Seating in Crowded Indoor Public Areas

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Abstract
Seating in indoor public spaces has always been an issue on university campuses. In many cases, there are sufficient numbers of chairs and tables to seat everyone, enough to create a surplus. Nevertheless, the root cause of the problem is the inefficient allocation of space, such that people are less likely to sit at tables and areas that are currently being occupied by stranger(s), even if those areas are not full. We conducted in-person interviews with students and faculty members (e.g. professors) on the Cornell campus regarding this issue. In attempt to alleviate this issue, we proposed three initial prototypes. The first design entailed Lego tables that could be attached together and detached based on the number of occupants, such that each table "block" seats exactly one adult. The second introduced a (grass) lawn in the center of the indoor area, and lastly, the third entailed a combination of the previous two prototypes. The results of our user testing strongly suggested that most students and faculty members on campus highly advocated the Lego tables with a lawn in the center of the indoor space over traditional and conventional

Introduction
College campuses offer a productive environment for instruction, research, and networking. Regardless of our activity, we are always interacting with physical space; a space we share with other people. During high peak hours, indoor public places at university campuses become extremely crowded, which makes it difficult to find seats for both individuals and groups while preserving time and patience. This may cause people to avoid certain locations where they have had negative experiences in the past, which makes the overall college experience more stressful.

We hope to address the challenge of finding a seat in indoor public spaces during crowded (busy) hours by exploring technical and social solutions. One of our most consistent observations is the inefficiency in the distribution and consumption of seating space in many areas on campus.

To address this, we designed tables that could be put together and taken apart, such as Lego tables. The size of each individual table is reduced to accommodate one person. For groups of two or more people, the tables could be pieced together to form larger tables, eliminating the issue of excess space in tables that are not fully occupied. We also applied advanced HCI techniques and concepts we have learned in this class to better conduct our project, such as participatory design, transfer scenarios, feminism in HCI and design wickedness. As for user testing, we built four floor-plan paper prototypes to simulate people's decisions and then recorded the corresponding emotional and verbal responses.

Related Works

There has been a few research on the behaviour of users in public space that aims to understand people's spatial preferences, which are essential considerations in any design. For instance, researchers at the University of California, Berkeley have developed a video tracking algorithm that can model the behaviour of users in public places. They found that people normally attract to the fountain located in front of Sproul Plaza [1]. It seems like there are opportunities to apply traits that normally only available in outdoor public places in designing indoor public places. Although we do not have video surveillance technology, we plan on observing people's seating arrangements indoors.

It seems hard for us to find space in public because they are becoming increasingly privatized[2]. When we see someone sitting at a big table in public, we tend to treat the space as her private space. Thus, we rarely sit in the same table with her.

Robson studied people's seating behavior for a chain restaurant in multiple locations with varying floor plans[3]. His goal was to investigate the psychology of picking seats in a restaurant in order to better control the amount of time customers stayed to sit down and reduce the feeling of being crowded. He varied the proximity of each chair and table, revealing the people have a sense of personal space and may choose not to sit with someone if they are too close to strangers. Additionally, another study on perceived crowding in cafe/restaurant settings revealed that participants were more positive when seating was less dense[4]. This shows that proximity plays a large role in people's sentiment and decision making when choosing seats.

Design Objectives

With the goal of alleviating the burden of squandering precious time trying to find a seat in a crowded area, we hope to improve the allocation of space amongst individuals. In order to do so, we first have researched people's seating arrangements, preferences, sentiments, and behavior in indoor public spaces. This is an important goal because students may have to travel far to find a place to sit down during the Cornell winter while there are indoor public spaces not being used efficiently. While keeping in mind the goal of filling the indoor space with more people, we will also attempt to create a design that is usable by minority groups so to account for feminism in HCI.

At the moment we are studying Bryant Park since it always has a large amount of traffic and it is relatively easy to find a seat there. Even though it is an outdoor public space, it uses methods such as moveable chairs and a large open lawn that could be used as a transfer scenario to indoor spaces.

We hypothesize that if we allow users to easily change their seating arrangements and provide features that make indoor spaces feel like an outside space, we can fill a greater amount of seats in an indoor public area.

Design

One of our most consistent observations was the inefficient allocation and distribution of space in public seating areas on campus. To accommodate for people's privacy and personal space concerns (e.g. sitting with strangers), as well the the burden of having to move and rearrange seats to fit their preferences, we propose movable table blocks, such that each individual block seats one normal-sized adult. Because each table block seats exactly one user, this eliminates the need to share tables with strangers. For groups, the blocks can be attached (and detached) to form larger tables based the number of individuals.By allowing users to interact and move tables around to their preference, we are allowing users to create a seating arrangement that they prefer. We predict that by allowing users to change the arrangement of seats whenever they want, public indoor seating areas will be able to accommodate more people by eliminating the issue of wasted space that is usually present in standard tables that are not fully occupied.

Furthermore, our revised model accommodates for major handicaps and disabilities such as obesity, walking-impairment, and blindness. Each block (individual table) is assigned a unique identification number and is equipped with a rechargeable battery. The disabled user registers this number into their phone, which sends a signal to the block. The table block then uses a real-time indoor localization algorithm known as triangulation to predict the approximate location of the user and directs the table to follow them to their destination. For people who are significantly larger than the standard body size, we have included larger blocks that are twice the size of the normal block. This allows the larger blocks to be joined with their smaller counterparts.

Accommodating for people with disabilities introduced a new problem, particularly because of the likely existence of obstacles (e.g. people, objects, furniture, etc.) in a more realistic setting, such that these obstacles may obstruct or collide with the moving table. The wickedness of our current implementation arises from this knowledge. In other words, deployment of moving tables that use indoor location sensing to accommodate for the disabled requires a highly accurate and real-time algorithm that reduces the possibilities of the table from colliding with obstacles that may exist in its path, which then introduces other "wicked" problems such as high power consumption and the need for highly advanced computing techniques.

Lastly, we introduced a grass lawn in the center of the indoor space. One of the major inspirations for this concept was Bryant Park, a 9.6-arc public park and recreation area in Manhattan, New York, which we selected as a transfer scenario. Bryant Park's tables and seats are located around a large grass field known as *The Great Lawn*, which captures the attention of visitors. This minimizes the *awkwardness* of sitting next to strangers, given that everyone shared a common spectacle that distracted them from this realization.

Methods

Interviews

In order to increase our understanding and intuition of how people interact with indoor public spaces, we decided that it would be best to interview a random sample of students and professors on the Cornell campus, given they represent the population that use indoor seating areas. Interviews were mostly informal

and were conducted in various locations on and off-campus, including our participants' homes, Duffield Hall, Okenshields Dining Hall, and the Cornell Dairy Bar. We focused on collecting data on people's decision making process in finding seats in those locations.

Field Observations

Additionally, we conducted field observations of people in crowded public areas. Our selected points-of-interest included Duffield Hall, Okenshields Dining Hall, Gates Hall, and the Cornell Dairy Bar. Measurements such as the time they took to find a seat, gender, activity, and spacing (distance from other people) were considered in order to better understand how people rationalize their choice of a particular seat. To better understand our data, we created visualizations by drawing a floor plan for each observed area, along with the people and their activities at a specific window in time.

User Testing

We created paper prototypes of 4 different floor plans of Duffield: normal Duffield, Duffield with a lawn on the south end, Duffield with Lego (block) tables, and a combination of the previous ideas (Duffield with a lawn on the south end and Lego tables). Tables and people are represented in paper cutouts and could be moved around by the participant. All objects are color-coded so that users could easily identify each element. For instance, tables were orange, strangers were blue, the interviewee was yellow, and red was used to mark points-of-interest such as cafes. The prototypes were separated into 4 corners of a room where the interviewees are invited into. The order of which prototypes are tested first were randomly picked for each interviewee for the purpose of reducing bias. Interviewees were given a task to find a seat by place their icon (yellow smiley face) in each respective scenario which had the same amount of strangers in each. They always have the option to go somewhere else and not sit in the scenario. The testing order was normal Duffield, lego tables, lawn, lego tables and lawn. Users' emotional and seating decision reasoning were recorded.

Findings

Student Interviews

Our interviewees emphasized the importance of personal space in their selection of seats. Although most of them preferred to not sit with strangers, certain values such as politeness and etiquette influenced them to act otherwise. One interviewee mentioned that when he was sitting down and someone approached him asking to share the table, he would politely let them know he did not mind them sitting down. In reality he was only being polite. Additionally, we found that strangers did not like sitting across from each other in small tables, such they they were in each other's view. This reinforced the notion that people value personal space over practicality, such that they are willing to disregard the latter in hopes of maintaining privacy. Thus, even when there are available spots at preoccupied (1-2 persons) tables, a majority of them still choose to wander off in search of an area that will suit them.

Professor Interviews

We interviewed one professor regarding his difficulty (or lack of) in finding seating at the Cornell Dairy Bar, a location he frequently visits to have lunch. Despite the observation that each table can only fit up to 5 people, the professor usually sits by himself, but will

occasionally eat with students. Although there are other students in the room, it is worth noting that he usually likes to sit by himself and will only sit with students when he schedules a lunch with them in advance. Consistent with the student data is that certain faculty members also prefer to sit alone or with people they know. Because of the limited sample size, we cannot extend this assumption to encompass the entire faculty population on campus.

Paper Prototype

We elected to use paper prototypes to test users' behaviours with different settings. Our choice of medium was motivated by the economical and cost-effective means of representing our ideas in a straightforward and comprehensive manner, which allowed us to conduct tests on a large sample of participants in a short amount of time.

We conducted user-testing on 14 participants. Our results indicated that:

- The majority of users in the lego tables setting surprisingly did not choose to detach smaller tables to sit. Some of them even quit finding seats and decided to go somewhere else.
- Although it may appear that the lawn would consume excess amounts of space in Duffield, its introduction nonetheless encouraged users to sit at tables closest to the lawn even if those tables were currently being occupied by strangers. Interestingly, many people preferred to sit directly on the lawn.
- The combination of both lawn and lego tables was most favored by our participants. Users who chose to go to different places in previous scenarios would now detach tables to sit around the lawn. Also, they were willing to sit next to strangers.

Because of the nature of the study, no quantitative data was collected. Thus, in order to find the best setting quantitatively, we selected users that gave up in finding seats at normal Duffield setting but eventually chose to sit with others settings. With that in mind, we found 11 of the 14 users that is appropriate for the quantitative analysis. We coded the responses of each of those users and the best performance settings are as follows:

- Duffield with lawn and lego tables.
- Duffield with lawn
- Duffield with lego tables

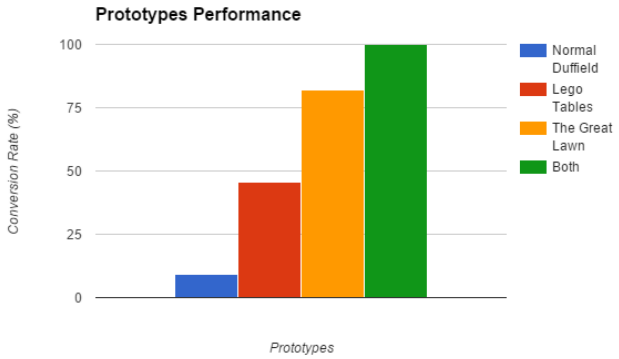

Figure 1. Data from user testing

Discussion

According to the user testing and data (n=11) that we obtained, it is evident that "Duffield with lawn and Lego tables" is the most favorable with 100% conversion rate. In other words, participants who chose to gave up finding seat at normal Duffield settings, now decided to

sit in this setting. The second best setting is "The Great Lawn" with 81% conversion rate. This proves that our belief of using outdoor features in indoor space would make it easier for people to find seats. "Lego Tables" gives us 45% conversation rate. This means that people do not want to spend too much effort to detach the tables and just to sit in the area while they always have an option to leave somewhere else. Another explanation for this situation would be the "fear of what others think about themselves" nature of human. Participants do not want to appear "mean" to someone when they try to detach preoccupied tables.

Conclusion

Public spaces play an integral role in bringing the community together; it is in these areas that people meet with friends, stop for lunch, enjoy time with their significant others, or relax in solitude. Because they benefit all who may interact with them, it is extremely important these areas are welcoming to everyone, especially on college campuses where the pressures of academics, jobs, and social life add to the turbulent experience. Seating gives people a stopping point, whether it be for lunch, a place to wait and meet others, and/or simply a place to relax and take in the scenery. The strenuous task of finding seats in indoor public spaces is a significant challenge that remains under addressed on university campuses and more broadly, in HCI. Our study revealed that the root of these hardships stemmed not from the lack of chairs and tables to accommodate for every person in the area, by rather by people's unease in interacting with strangers. This resulted in an inefficient allocation of space (in many cases, we observed large tables being occupied by only one or two people). To address that, we proposed the blocked (Lego) tables concept that allowed users the freedom to customize their tables by attaching and detaching table blocks. We also studied Bryant Park and transferred its signature "Great Lawn" concept into our design. The data we obtained from conducting user testing indicated that the combination of the lawn with the Lego tables in indoor public place produced the most optimal results in regards to the distribution of seating space as well as increasing people's overall satisfaction of finding a seat in a crowded indoor area.

Future Works

We would like to spend more time in studying the seating patterns to draw the optimal tables and chairs set up. We would replace manually observing and drawing seating patterns by applying computer vision techniques to examine and continuously getting data from public camera.

We could conduct more interviews as possible, both for students and faulty members.

We used paper prototype to simulate people's decisions to choose seats in indoor public spaces. If we had enough resources, we would have actually created our tables and tested them out on users. This would have immersed the user in the indoor public space which would have produced more accurate behavior than our simulated user testing setup.

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