Applied Geography 60 (2015) 77–83

Contents lists available at ScienceDirect

Applied Geography

journal homepage: www.elsevier.com/locate/apgeog

Visualizing the spatial dynamics of student success

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A R T I C L E I N F O

Article history:
Available online

Keywords:
Classroom dynamics
Indoor GIS
Classroom space visualization

A B S T R A C T

This study attempt to visualize the spatial patterns of selected academic attributes across college classroom space based on data from a map-embedded smart attendances and GIS visualizations. The academic attributes of 542 participants from Los Angeles Mission College (LAMC) in California were analyzed in a GIS platform. The spatial dynamics of student success revealed the distance decay effect on test scores, class participation, and class attendance. The visualization of class performance highlighted the spatial interdependence between seat location and academic attributes, which was validated by 145 sample students' perceived mental maps generated from the accompanying questionnaire survey. The replication of the visualization technique across different class sizes and courses could help educators identify seats for early intervention and micromanagement of classrooms.

Introduction

In higher academic institutions, students self-select seat positions in classrooms. Unless ordered by instructors to sit at assigned seats, most students remain loyal to the seats selected at the start of each semester (Kaya & Burgess, 2007). Investigations of the positive and negative impacts of such seat locations on aspects of academic performance date back to the 1920s (Griffith, 1921), but these have been inadequate. Compared to research regarding the delivery of course knowledge and material, less attention has been paid to seat patterns within a classroom (Meeks et al., 2013).

Burda and Brooks (1996) reported that students select seats based on achievement motivation. People seated in the front rows learn more, participate more, interact the most, and are more enthusiastic than those seated in the back (Adams & Biddle, 1970; Benedict & Hoag, 2004). On the other hand, those seated in the back tend to be less engaged than those seated in the front. As Rebeta, Brooks, O'Brien, and Hunter (1993) pointed out, when students sit farther away from the "action zone," their grades and participation decline, while their absenteeism rates increase (Dykman & Reis, 1979; Perkins & Wieman, 2005; Walberg, 1969).

With the exception of a few studies (e.g., Kalinowski & Taper, 2007; Levine, O'Neal, Garwood, & McDonald, 1980; Tagliacollo, Volpato, & Pereira, 2010) that reported a lack of correlation between seat location and academic performance, several studies have underscored the variation of academic attributes within the classroom as a function of seat location (Anderson, Benjamin, & Fuss, 1994; Armstrong & Chang, 2007; Benedict & Hoag, 2004; Kalinowski & Taper, 2007; Levine et al., 1980; Parker, Hoopes, & Eggett, 2011; Perkins & Wieman, 2005; Rebeta et al., 1993; Schee, 2011). However, these studies paid little attention to the pattern that lies between the two edges of the academic spectrum. While spatial analysis could identify patterns and peculiarities in spatial autocorrelation (Ord & Getis, 2001), the pattern of academic attributes within classrooms has hardly benefited from the potential of GIS-based visualization techniques.

The analysis and visualization of data in the context of indoor space has not been adequately explored. Klepeis et al. (2001) found that even though the average American spends only 13% of the time outdoors, the GIS domain has always been the outdoors, offering almost no support for navigating the complex indoor spaces of shopping centers, hospitals, mines, or airports. With the advanced progress of GIS and computing technologies, however, attention has been extended to indoor space (Li, 2008). But indoor GIS has lagged well behind outdoor space applications due to weak and unreliable GPS signals (Googchild, 2011), the failure of aerial photography to see through roofs, and the unavailability of GPS signals inside buildings (Worboys, 2011).

Against the backdrop of these challenges, some companies and educational institutions have attempted to bring selected aspects of GIS applications indoors. For instance, the University of Washington (Murray, 2014), Google Maps (McClendon, 2011), Trimble (2010), and Delaware County's GIS department (Ensinger, 2014)

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http://dx.doi.org/10.1016/j.apgeog.2015.03.006
0143-6228/

have not only succeeded in mapping floor plans within buildings, but have also located desks, chairs, stairs, doors, equipment, plumbing, lighting, smoke detectors, HVAC systems, fire alarms, accessible routes, and ceiling access doors in classrooms and offices. Nevertheless, these attempts hardly apply the spatial analyses of features within the classroom setting.

Tobler's (1970) First Law of Geography states that everything is related to everything else, but that near things are more interrelated than distant things. By implication, students seated near the instructor perform better academically than students in distant seats. The management of classroom seats is an inherently place-based process and could be critical to addressing many of the challenges to managing classrooms. Because classroom management is fundamentally based on spatial information, data regarding location-specific test scores and class participation are central to the decisions that are made. Maps could add context to the class management narrative and are indispensable to fully understanding spatial data (Hallisey, 2005) such as classroom seat locations. The use of GIS technology in space-dependent variable mapping has become increasingly relevant over time as technologies improve for various applications.

The aim of our study is to visualize the dynamics of academic attributes using GIS-based techniques. We hypothesize that the patterns and attributes of classroom seat location could best be geo-referenced, analyzed, and visualized in a GIS platform.

Research methodology

Context of the study

The study was conducted in Los Angeles Mission College (LAMC), an institution that serves a primarily Hispanic population in Los Angeles, California. Established in 1975, the college is the newest of the nine colleges in the Los Angeles Community College District. In 2013, about 9279 students were enrolled in the college. Hispanics, Whites, Asians, and Blacks accounted for 74.3%, 12.3%, 7.8%, and 4.1%, respectively, of the student body. Female students made up 59.8% of the student body.

Physical Geography was the course chosen for our study. It is a three-unit course transferable to four-year universities such as the University of California (UC) and the University of Southern California (USC). The course is among the most popular at LAMC. It is offered in three sections during the fall and spring semesters. During the winter and summer intersessions, however, it is offered in a single section only. The course is offered in a general purpose classroom at the Center for Math and Science, with a maximum capacity of 68 students. The classroom allows students to see any material presented visually, to hear any audible presentation without distracting noises and distortions, and to be physically comfortable regardless of the method of instruction. A projection screen is mounted in the center of the classroom. The hall is large enough for the students to find their preferred seats freely with movable tables and chairs. The lectures were presented using PowerPoint. To encourage active learning, students were motivated to answer questions, participate in discussions, and ask questions at any time during the lectures.

Data acquisition

We acquired data from two sources: (1) a smart attendance system and (2) a questionnaire survey.

Smart attendance data

Smart attendance is a specially designed class attendance format embedded with a classroom seat map. It enables the researcher to record data from 542 students (e.g., seat location, class participation, and tardiness) in a span of two regular semesters and two intersessions. Attendance was collected at every class of 11 sections throughout the semester, totaling 15 attendances for once-weekly classes and 32 attendances for twice-weekly classes. While the majority (88%) of students tended to remain seated in the same location for most of the class throughout the semester, only 12% made casual seat decisions.

Questionnaire survey

The aims of the questionnaire survey were (1) to understand students' perceptions of the link between seat location and grades and (2) to validate the results obtained from the visualization of classroom dynamics. A total of 145 randomly selected students completed the questionnaire consisting of 18 items. The questionnaire was accompanied by a classroom seat map partitioned into nine sections: front left, front center, front right, middle left, middle center, middle right, back left, back center, and back right. Analysis of the survey data helped the researcher produce students' perceived mental maps of academic attributes in the context of classroom seats. Students were informed in a cover letter accompanying the survey instrument, and verbally during class, that participation in the survey was voluntary and that their anonymity was guaranteed.

The demographic and ethnic background of sample students closely matched the college-level statistics. The survey sample was 53.7% female. Over half (54%) of the participants were between 20 and 25 years of age, while students below 20 years old accounted for 21% of the sample. Only 6% of the participants were older than 35. The participants were overwhelmingly Hispanic (79%), followed by Asian/Pacific Islanders (11%) and Caucasians (7.7%). With respect to academic preparedness, over 75% of the participants had completed a minimum of 16 credit units. Only 1.4% of the participants did not have any college units prior to the first day of the term.

Data analysis

In the smart attendance system, each seat was established as geo-referenced point data within the classroom space. Based on such data, the following GIS analyses were undertaken:

Geodatabase preparation

Scholastic attributes such as test scores, gender, class participation, and class attendance for each section were exported from the smart attendance analysis into a spreadsheet. The students' overall test scores (percentile) were cumulated from three tests and a final exam. Class participation was quantified as “active” (coded 3), “moderately active” (coded 2), “passive” (coded 1), and “dropped out” (coded 0). Class attendance was categorized into two groups: “less than three absences” (coded 1) and “three or more absences” (coded 0). Finally, the composite database was imported into ArcCatalogue and linked to the digitized (geo-referenced) classroom map in the ArcMap 10.2 platform.

Interpolation and contours

Interpolation assumes that spatially distributed objects are spatially correlated: Things that are close together tend to have similar characteristics. We used inverse distance weighting (IDW), a deterministic method for interpolated surface generation with a known scattered set of points.

Hot spot and cold spot analyses

Hot spot and cold spot analyses are used to identify statistically significant spatial clusters of high values (hot spots) and low values