What Can Buildings Tell Us, What Can We Tell Back

SIMOS YANNAS

Environment & Energy Studies Programme
Architectural Association School of Architecture, London, UK

ABSTRACT: The paper introduces a set of field studies and analytic work undertaken on some thirty different spaces in over a dozen buildings in and around London. The buildings included recent schemes as well as converted Georgian and Victorian structures. The spaces studied included classrooms and seminar rooms, open plan studios as well as cellular offices, and public spaces including semi-outdoor transitional structures and pavilions. Field studies dealt with measurements and the mapping of occupant activities and environmental preferences. Data collected on site provided inputs for parametric studies which in turn served as starting points for the development of new building programmes and research agendas.
Keywords: field studies, occupant environmental control, adaptive comfort

INTRODUCTION

This year's research agenda for the masters programme in Sustainable Environmental Design stressed the importance of observation from the earliest stages of environmental design research. The year's projects were planned in stages that combined team work with individual effort. The first stage started at the beginning of the academic year (first week of October 2008) with building studies in and around London. Fieldwork included on-site observations, measurements and interviews with occupants and facilities managers. This was preceded by preliminary consultations with the buildings' architects or engineering consultants. Data collected from the fieldwork and other sources were used as inputs to calibrate computer models for thermal and lighting studies. A series of parametric studies were undertaken to identify the effect on thermal and visual comfort of key operational and building design variables. This work was supported by regular studio tutorials, instruction on the use of fieldwork techniques and environmental simulation software, and weekly lectures on the principles and practice of sustainable environmental design. Preparatory work drew from the findings of the PROBE studies that had been conducted in the UK [1], and the continuing research and debate on environmental control studies in buildings [2].

The 34 students on this year's masters programme, architects in their late twenties and early thirties from some fifteen different countries, were assigned to work in 9 teams of 3-4 members each. Over the ten weeks of this first stage of research some 30 different spaces were studied in a dozen buildings to investigate how the spaces served occupant requirements over daily and seasonal cycles; how occupants defined desirable environmental conditions for themselves; the means that occupants could employ to vary environmental conditions in their vicinity; the role, if any, of automatic controls for regulating environmental conditions in these spaces. In the second stage of the year's project work (started mid-January 2009), the environmental design issues highlighted by these building studies serve as starting points for design research that explores building programmes in different urban contexts and climatic regions. The paper provides an overview of the methods and findings of the work carried out so far.

SCOPE AND METHODS

A number of London architectural and engineering practices nominated one or more buildings as case studies on this year's research agenda. Within each of these buildings project teams selected three to four characteristic spaces as the objects of their field studies. These included classrooms and play rooms, cellular offices and seminar rooms, open plan studios and public spaces, IT rooms and libraries, and semi-outdoor transitional spaces and pavilions. The spaces chosen for study varied in size, proportions, room height, occupancy, orientation and glazing ratios, as well as in other architectural, constructional and environmental attributes and features. For each of these spaces initial spot measurements of environmental variables (air and surface temperatures, relative humidity, air velocity and illuminance levels) were followed by readings with temperature and humidity dataloggers over periods of one to two weeks. Architects, engineers and facility managers were consulted and occupants were interviewed. The purpose of the fieldwork in the selected buildings was to provide sources of empirical information complementing the theoretical inputs of the taught courses on the Masters programme, as well as helping to calibrate computational tools for thermal and lighting simulation studies. Occupancy schedules, occupant activities, and environmental conditions and controls were mapped over the working day in cross-sections of the selected spaces. Figures 1-3 illustrate different ways in which results were plotted in order to study spatial and temporal effects. Figure 1 shows a mapping on the plan and section of the room (an architects' office in this case) of the positions of those occupants interviewed by the student team identifying occupants' comfort votes (shown with grey circles on plan and silhouettes on the section) and occupants' access to environmental controls. Figure 2 plots the measured temperatures against variations of operational variables to assess the influence of the latter on thermal comfort. Figure 3 shows that spot measurements along a section of a building can identify important variations that may be worth studying further. In this case the variations arise from the combination of a deep plan form, the positions and form of the three different types of openings (shown on the axonometric), the variation in room height and the projecting canopy that forms a protected outdoor play area. The figure also shows how spot measurements can also serve as calibration data for simulation models. Combined study of the architectural form and observed operational conditions provides a powerful starting point for diagnostic and remedial action, as well as providing insights toward alternative design possibilities. Following calibration against measured data, simulation tools can be used to perform parametric studies investigating the likely thermal and lighting performance of the selected spaces under different operational conditions (occupancy, air

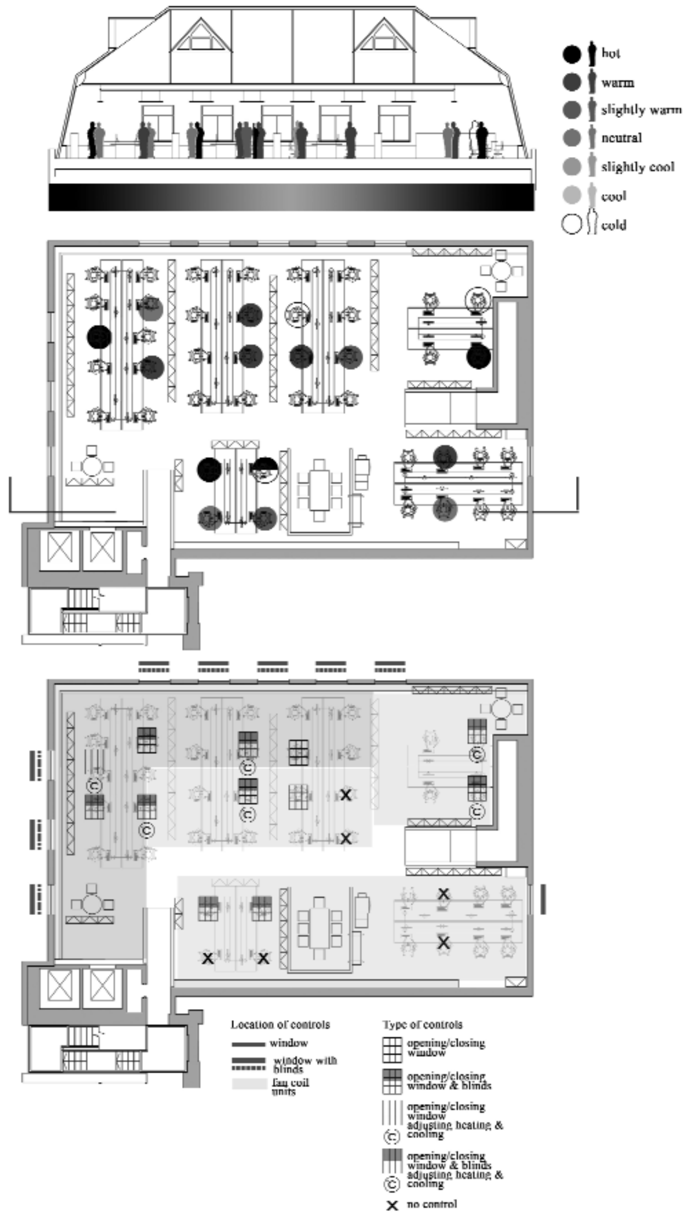

Figure 1: Mapping showing variations in occupant thermal comfort votes, sitting positions and available environmental controls in top floor design studio (October 2008).

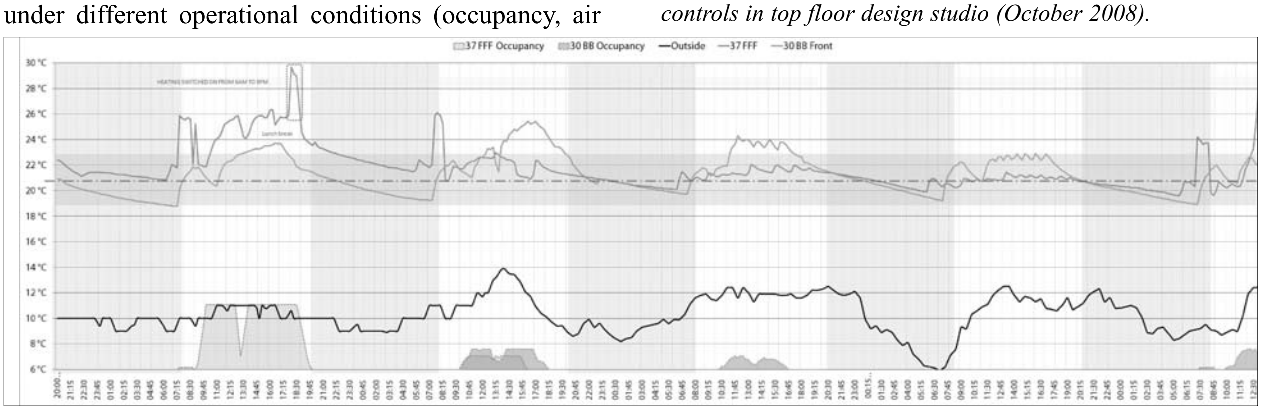

Figure 2: Measured temperatures in two adjacent seminar rooms over a six-day period in November 2008 showing temporal responses to outdoor air temperature, occupancy levels and heating schedule.

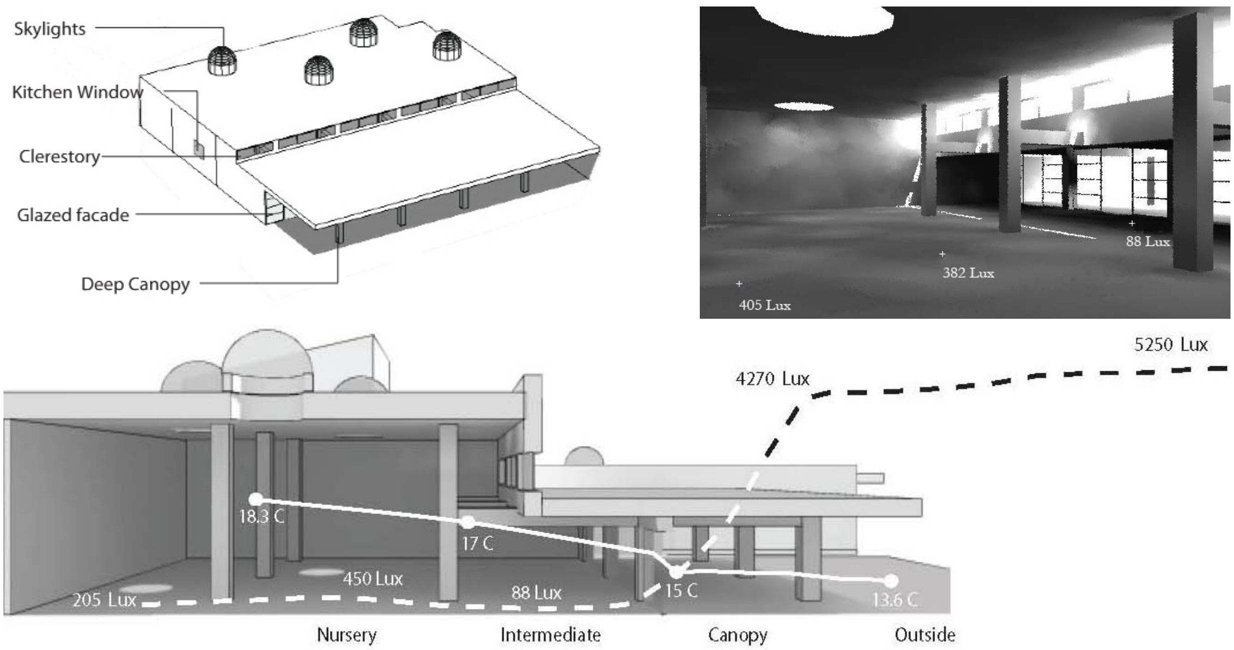

Figure 3: Combined use of architectural drawings, spot measurements and computer simulation for diagnostic analysis and design research. The interior view (top right) is output of a daylight simulation using Radiance with the same conditions as those of the spot measurements to calibrate the digital model for subsequent parametric studies.

exchange rates, weather, etc.) and/or changes in building design. The results of such a parametric study are shown in Fig.4 in the form of simulated hourly temperatures for a sequence of typical London summer days. The only parameter varied is the number of occupants following the typical occupancy period of the seminar room modelled for this exercise. It can be seen that despite the mild outdoor air temperatures the room temperature is predicted to rise above comfort (comfort zone shown with a grey horizontal band on the graph) even with partial occupancy due to metabolic heat gains, and therefore measures should be taken to prevent or moderate the overheating. The sequence of tasks undertaken on each building study was set by the project brief from the outset and included the following:

- study of relevant literature
- consultation with designers
- on-site observations and spot measurements
- temperature and humidity readings with dataloggers
- spatial-temporal mapping of occupant activities
- comfort surveys and interviews
- estimation of adaptive comfort zones
- daylight and sunlight simulation studies
- thermal simulation studies.

Undertaking of these tasks followed the weekly delivery of taught courses which introduced the principles and practice of sustainable environmental design and provided instruction on fieldwork techniques and the use of data processing and computer simulation tools. Weather files for climate analysis and thermal and daylighting simulation studies were provided to all

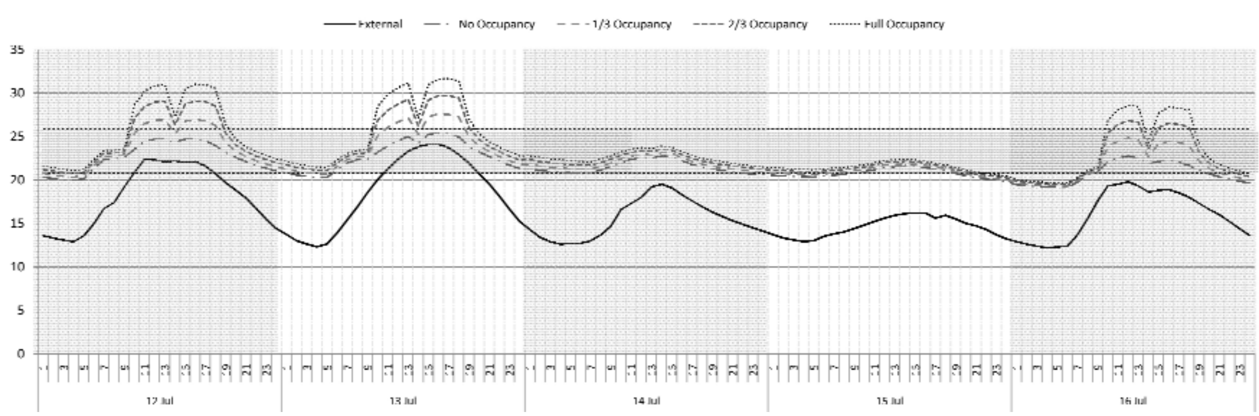

Figure 4: Results of parametric study with Tas showing the effect on hourly room resultant temeprature of variations in the number of occupants with all other parameters unchanged.

Figure 5: Two of the educational buildings studied. (Top) Southerly elevation of Modern Language Facility for the University of London in Egham; (Bottom) North elevation (left) and South elevation (right) of primary school in Greenwich.

teams by the Meteonorm global meteorological database [3]. Meteonorm (version 6.0) includes statistical data for the period 1961-90 for a number of weather stations in and around London, as well as more recent data covering the period 1996-2005, and forecasts for up to the year 2100. These provide a good basis for investigating effects of climate change scenarios. Thermal simulation studies were performed with the dynamic thermal simulation model Tas [4]. Satel-Light [5], the European database of daylight and solar radiation, provided plots of hourly sky illuminance in useful graphical formats that allowed quick assessments of likely daylight availability at different times of the day and year. The adaptive comfort zones were determined using algorithms given in the CIBSE Guide A [6], the ASHRAE Standard 55-2004 [7] or the PLEA Note on Thermal Comfort [8], and were expected to follow criteria outlined in the EN 15251 [9] [10]. Given that all of the buildings studied were mostly densely occupied, fresh air requirements and internal heat gains as well as variations in occupancy affecting them became topics of parametric studies to assess the effects of these variables on indoor temperatures and thermal loads. The range of values quoted in the literature is such as to dominate the thermal balance of any densely occupied space [6][11]. Solar access, shading, overshadowing and daylighting studies made extensive use of Ecotect [12] and Radiance [13].

CASE STUDIES AND FINDINGS

The selected buildings included six recent schemes, of which some designed on environmental agendas, as well as converted Georgian and Victorian structures housing offices and an academic institution. Three of the schemes were recent educational buildings housing

Figure 6: Top floor and intermediate floor design studios in converted Victorian building in dense central London location.

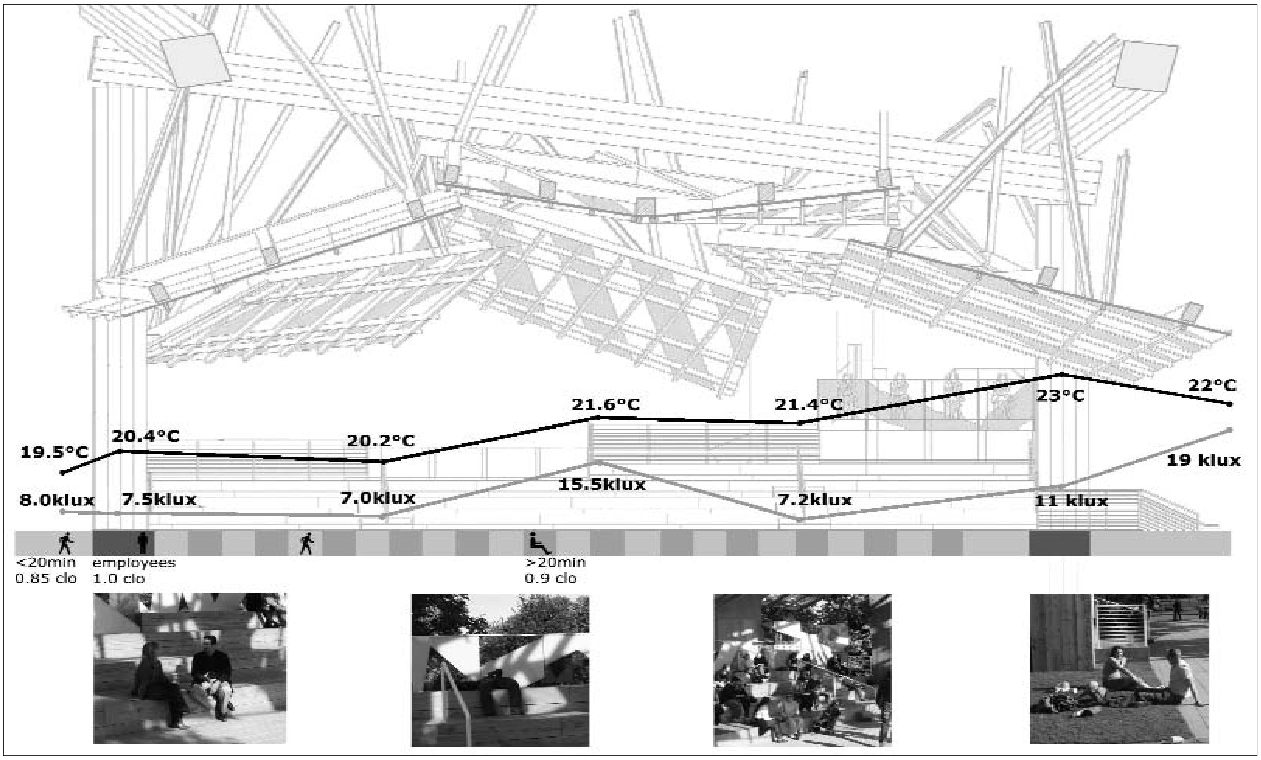

Figure 7: Variations in air temperatures, light levels (shown in kilolux), occupancy and occupant activity along a section of the Serpentine Gallery Pavilion at midday on a sunny day in October 2008.

respectively a nursery and community centre, a primary school and a tertiary educational establishment. These provided a variety of different spaces for study: classrooms, play areas, library, multipurpose spaces, IT rooms, cellular offices. Figure 5 shows two of the educational schemes that were designed on relatively shallow, linear plans and have glazing ratios that took account of daylight and /or solar heat gain criteria. Three of the other selected buildings functioned as architectural design studios occupying several floors in open plan configurations. Several of these open plan spaces, Fig. 6, were studied to investigate the effect on thermal and visual comfort and indoor air quality of room geometry, location within the building, glazing ratios and position of openings. A group of Georgian buildings that now house a school of architecture provided seminar rooms, studios and multifunctional rooms for study. All of the older buildings were characterised by relatively low glazing ratios. By contrast two other schemes provided the opportunity to study the effects of fully glazed elevations. Finally, one of the building types considered on this project was the pavilion. This was observed both as a seasonal building form and as a permanent urban structure. The former was studied on the Serpentine Gallery Pavilion 2008 and measurements were also taken in several variants of the latter including Hays Galleria and the Spitalfields Market. Activity mapping and environmental measurements at the Serpentine Pavilion were undertaken over the last two weeks of October 2008 just a few days before the pavilion was taken down and removed permanently. Figure 7 shows measurements taken around midday on a sunny day overlaid on a cross section of the structure and illustrations of occupant activity. Study of how visitors used this pavilion provided instructive observations of the freedom of choice and adaptive opportunities that occupants have in such a space, essentially an outdoor space, compared to formally enclosed indoor spaces.

In terms of site location, all of the selected buildings would be classified as urban with about half relatively free from major site obstructions. The other half could be seen to suffer from heavy obstruction from adjoining structures in ways that could affect both daylighting and ventilation. Four of the buildings were of deep plan form with spaces on different floors providing variants of the problem of daylight penetration and distribution in such plan forms. In combination, the fieldwork and use of simulation tools provided the means for testing most of the common rules-of-thumb given in textbooks, as relating to natural ventilation and daylighting. Clearly, none of these rules-of-thumb applied to the actual buildings in the generic form stated in the textbooks and this was one of the lessons of these building studies. Site conditions, plan depth and glazing ratios provided starting points for extensive sets of parametric studies on the effect of external and /or internal obstructions and other design parameters. In densely occupied

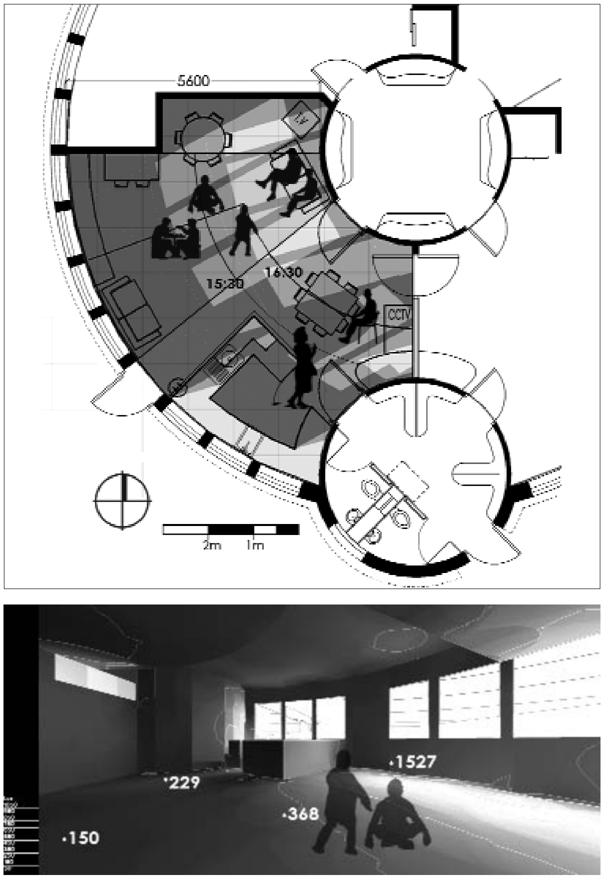

Figure 8: Simulated daylight and sunlight penetration in a primary school play room.

work environments with occupants in fixed positions, daylight is commonly desirable whereas direct sunshine can be a nuisance seasonally or permanently. This issue was studied in most of the selected spaces that had access to sunshine. For example, the classrooms of the primary school shown in Fig. 5 faced due south with fully glazed elevations largely unobstructed. These features suggested a clear intention by the designers to admit direct sun, a critical decision underlined in this case by the presence of both internal and external solar protection on the southern elevation. A less critical example, from the same school, is depicted in Fig. 8 with simulated solar penetration and daylight levels. In this space which is used for play rather than as a formal classroom occupants may seek or avoid the sunlit areas for as long as they have choice of movement. By contrast a densely occupied classroom or studio with fixed sitting positions affords much less freedom of movement making certain spatial positions as well as particular times of the day and year more susceptible to occupant discomfort and complaint.

The issues and findings of these building studies have provided the starting points for the formulation of team programmes and individual design research agendas that are currently being pursued in different urban contexts and climatic regions.

CONCLUSION

Overall the range of building types and spaces studied provided comparative quantitative and qualitative information encompassing most common spatial and constructional configurations in non-residential buildings. The undertaking of parametric studies has extended this range much further. Through this process that combined theoretical, empirical and analytic inputs driven by the demands of the project students were able to gain insights that are not available through any single means of learning. Further insights were obtained on knowledge that is tied down to specific contextual conditions and knowledge and data that can be made applicable more widely. Such generalisable knowledge was obtained on several parameters that affect the thermal and lighting performance of buildings.

ACKNOWLEDGEMENTS. The illustrations in this paper are from Autumn Term 2008-09 projects on the Masters programme in Sustainable Environmental Design. With thanks to Architype Architects, Building Design Partnership, ECD Architects, Edward Cullinan Architects, Fulcrum Consulting.

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