

University CSU: A Web-Based Space Utilization Tool for Investigating Trends in University Room Use

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ABSTRACT

Understanding utilization of existing space resources across a university campus has applications to both immediate and long-term needs. This can be used to support plans for upgrades and expansions of the physical plant of the institution. Historical data can help to understand trends in space usage, provided it can be collected and organized uniformly. Additionally, fundamental characteristics that define the potential use of the elements must be included to understand trends in use of specialized spaces within the physical plant. With such information in hand, an interactive, web-based dashboard for assessing campus space utilization (CSU) called University CSU has been developed as a tool for visualizing and optimizing room use across a university.

INTRODUCTION

Managing teaching space at the university level efficiently is often a difficult task. Many factors such as room capacity, specialization of the room (e.g. computer lab versus general instruction space), and classroom ownership play in to how a room is used. Room bookings have historically been done by department administration, with some departments more adept at efficiently booking rooms than others. Understandably, teaching space becomes increasingly valuable as student populations grow and as more programs are offered. A thorough understanding of how well teaching space is being utilized across campus can be a useful tool not only during the booking process, but for future planning as well.

A tool that displays current and historical room booking information in detail is useful for anyone who has the responsibility of booking rooms, or wants to understand trends in the usage patterns for rooms more generally over time. To this end, an online dashboard has been built which allows users to visualize room usage trends across several buildings on an academic campus (starting with two buildings and later expanding to nine buildings). These initial buildings best capture the general picture of the classrooms that all departments have access to, and span more than a decade of academic use.

PROBLEM

Studying the trends in historical room booking practices across a university campus can potentially shed light on how to better utilize the resources already available to the university, as well as inform future planning of course offerings and planned construction. The objective of this work is to create a tool that can help stakeholders gain insight into historical trends and provide guidance for planning in both the short and long term.

DATA

In order to comprise a dataset for class bookings, an initial web scrape from the university website was performed. This scrape was done manually by copying and pasting all classes from the university registration page for each spring and fall semester from 2006 to fall of 2017, creating a unique CSV file for each semester and year. For analysis and consistency purposes, all summer sessions were excluded from the web scrape. The information contained in the resulting CSV files includes multiple characteristics for each course offered – course title, course instructor, the building and room in which it is held, the capacity of the room, the enrollment for the class, etc. Since online classes do not meet in a physical location and at a designated time, these courses are excluded from the analysis. Information relating to room capacities, actual enrollment in courses, room type (i.e. departmental lab, computer lab, traditional classroom, etc.) and room ownership (which department does the room 'belong' to) are most relevant to the analysis.

Once the initial web scrape is completed, each individual CSV is read into SAS 9.4 directly through the data step using INFILE and INPUT statements. This method is preferred to a simple PROC IMPORT due

to the presence of extraneous observations, such as header rows, throughout the CSV files, making a data step a necessary part of the data cleaning process. To streamline the importing and cleaning of numerous CSV files, a macro is implemented so that the process depends only on the CSV file name and path, along with the desired output dataset name. Figure 1 below shows a screen shot of the raw data before cleaning, while Figure 2 shows the same course and section once the cleaning and validation is complete.

To provide a visual basis for each building in the dashboard, floor plans of academic buildings were obtained internally through the university and manipulated through SAS 9.4 using PROC MAPIMPORT and PROC SGPLOT. In order to make the floor plans usable for creation of polygon plots, shape files were read in using PROC MAPIMPORT. Beyond the x and y positioning variables, important variables available in the plan files that were preserved include a room number and the object identifier (which gave a unique identifier for each polygon), with a variable indicating the building being constructed as part of the conversion process. SAS implemented macro calls %annomac (required for annotations) and %centroid (finds centroids of a given dataset) enable annotations of room numbers within the output floor plans. The POLYGON plotting statement is used within PROC SGPLOT on the converted shape data set to output it to an html file, including an image map to make various rooms clickable. These form the foundation for the landing point on each building inside the dashboard.

DATA CLEANING/VALIDATION

Significant cleaning of the data is required in order to prepare it for use in the reports. As mentioned above, the majority of the data is scraped from the university website - the bulk of which dates back more than 10 years. Not surprisingly, there are some variations (as well as errors) in how the courses have been entered into the university system over the years. For example, because the data is scraped from the web, there are extraneous columns and rows (i.e. header rows comprised only of spaces, columns that include information irrelevant to the analysis, etc.). Some of the column headings may be incorrect, and many of the observations are completely blank. Easily identifiable errors or extraneous listings such as blanks or information irrelevant to the analysis are deleted.

Further organization of the data includes expanding each course listing to produce one observation for each day that a given course is scheduled. For example, if a course is taught on Monday, Wednesday, and Friday, the final dataset will include an observation for that course for Monday, an observation for Wednesday, and an observation for Friday. In the raw data table, a course may span multiple records and values that are assumed the same for all records are only populated in the first one. Missing values must be filled in with values from the initial course listing for classes these classes as part of the data preparation process. New variables are added to track the level of the course (undergraduate versus graduate) and to keep track of starting dates and ending dates of courses (to account for half semester courses), along with the semester and year. Formats and attributes are set for all the variables, and finally all the semester datasets are concatenated in order to gain a full picture of course bookings. It should be noted that any course listings that are missing entries for meeting days or meeting places are deleted, as those are online courses and do not affect physical room booking analysis. The data is validated by two separate teammates, wherein PROC COMPARE is performed to compare both of the independently programmed datasets to ensure that the final dataset is accurate. Figure 2 shows the data once it has been cleaned.

Chemistry										
Select	CRN	Subj	Crse	Sec	Cmp	Cred	Title	Days	Time	Cap
NR	10001	CHM	101	1	M	4	General C	MWF	08:00 am-11:00 am	24
								M	11:00 am-01:50 pm	
								R	07:30 pm-09:30 pm	

Figure 1. Screen shot of raw data showing one section of a course.

	Course Record Number	Course	Course Title	Starting Time	Ending Time	Day of Week	Maximum Room Capacity
1	10001	CHM 101	General Chemistry I	8:00	10:50	M	24
2	10001	CHM 101	General Chemistry I	8:00	10:50	M	24
3	10001	CHM 101	General Chemistry I	8:00	10:50	M	24
4	10001	CHM 101	General Chemistry I	8:00	10:50	M	24
5	10001	CHM 101	General Chemistry I	8:00	10:50	M	24
6	10001	CHM 101	General Chemistry I	8:00	10:50	M	24

Figure 2: Data after the cleaning and validation process is complete.

Information from a university-wide room inventory is then joined to the course listing dataset in order to add true capacity, square footage, room ownership, and other characteristics for each room. This is done in PROC SQL, joining the two datasets on the name of the building and room number

VISUALIZATION

The analysis of this work culminates in an interactive dashboard that allows users to observe the trends in teaching space utilization over time. The dashboard initially includes two buildings at a university, which house different academic departments. Clicking on either of these buildings brings the user to a page that shows the floor plans for one floor of the building, with options displayed to allow the user to select the desired academic year and semester, along with the level of the building. Once the semester and level of the building are selected, the dashboard brings the user to a visualization of the floor plans displaying overall percent use, or how often a room is booked during the hours of 8 AM to 5 PM (henceforth referred to as “prime time”) for each room for the specified semester. By clicking on each room, user is able to access a selection of four reports describing the space utilization and scheduling of that room. The reports include a heat mapped classroom calendar, with the heat mapping reflecting the percentage of the room capacity used for the chosen semester. A stacked bar graph is displayed to show the distribution of hours among departments for that semester. A horizontal bar graph on historical trends of the percentage of capacity used across all semesters is included. Finally, a report of daily capacity percentages that included all other rooms of the same type for comparing the efficiency of scheduling. Each report can be clicked on to expand the display to fill the window. Figure 3 below illustrates screenshots from the dashboard, and the entire dashboard can be viewed at <https://superfreqs.github.io/UniversityCSU/>.



Figure 3. Screenshot of the flow of the website. The user chooses a building from the home page (pictured here is Dobo Hall) and is brought to a selection menu allowing the user to select year, semester and building floor (default is first floor of the building). By clicking a room, the user is brought to a dashboard showing reports and graphs, each of which can be expanded by clicking on it.

GENERALIZATION

While this dashboard is currently configured to analyze teaching space at the university level, and would be applicable to the needs of any university, it could also readily translate to any organization or entity that needs to manage a large amount of activity across a large amount of space, possibly such as a hospital or campus of a large company. Public school systems could also benefit from a tool that provides a look at both past space utilization as well as current trends in how classrooms and other spaces are used.

SUGGESTIONS FOR FUTURE STUDIES

There are many potential additions to this dashboard that can be made to enhance its utility, as it just begins to scratch the surface of trends in room usage at the university level. An obvious path forward is to include as many buildings on a campus as possible – including a wide variety of space open for reservations, not purely classrooms in academic buildings. Optimization of room bookings is also a long-term goal for the tool described here.

Such optimization would likely include a model that would identify rooms to be used to alleviate pressure from chronically over-used rooms, and make suggestions based on rooms that are chronically under-utilized. Because room ownership can be contentious, a future version of this dashboard could potentially include a summary of the growth of the academic departments – including both students and faculty. The dashboard could also be modified to display results based on projected and/or simulated growth. Ideally, this dashboard would include a complete picture of the special characteristics available in all rooms, which would be of particular help in placement of more specialized courses; whether it be a small graduate class that needs only a handful of seats, or a computer programming class that requires access to a computer lab.

The data is what ultimately drives any dashboard and, obviously the better the data, the better the dashboard will be. As discussed previously, the course listings over the past 10 years contains errors and variations of how courses were entered. Uniform entry of the course listings, as well as continuous, detailed, and accurate room inventory data is essential for the success of the dashboard and any future models that could be added.

CONCLUSION

In conclusion, an interactive dashboard is created in order to visualize and understand trends in room usage across a university campus. The goals of this dashboard are such that the utilization of space at the university is well understood, and that it could potentially inform future room bookings and planned construction. The dashboard has been configured so that it is both informative and aesthetically pleasing, and it can easily translate to any other entity that has space management needs.

REFERENCES

Robert Allison's SAS/Graph Examples! Accessed January 19, 2018 <http://robslink.com/SAS/Home.htm>

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