, signage on the large multi-seat tables might be helpful to remind groups of students not to engage in conversation or intense whispering.

Technology

Printing is the technology most used by survey participants. This is certainly backed up by data from our Pharos print management system and local printer leasing vendor, which indicate that printers in the library are some of the most used in the entire state. While some academic libraries have made efforts to reduce printing and printing waste due to environmental and cost-recovery concerns (Ashmore & Morris, 2002; Calloway & Callahan, 2003), the university library has made strides to make printing more accessible to students by dropping printing fees from ten cents per page to five cents per page and offering free printing days at the end of each semester. Although students and faculty are actively engaged in environmental campaigns such as banning the sale of bottled water on campus and divestment from fossil fuel industries, the demand for paper printing has not attracted much attention. In fact, the student government has asked that printing become more accessible by reducing or eliminating printing fees. A campus study targeted at students and faculty's printing habits and needs could be useful in understanding the importance that this service plays for the campus community and whether financial and environmental waste are concerns.

Computers and scanning equipment saw modest rates of reported use. In fact, logins for library-provided computers have seen a significant decline over the past three years in the library. Yet the computer pod seating in the reference area is frequently overcrowded during peak library hours throughout the academic year. This is substantiated, albeit anecdotally, by reports from public services staff as well as commentary from this survey that computer seating is frequently occupied by patrons who are not making use of the library-provided computers.

The declining need for library-supplied computers coupled with a need for more seating should prompt a redesign of the collaborative first-floor computing area. Eliminating collaborative study floor computers and replacing the densely packed pod-type desks with large tables with generous egress between them will enhance the user experience by reducing overcrowding. It could reduce noise levels as groups will not feel compelled to talk over one another. The existing library-supplied computers on the first and second floors that are intended for printing and quick look-up access should remain as their need is still strong enough to justify their location in those spaces.

Using Data for Reopening During the COVID-19 Pandemic

Social distancing guidelines and a strict building capacity limit dictated by the State made reopening the library a challenge. In-person socializing and group study were not feasible under the social distancing guidelines in place between August 2020 and May 2021. A building capacity limit of 225, where we

regularly see over 800 at peak hours, required removing desks, chairs, and soft seating. Data collected and analyzed from this study were used to inform the functionality of the "new normal" library for reopening at the start of Fall 2020 and through Spring 2021 semesters.

Mask wearing and social distancing were mandated by the university and state officials. But it was up to us to reopen the library and implement policies designed to encourage social distancing and face coverings, discourage group work, and foster an environment for research and study that would benefit most students on campus. This study's data revealed that many participants do not like the excessive noise and social atmosphere on the collaborative first floor. In response to this, we implemented a quiet study policy for the entire library. The designated "quiet" second and third floors remained silent study areas. The previously noisy and collaborative first floor was transformed into a mostly quiet work area where users could talk or participate in online courses at a low conversational level. Based on our students' observational data and verbal gratitude, we can see that this new pandemic-specific policy was well-received. Items identified in the study as having low value to users, such as computers and small tables, were removed from the library to give users access to things participants think have a higher value such as larger desk spaces and printers.

Using Data for Post-Pandemic (Vaccination) Reopening

With the removal of state-mandated social distancing guidelines and building capacity restrictions, campus administration planned for a fully in-person campus experience for the Fall 2021 semester. We were instructed by campus officials to open the building to all visitors free of nearly all of the previous year's COVID-19 restrictions, with mask wearing being the exception. Despite an overwhelming vaccination rate among students, faculty, and staff, campus administration mandated a strict mask-wearing policy for all occupants in campus buildings, including the library. With the removal of the past year's restrictions, students were welcome to engage in collaborative in-person study and enjoy eating in the library building once again.

Data from the study revealed that many students come to the library as a destination for collaborative study. At the same time, data revealed that overcrowding and noise were major problems for most students. To accommodate the overwhelming desire for less crowding and less noise, in addition to the need for collaborative study, we made efforts to improve the quality of the study spaces by sacrificing the number of seats in the building. For the Fall 2021 semester, we reduced seating in the building from 1288 seats to 670 seats. Large tables on the first floor that once had eight seats crammed into a table now have four seats but offer a much larger table surface to work on and a less crowded study experience.

Changes to our technological offerings also helped to reduce crowding issues in the building. Many of our printers and scanners were in the middle of prime collaborative study space. Printers are noisy machines that often see significant queues build up and require frequent maintenance. To address the noise and crowding around printing and scanning activities, we moved all printers and scanners to the already noisy coffee and snack bar. The result, coupled with the reduction of first-floor computers from 120 to 50, allowed us to make room for more open desk space on the collaborative first floor. Data gathered from diminishing login numbers coupled with a new university mandate that all students purchase a laptop tell us that the reduction in machines will not be missed by our students.

At this point, it is too early to draw conclusions on the impact of these changes. We have observed significantly less crowding in the building. Groups of students are studying on the collaborative first floor and there appears to be more productive study and less frivolous socializing. This is especially true

in the areas of the first floor that offer large multi-seat tables. We have observed some of the computer pods on the first floor tend to be more social and over-crowded than the large group tables. While the reduction in seating and relocation of printers may have helped to reduce noise and crowding, there are other factors at play. The campus-wide mask mandate and fear of COVID-19 might have kept some students away from the building. The university also has a large and academically proficient first-year class and a shift of focus on academic achievement may also be a factor in the changes we have observed. Another, more tangible factor is the closing of the coffee and snack bar. In pre-pandemic times, the coffee and snack bar could attract over 45,000 visitors per semester. We need at least one complete academic year post-pandemic, without restrictions, to determine how students use spaces optimally. Keeping the food and coffee service closed might also contribute to less congestion, noise, and socializing and contribute to a more productive study and academic experience.

Limitations and Future Research

This study provided useful qualitative information, but some limitations should be noted. While the results are similar to other studies, as indicated in the "Discussion," the findings of this study are limited to one institution. A more exhaustive mixed methods approach that employs focus groups, ethnographic, exit, and observational methods could have enhanced our findings and given us an opportunity to gain more insights from participants. We also recognize that the survey was distributed during day-time hours, and therefore the data may not apply equally to evening use. Finally, this study only surveyed students who were in the library and did not represent those students who do not come to the library. Discovering why students choose not to use library spaces could be just as useful as gaining insights from regular users.

Conclusion

This space study proved to be extremely useful for an event we did not anticipate when we first developed the research questions and implemented the research. The data from this study provided sound guidance for the reopening of the library and its study spaces during the pandemic. We know that students want variety and balance in library study spaces and that our past efforts spun our collaborative spaces out of balance. When the building was renovated in 2017, we prioritized fitting as many seats in the building as possible, especially on the first floor. We realize now that, in emphasizing seating quantity and fostering an "anything goes" approach, we created a library space that lacked balance between productive work and social interactions. Academic libraries should take *balance* into consideration when designing library study spaces. Librarians and space designers should strive to strike an appropriate balance between seating quality and quantity, acceptable noise levels in designated collaborative and quiet study spaces, and the impacts of environmental factors such as printers, food services, exhibit and art displays, restrooms, and walkways on library study spaces.

The pandemic was a helpful inconvenience. Without it, we might never have experienced reduced occupancy and seating levels, reduced or changed hours, and the closing of the coffee and snack bar. We have a nagging suspicion that the loss of 45,000 visitors attracted by the coffee and snack bar might contribute to less congestion and noise. A future survey to follow up on any new seating arrangements and where we might deploy technologies is undoubtedly in our future. We are currently working with a vendor to purchase portable indoor Zonez soundproof privacy booths in our libraries, informing a follow-up study. The COVID-19 pandemic spurred the rise of remote communications technologies such as Microsoft Teams and Zoom that expand the way students, faculty, and staff work in the post-COVID era. Academic libraries should be prepared to accommodate and facilitate the use of these technologies so

that library users can engage in remote classes, meetings, and other activities like tele-health appointments with privacy and environmental impact considerations in mind.

Author Contributions

Aaron Nichols: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Visualization, Writing - original draft, Writing - review and editing **Paul Philbin:** Conceptualization, Investigation, Methodology, Writing - original draft, Writing - review and editing

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Appendix
Sample Survey Instrument

Qualitative Survey of Space Usage in the Library

1. What is your status at the University? (Circle one choice only).
(a) Undergraduate (b) graduate (c) faculty (d) staff (e) community user

2. How often do you use this area/space? (Circle one choice only).
(a) Daily (b) weekly (c) monthly (d) less than monthly (e) other:

3. What are you doing in this space? (Circle all that apply).
(a) Academic work/study (b) social (c) leisure reading (d) personal work
(e) Other:

4. Why do you use this space/area? (Circle all that apply).
(a) Furniture (b) quiet (c) fewer noise restrictions (d) access to technology
(e) lighting (f) access to outlets (g) other:

5. When using the library what are your needs? (Circle all that apply).
(a) Quiet atmosphere (b) collaborative atmosphere (c) computers (d) 3-D printing (e) microfilm readers (f) scanning technology (g) printing (h) other:

6. Are we meeting those needs?

7. Which space(s) in the library do you avoid? Explain:

8. Sound Off (what else is on your mind in terms of library space usage).

Date: October 2019/Atrium1