From Drawing Board to Occupied Space:
Assessing the design process of a transformational learning space

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ABSTRACT: The aim of this research is to identify how a successful special needs school was designed through building monitoring and post occupancy, evaluation over the coming year(2009). The paper outlines the research methodology that will be followed to evaluate the design against the predicted assumptions and the actual occupied building. The questionnaire based post occupancy evaluation will further inform the accuracy of the design prediction and identity the design gaps in the construction process. It is assumed that the results will inform the design community and improvise the way designers predict comfort and user patterns in a special needs school in UK.
Keywords: energy, comfort, school, post occupancy.

INTRODUCTION
Michael Tippett, situated in Lambeth, is the first Special Education Needs (SEN) school to be built under the Building Schools for Future BSF programme, in London.

The school was originally located on two sites, but now has been relocated and rebuilt on a single site (Fig. 1 & 2). The new school provides a successfully unified learning environment for 80 pupils. The facility features teaching spaces, group activity and meeting rooms, along with hydrotherapy pool, a sensory room and therapeutic colour schemes, to help the special students to easily find their way around the building.

Designed by Marks Barfield Architects, the school recently won the "Best Design award for a New School" (excellence in BSF Awards 2008) in UK and has been highly regarded as a *transformational and inspirational learning space*. It was completed on budget and in record time, 21 months after the design was commissioned and only nine months after work started on site. The school has been occupied since February 2008.

The aim of the paper is to identify how this successful school was designed and outline how we propose to evaluate the design, over the coming year (summer of 2009) against the result of the built school, followed by a post occupancy evaluation.

RESEARCH OVERVIEW AND TIMELINE
The aim of the study is to evaluate the performance of the school building through building monitoring and post occupancy evaluation. The evidence based information will be shared in the industry. The evaluation will be carried out in two ways. First, the performance of the building will be monitored based on three parameters: energy consumption, environmental impact and occupant satisfaction.

Then the pre construction environmental and energy modelling results will be compared, against the monitored results obtained from the actual built structure and energy data.

Second a post occupancy evaluation will be carried out, to determine the occupant's response to the new building, against the aim of the design team.

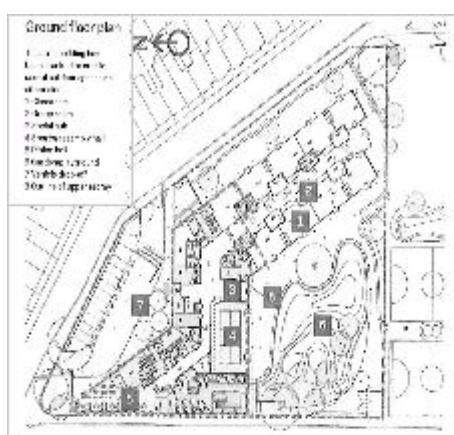

Fig. 1: Site Map and Floor Plan.

The study will be undertaken in summer of 2009, from May till September. Being a Special needs school, the teaching spaces will be fully occupied during these months.

This paper will act as a briefing paper, identifying the objective, scope and the methodology of the study. After the study and analysis haven been undertaken, in the course of 2009, a second paper will be written with the results.

The Poe Methodology followed would be:

Information		**Source**	**Tools**
Design	Design Features	Architect, Facilities Managers, Engineers, Teachers	Interview, Email
Energy Audit			
Fuel Bill Analysis	Gas and Electricity Bills Usage	Bills	
Space Heating	Boiler specification		
	Controls and BMS	observation	Walk by survey, talking to facility managers
	Radiator and User control	observation	Walk by survey, talking to facility managers
Natural ventilation	Window types and Controls	Observation, facility managers,	Walk by survey, talking to facility managers
		occupants	questionnaire
Lighting	Light & Controls	Observation, facility managers, occupants	Walk by survey, talking to facility managers
	Blinds	occupants	questionnaire
Environmental Audit			
Internal Environment	Temperature, humidity, light levels	Field measurements	Data loggers, spot reading taken manually,
Water	Water consumption	Bills	
Waste	Recycling method	Observation, facility managers, occupants	Interview, questionnaire
Travel Impact			questionnaire
Occupants Satisfaction Survey			
Comfort	Thermal comfort, noise, air quality	occupants	questionnaire
Controls	Heating, lighting , ventilation	occupants	questionnaire

BACKGROUND

INVESTMENT IN WORLD CLASS SCHOOLS

BSF was launched by the Department for Children, Schools and Families (DCFS) in February 2003 to rebuild or upgrade England's secondary schools. It is the largest single capital investment programme in schools in England for 50 years. Its aim is to ensure world class learning environments be built, which will support current and future generations of young people to achieve their full potential [1].

Most school building built in United Kingdom are from Victorian age. There are examples of recent schools

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Fig. 2: Model of the project (Street view).

Designs, but nevertheless the running cost of these building are very high, due to high energy bills. In 2007, £425 million was spent by schools on energy and water bills (approximately £60 per pupil per year) [2].It is important to consider how energy and water, and ultimately money could be saved by investigating how and where energy and water is used. UK government also aims all new homes and schools to be zero-carbon by 2016, and all new public sector buildings by 2018.In this backdrop, London Borough of Lambeth under the partnership with Building Schools for Future (BSF) program, has acquired government funding of 200£M in two waves to implement *classrooms for the future* into reality.

To strengthen and support the BSF programme, Department for Children, Schools and Families (DCFS) has published design guidance - Building Bulletin 101 (BB101)- 'Ventilation of School Buildings.' [?].This guidance provides additional framework, in support of the Building Regulations, for providing ventilation and avoiding overheating in school buildings in line with the 2006 editions of Approved Documents (AD) F and L of the Building Regulations in United Kingdom [4].

According to Building Bulletin 101 (BB101) the performance standard is in compliance with the new Building Regulations Part F (Ventilation) in England and Wales. In BB101 CO_2 concentration has been chosen as the key performance indicator of the indoor air quality and ventilation in schools.The recommended ventilation performance standards are as follows:

1. The average concentration of CO_2 should not exceed 1500 ppm during occupied hours.
2. The maximum concentration of CO_2 should not exceed 5000 ppm during the teaching day.
3. At any occupied time, including teaching, the occupants should be able to lower the concentration of carbon dioxide to 1000 ppm.
4. Purpose provided ventilation in naturally ventilated buildings should provide an external air supply to all teaching and learning spaces with (a) a minimum of 3 l/s per person (litres per second per person), and a minimum daily average of 5 l/s per person, and the capability of achieving a minimum of 8 l/s per person at any occupied time.
5. Purpose provided in mechanically ventilated buildings should provide external supply air to all teaching and learning spaces with a minimum daily average of 5 l/s per person. In addition, it should have the capability of achieving a minimum of 8 l/s per person at any occupied time.

Section 8 gives the recommended standards for compliance with Building Regulations Part L for the avoidance of summertime overheating.

The recommended overheating standards are as follows:
The performance standards for summertime overheating in compliance with Approved document L2 for teaching and learning areas are:
a) There should be no more than 120 hours/ annum when the air temperature in the classroom rises above 28°C.
b) The average internal to external temperature difference should not exceed 5°C (i.e. the internal air temperature should be no more than 5°C above the external air temperature on average).
c) The internal air temperature when the space is occupied should not exceed32°C.

In order to show that the proposed school will not suffer overheating two of these three criteria must be met.

Day lighting criteria:
Only the schools under the BSF (Building Schools for future program has to comply with the BB101 performance criterion using TRY (Test Recommended Year) weather data.

DESIGN AIMS FOR MICHAEL TIPPETTS' VISION

The design aim was to create an exemplar school in an urban context. To achieve this overall aim the following goals were established:

- To create an exemplar environment in which pupils will be proud to learn and work;
- To create a sense of belonging and inspiration among the building users so they will be proud to be there everyday.
- To provide a building that people will care for and want to look after inducing a sustainable lifestyle and awareness.
- To incorporate features which are simple and that enhances the day to day function and use of the school..

POE OF SCHOOLS

Under the DCSF, different post occupancy evaluation has been undertaken in schools throughout the UK.

In 2006 the DCFS published Design of sustainable schools: Case Studies in the Schools for the Future series. This includes a series of case studies of recent schools that had sustainability as a main driver for their design. The authors used post-occupancy evaluation to assess the success of the designs and the book describes the various methods of POE available at the time.

The Sustainable Schools Strategy introduced by the DCSF, addressed the National Framework for sustainable development through 8 'doorways' linked to the campus, the curriculum and the community.Recently through Student Works a post occupancy evaluation tool has been introduced which is still in development. The Design Quality Indicator for schools is another method available to evaluate the design and construction of new school buildings and the refurbishment of existing buildings.

From all these documents and the ongoing work it is clearly stated that most schools in UK are facing a challenge to make better teaching spaces and ongoing research and studies are being undertaken to enhance our knowledge and understanding of this issue.

BUILDING DESIGN CHARACTERISTICS

The architectural focuses on flexibility, adaptability and functionality in design project. Particularly the proposed form attempts to pull away from a deep plan design of a typical school, to deliver a sensitive building, with an enhanced internal environment flooded with natural daylight and natural ventilation. The “drawing board design” therefore considered several areas which could be used to improve the schools design.

FORM AND ORIENTATION

After considering 21 design options, the specific design was selected because of its flexibility and adaptability with the present curriculum and probable future extension (Fig. 3). The elongated North South orientation selected aids in meeting the BB101 daylight criteria for classrooms, where each class room has 4% Average daylight factor (ADF). Instead of a 2.7m traditional ceiling height, the classroom opens into an airy void lit by clerestory windows (Fig. 4).

NATURAL VENTILATION AND DAYLIGHT

It is a naturally ventilated building. The teaching spaces have adequate height that helps with natural ventilation as well as daylight. Most of the class rooms have double sided ventilation with operable windows (Fig. 3 & 4).

Fig. 3: Internal view from Classroom.

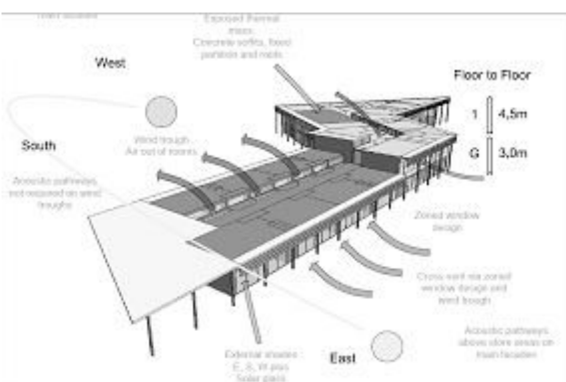

Fig. 4: Thermal Modelling Study

VISIBILITY AND OPENNESS

The old school had low ceiling heights, in comparison the students and the teachers wanted an openness and visual connection with the surrounding environment The facade design gives special focus to creating a visual connection between the internal teaching spaces and the external view (Fig. 4).

Fig. 5: External coloured fins.

SOLAR CONTROL

Solar control was needed to reduce the solar gains in the spaces. Colourful fins were added on the external façade that acts both in giving shade and also creating a playful effect on the facade. The architects specified fins with three vibrant colours, orange, red and purple, making a bold statement to the surrounding area (Fig. 5). Solar glass is utilized on both the east and west facades

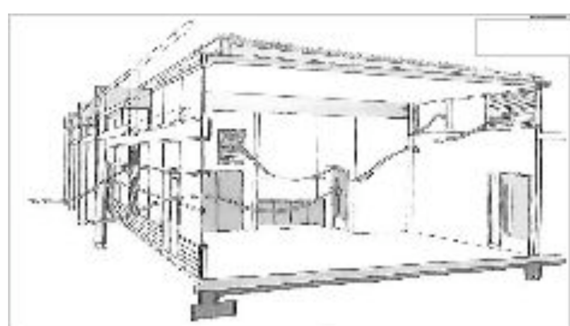

Fig. 6: Section through Classroom.

MATERIALS AND EMBODIED THERMAL MASS

Locally sourced materials with low embody energy, which are robust and user friendly were chosen to aid in the environmentally friendly nature of the building and construction. U values used in the construction are below:

Glazing U = 1.60 Ww/m2.K – composite timber, argon fill, soft low E coat
Ext walls U = 0.25 W/m2.K – can be low mass
Roof U = 0.16 W/m2.K – with exposed thermal mass (concrete)
Floor U = 0.16 W/m2. K
Fixed U = n/a – with high thermal mass

NOISE ATTENUATION

The site is situated on a noisy road. The classrooms were located away from noise sources such as the road to minimise acoustic measures where possible. Noise attenuation via secure louvers and attenuated pathways were incorporated (Fig. 1). Less sensitive spaces or mechanically ventilated spaces were positioned closer to the noise sources.

ICT

The ICT space is located in a large double height space to vent heat gains away from the occupants and to avoid the need for mechanical cooling.

MODELLING RESULTS

OVERHEATING

Analysis was performed on the design to check whether it complied with BB101 overheating requirements. The design allows the exposed thermal mass of the ceilings to be used to retain heat during the winter and store coolth at night during the summer. The result of this analysis is shown below (Table 1).

Table 1: Predicted overheating results

	Tres Hrs > 25 degC	Tres Hrs > 28 degC	Comment
East class	86	7	Best result
West class	77	6	
Hall	88	8	All tested spaces perform very well with a nat vent scheme
Single story corridor	27	0	
IT library	42	0	
Dining	93	11	
Admin office (s/s vent)	121	7	
Music drama	95	13	

DAYLIGHT RESULTS

From the daylight analysis, it was identified that most of the teaching spaces meet the Average Daylight Factor (ADF) of 2.5% or better.

ENERGY

A target was set to reduce the energy demand of the school to 60% against the 1990 baseline. Initially three different energy strategies were suggested but at the end, the most effective energy strategy was chosen for the SEN School. A mini gas fired CHP with 60% heat recovery from mechanical ventilation was included in the design. This provides 13.4% savings on Carbon Emissions against a good practice school.

The project meets the London Planning- Part L criterion for reducing carbon emission. The predicted carbon dioxide emission rate is 19.99kgCO2/m^2 per annum. This means that the Building Emission Rate (BER) for the proposed building is less than the Target Emission Rate (TER) and thus complies (refer to table 2)

Table 2: Predicted CO_2 Emission of the building.

Notional Emission Rate	27.54 kgCO2/m2	Improvement Factor
Target Emission Rate	20.90 kgCO2/m2	LZC Benchmark
Actual Building Emission Rate	**17.70 kgCO2/m2**	

DESIGN ASSESSMENT

As mentioned earlier in this paper the success of this schools design will be assessed based on two methods.

ENVIRONMENTAL PERFORMANCE

By comparing the environmental analysis undertaken during the design stage against environmental readings obtained from the functional school.

OCCUPANT'S EVALUATION

By using a set questionnaire, the user's responses, views and opinions about the school will be assessed against the design aims.

ENVIRONMENTAL PERFORMANCE

Temperature, CO_2 and daylight sensors will be used to measure both internal and external environments over a two week period in both summer and winter terms. The results will be compared against those expected based on model of the building at the design stage. The readings will also be used to validate the BMS strategies implemented by the functional building.

BMS monitors/ observe controls from the working building will also be used to make comparisons with the energy consumption figures estimated at the design stage of this building project.

Spatial quality and occupants satisfaction surveys will be undertaken in key selected spaces, as a sample for the entire school. These areas will be as follows:

- A typical class - South elevation
- A typical class - North elevation
- The atrium - Double height ICT space & common room a typical corridor.

OCCUPANT'S EVALUATION

Keeping in mind that these are a special need schools, a group interview/ discussion session might be more effective to understand how the students use the building. All occupants of the class rooms will be asked to complete a post occupancy evaluation based on their experiences of the school. The degree and level of this evaluation will depend on the nature of the occupant needs due to the special nature of the school. We will be consulting the teaching staff regarding the matter. A post occupancy questionnaire has been chosen as the best method to evaluate the occupants' opinion of the school building and its internal environment. The questionnaire process will be aimed at three user groups:

- Students
- Teachers
- Facilities manager(s)

The questions will be formulated to suit the different user groups but will focus on the same four key factors of the designed environment, which are as stated below:

- Daylight
- Ventilation
- Thermal Comfort

- Connectivity between internal and external spaces.

This questionnaire will be undertaken, at the end of each two week comparison period. Additionally school management will be asked for their opinions of the school based on their understanding of the design aims the school was based on.

CONCLUSION

This paper has highlighted the key concepts that were put in place to allow the designers and builders of this exemplar school building. The paper has also given details of how we plan to assess the design against the constructed building in terms of both its actual performance and its perceived performance, by its occupants for four key areas are: Day lighting, ventilation, thermal comfort and connectivity with the external environment.

From literature review of all the post occupancy evaluations performed at different times in various schools it has been identified that in most cases, the design was not complementing the users need. As a result a level of discomfort and dissatisfaction was noted. In Michael Tippettt School the pre construction stage dynamic modelling was performed keeping the building user needs in mind. Because the building will be evaluated against the predicted assumptions, it will be easy to identify the design gaps and ways to minimise it.

The post occupancy evaluation will work as a foundation to do comparative analysis of the predicted / simulated comfort and uses, with the reality. It is assumed this will be valuable information for all the designers, to design their buildings with high levels of accuracy for the user usage pattern and comfort levels.

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REFERENCES

1. Department for Children, Schools and Families Evaluation of Building Schools for the Future – 2nd Annual Report, December 2008.
2. Building Schools for Future, Annual Report, 2008.
3. Transforming Secondary Education: Building Schools for the Future and the Academies Programme: Lambeth BSF Education Vision, 2006.
4. Building Bulletin 101, Regulations Standards Design Guidance, July 2006.
5. The London Plan: Spatial Development Strategy for Greater London, February 2008.
6. Chandiwala, S and Gupta R (2007) Post Occupancy Evaluation of Schools, Oxford Brooks University.