Proceedings of 8th Windsor Conference: ***Counting the Cost of Comfort in a changing world*** Cumberland Lodge, Windsor, UK, 10-13 April 2014. London: Network for Comfort and Energy Use in Buildings, http://nceub.org.uk

Occupants' behaviours in controlling blinds in UK primary schools

Azadeh Montazami[1] and Mark Gaterell[2]

1 Coventry University, UK, azadeh.montazami@coventry.ac.uk

2 Coventry University, UK, mark.gaterell@coventry.ac.uk

Abstract

The environmental conditions experienced in UK schools not only influence the effectiveness of teaching and learning but also affect energy consumption and occupant behaviour plays a critical role in determining such conditions. The aim of this study is to understand occupant behaviour in controlling window blinds in UK primary schools which not only mediate internal conditions but also influence the use of artificial lighting and consequently electricity consumption.

Occupant behaviour in controlling blinds against direct solar gain and glare through windows in 140 classrooms of 22 primary schools between 2007 and 2008 was studied through questionnaires, interviews and observations of blind status. Results show that on average blinds are closed very regularly in all the schools except one. This is due to a wish to prevent overheating, reduce glare and also limit the impact of distractions from outside, as some classrooms are located on the ground floor. Such behaviour affects both the effectiveness of teaching and learning and also electricity consumption and consequently a school's carbon foot print. It is also likely to be at least in part responsible for the gap between design the energy consumption predicted at the design stage and that actually experienced when the school is in use. Designers need to understand the implications of this behaviour to ensure they deliver effective, energy efficient spaces that perform as anticipated.

Key words: Occupant behaviour, control, primary school, classrooms, window, blind, curtain

1 Introduction:

Increasing demand for more energy efficient buildings means the construction industry needs to ensure that the energy performance predicted during the design stage is achieved post-occupation. However, evidence suggests that there is a significant gap between design and in-use performance (Demanuele et al, 2010; Bordass et al, 2004; UBT, 2011; Bordass, 2001).

Figure 1 illustrates the predicted and actual electricity consumption in three building sectors: schools, general offices and university buildings. These data suggest there is a significant gap between the predicted and actual electricity consumption in school buildings.

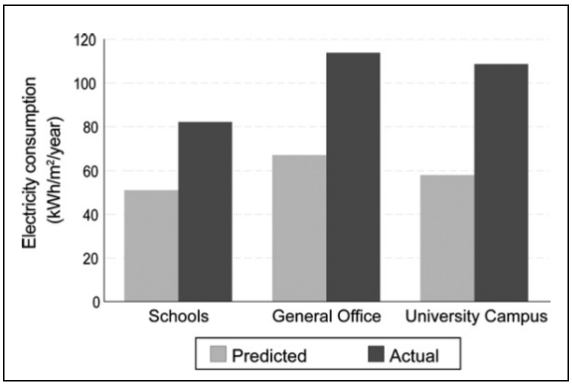

Figure 1. Electricity consumption per-sector – predicted vs. Actual (Menezes, A.C. et al., 2012.)

This gap is attributed to the lack of feedback to designers after handover, inhibiting improvements both to existing buildings and future designs. The practice of Post-Occupancy Evaluation (POE) aims to address this issue by evaluating the performance of a building after it has been built and occupied. Factors that contribute to the discrepancy in energy consumption are model simplification, changes to the building design between making predictions at the modelling stage and final construction, occupant behaviour, commissioning, and maintenance (Demanuele et al, 2010; Menezes, 2012).

The UK Government has committed to reduce CO_2 emissions by at least 80% by 2050, relative to 1990 baseline levels (Global Action Plan, 2006). Currently, there are over 25,000 schools in the UK and in total they are responsible for approximately 14% of the UK public sector's total carbon emissions (Climate Change Act, 2008). The Carbon Trust (2012) reported the energy consumption pattern for schools for both fossil fuels and electricity (Figure 2). According to this report, 16% is due to electricity consumption which is used for hot water, lighting, office equipment etc. with half (8%) used for lighting alone.

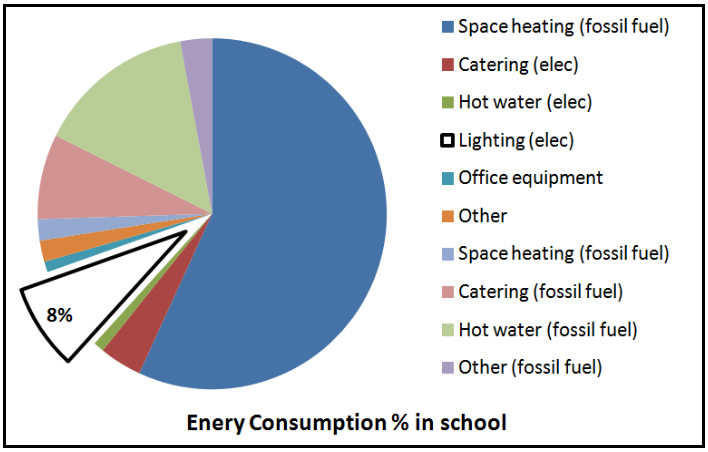

Figure 2. Electricity consumption profile for school (Source: Carbon Trust, 2012)

Exploring the reasons for the gap between designed and predicted electricity consumption is essential because of its high cost and carbon footprint. Also the use of natural light rather artificial light in schools is thought to have a positive impact on student health and performance (Walden.R, 2008).

Although only 8% of the total energy is consumed for lighting in schools (Figure 2), data in Figure 3 suggests the higher unit price and carbon intensity associated with electricity in comparison to fossil fuel energy mean such consumption is likely to account for approximately 20% of the overall energy costs and carbon footprint.

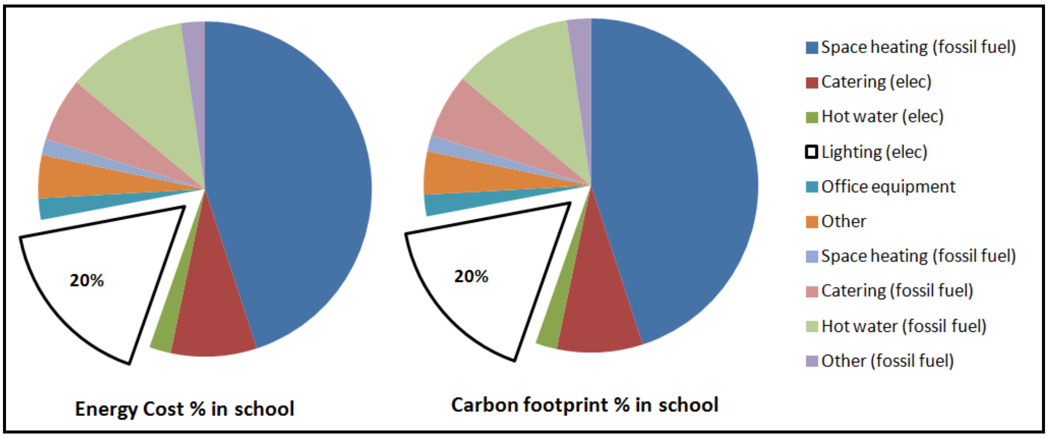

Figure 3. Cost and carbon foot print profile for school
Cost profile (Source: Carbon Trust, 2012) - Carbon foot print profile (drawn by A. Montazami)

The level of natural light inside a building and, therefore, the likelihood of artificial lights being used, depends on the location of windows, window area, surrounding buildings, internal surfaces and occupants' behaviour in controlling blinds (BB90, 2003; CIBSE TM37, 2006). The main reasons for closing blinds in office buildings are visual comfort, thermal comfort and also distractions from outside (Inoue et al., 1988 ; Lindsay and Littlefair, 1992; Reinhart, 2004; Inkarojrit, 2005; Sutter et al., 2006 ; Sutter Y, 2006; Lindelöf and Morel, 2006; Inkarojrit, 2008 ; Foster and Oreszczyn, 2011). Clearly, where such devices are used in ways not anticipated by the building's designers, and result in the use of artificial light, the energy consumption profile is likely to higher than expected. Similar behaviour in schools could account for some of the performance gap outlined above.

It is important to note that not only does the use of natural light instead of artificial light have a significant impact on reducing the carbon foot print and cost for schools, but a good level of natural light also benefits the health and performance of students. A study by Taylor and Gousie (1988) suggests that lack of lighting comfort (in terms of lighting level, glare, spectrum etc) has a negative effect on students' physiological and psychological functions such as neuron doctrine functions, hyperactivity and task behaviour. Good natural lighting can only be achieved by combining direct and indirect lighting (Barnitt, 2003; Butin, 2000) and lighting controls such as blinds to provide an opportunity for adjusting lighting levels in classrooms (Butin, 2000). One of the main benefits of natural light is that it consists of all light spectra (full spectrum). Lack of adequate levels of light can increase fatigue, headaches and also damage eyesight, while a light which is too bright also has a negative impact on well-being. Glare can lead to diminished vision and headaches resulting from overexerting the eyes (CIBSE KS6, 2006). It has also been found that illness and mental fatigue can be reduced by the use of full spectrum natural light especially on children with hyperactivity disorder (Dunn et al., 1985). Performance improves in the presence of daylight and its positive effects are manifested in better social behaviour. There is a significant relationship between students' academic attainment and natural daylight. Children's attention increases (Ott, 1976) and student absenteeism decreases (London, 1988) as a result of full spectrum natural light. According to the study carried out by Collaborative High Performance School (CHPS, 2006), students in well-lit classrooms had higher scores (up to 26%) on the New Stanford Achievement Test in comparison with the ones in poorly lit classrooms.

Through the study of occupant behaviour in controlling blinds in London primary school classrooms, this paper aims to understand why such devices are used, the potential implications of their use on light levels and consequently their likely role in the gap between predicated and actual electricity consumption. It also considers how occupant control affects various comfort factors and thereby influences our ability to deliver well-lit classrooms that increase students' productivity with the minimum carbon and financial cost.

2 Methodology:

This study is based on a case study approach using post occupancy evaluation (POE) and quantitative research techniques such as observation, taking photos and conducting interviews in the cooling seasons (i.e. June and July) of 2005, 2007 and 2008. The aim was to evaluate occupant behaviour in controlling blinds and the usage of windows in controlling overheating and glare during cooling seasons.

The UK school stock is a mixture of schools constructed in different eras with different characteristics (i.e. solar gain, thermal mass, ventilation potential, internal gain). The stock has previously been characterised in terms of Victorian, open-air, post-war and post-energy crisis schools (Montazami and Nicol, 2013). In this study 22 schools constructed in these different eras were selected (i.e. four Victorian, four Open-air, four Post-war and eight Post-energy crises) from three London boroughs of Hounslow, Haringey and Islington.

140 teachers from the selected classrooms participated in this study completing questionnaires during 2007 and 2008. Between one to ten questionnaires were filled out in each school. Unfortunately, the teachers of some schools refused to fill out the questionnaires both in 2007 and 2008. Interviews and the taking of photos of the teachers' behaviour in controlling blinds and the usage of windows were carried out by the lead author in 2005, 2007 and 2008. Table 1 shows the name of schools which participated in this study according to the era of the schools, the level of thermal mass in each school, the mode of ventilation and also the number of questioners filled out by the teachers in both 2007 and 2008.

Table1. School information and number of questioners filled out by the teachers in 2007 and 2008

Era		Victorian				Open air			Post war					Post energy crisis									
Schools		AM	CL	FL	HF	CR	HS	WL	HL	NW	RO	MF	OC	AN	GC	SG	GR	LD	PP	MM	BR	BF	NT
Thermal mass		Heavy Thermal mass				Low Thermal mass								Meduim Thermal mass									
Ventilation Natural (N) / Mechanical (M)		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	M	M	N
2008	Numbers of Questionnaires	5	3	4	3	3	3	5	1	3	2	10	9	5	0	0	5	0	0	5	3	1	5
2007		0	0	6	4	6	0	3	0	5	0	0	0	8	0	0	6	3	0	9	3	6	6

The questionnaires focussed on collecting data on teachers' perceptions regarding the internal environment (i.e. thermal comfort, visual comfort, acoustic comfort and air quality), teachers' behaviour in controlling blinds, the reasons for closing blinds and also their level of control over the internal environment. The research questionnaire was based on that designed by 'Usable Building Trust' to evaluate the environmental conditions in offices. This questionnaire was the most relevant as it is can reflect the occupants' feelings regarding their internal environment. Observation has been used in a variety of disciplines as a tool for collecting data (Kawulich, 2005). In this study, observation followed by taking pictures is used as a method to record the teachers' behaviour in using windows in 9 out of the 22 schools.

Figure 4 shows the sets of questions designed to evaluate the internal environment factors in general.

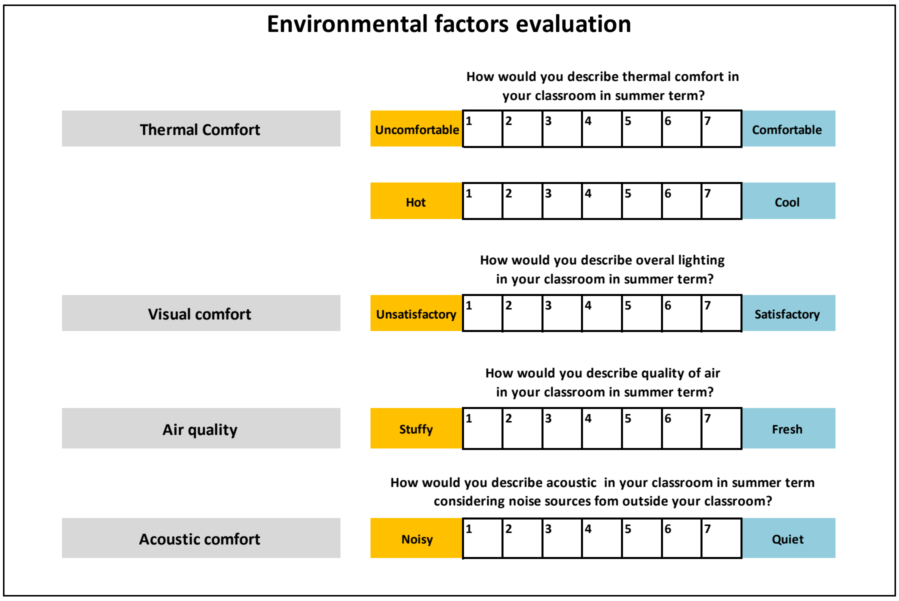

Figure 4. Lickert scale questions to evaluate environmental factors

Figure 5 shows the sets of questions designed to evaluate occupant behaviour in controlling blinds and the reasons for such behaviour.

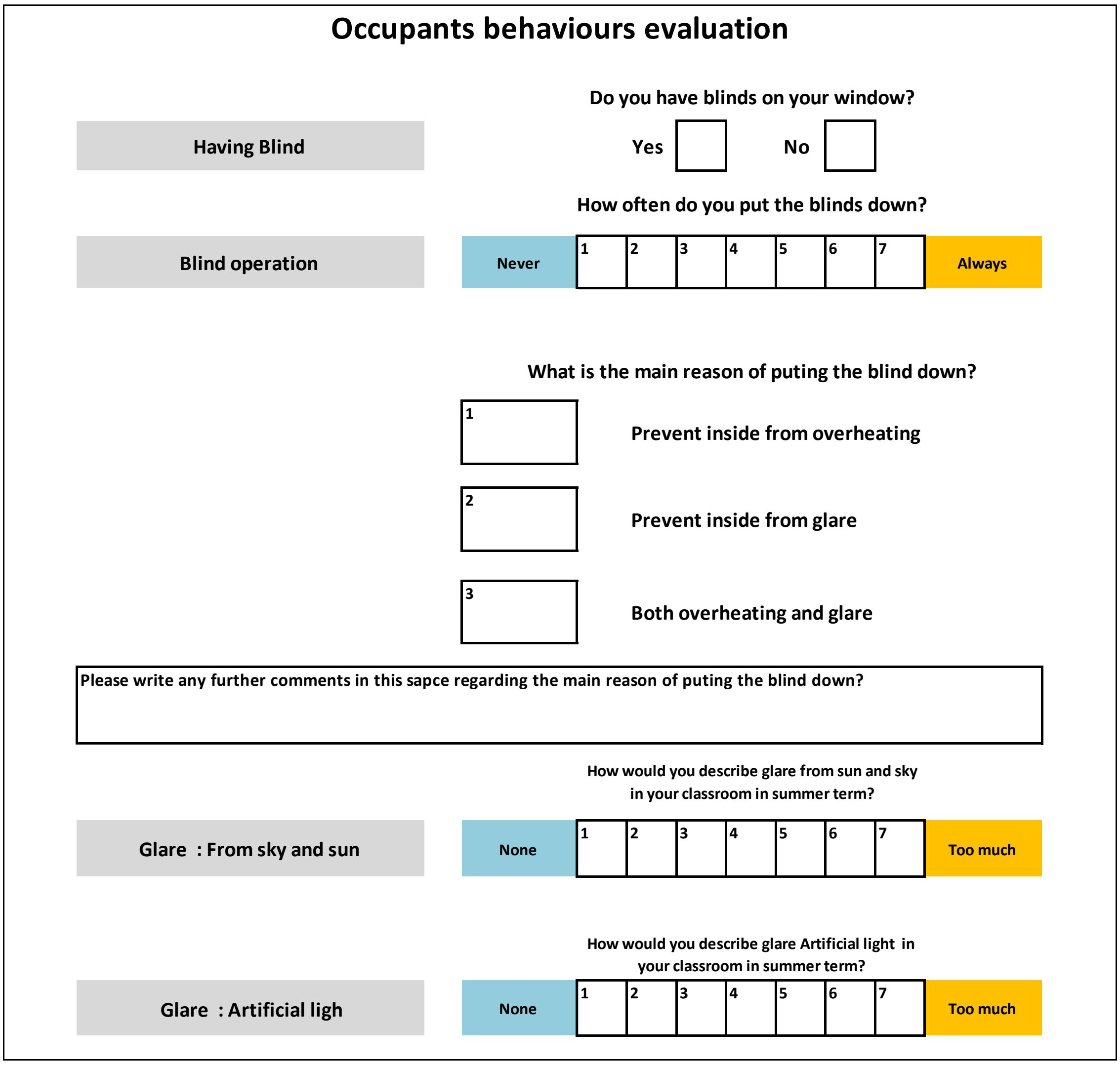

Figure 5. Questions to evaluate occupant behaviour in controlling blinds.

Figure 6 shows the sets of questions designed to evaluate occupant control over the internal environment.

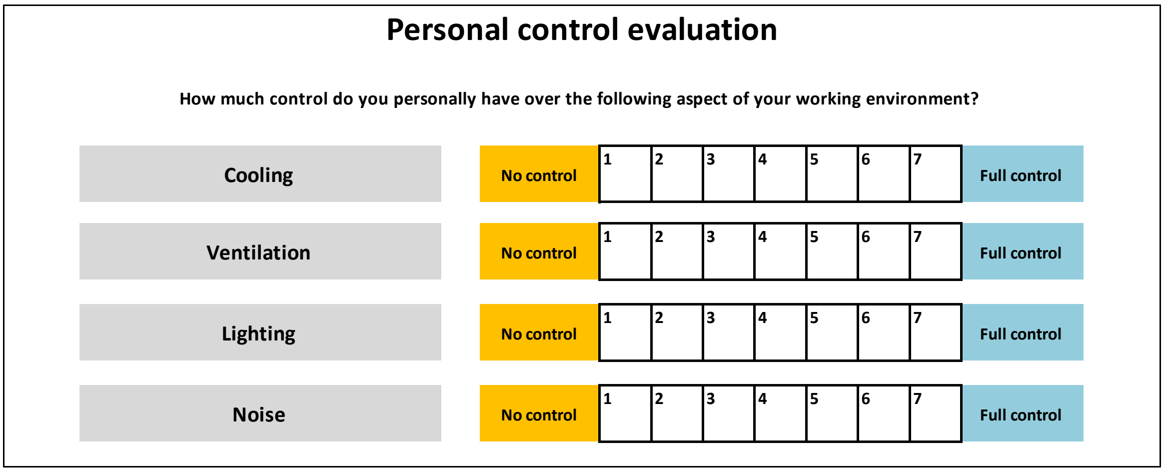

Figure 6. Questions to evaluate occupant control over comfort factors.

3 Analysis:

In this study, occupant behaviour in controlling blinds was studied followed by an examination of the reasons for such operation. The occupants' usage of windows was also monitored. The level of occupant control over lighting comfort was compared with the level of control over other comfort factors in order to understand areas where a compromise between comfort factors occurs and the potential implications for any gap between design and in-use energy performance.

3.1. Factors which impact on occupant behaviour in controlling blinds

The authors studied the occupants' behaviour in controlling the blinds in 20 primary schools during the cooling seasons (i.e. Jun and July) of 2007 and 2008. In this study, out of 140 classrooms, 110 classrooms had blinds. Eleven out of sixteen schools which had blinds participated in this study in both years.

Figure 7 shows the frequency of movement of blinds in the 110 classrooms from 1=Never to 7=Always. As can be seen, the average frequency of closing the blinds in all of these classrooms (except one classroom of one school) was more than 4 and are towards 7=Always.

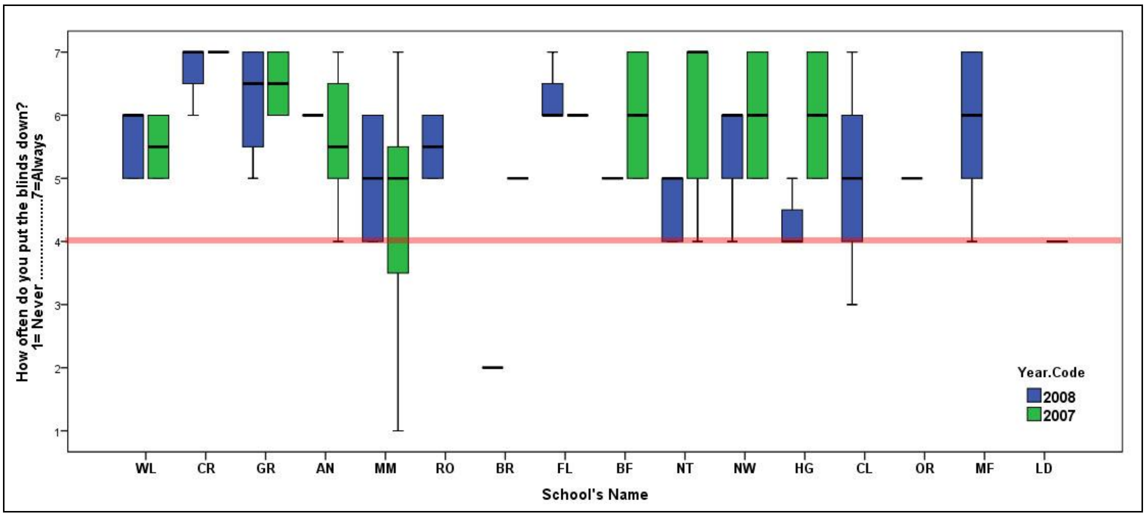

Figure 7. Occupants' behaviour in controlling blind in 110 classrooms.

A Paired sample T test was carried out between the frequency of occupant behaviour in operating blinds in 2007 and 2008. The result shows that there is not a significant difference between occupant behaviour in both year ($p= 0.084>0.05$).

Questionnaires were distributed among teachers to determine the reasons for putting the blind down. 51% of teachers suggested the reasons were a mixture of preventing glare and overheating while 22% believed use of the blind was only related to glare and 5% linked it only with overheating (Figure 8).

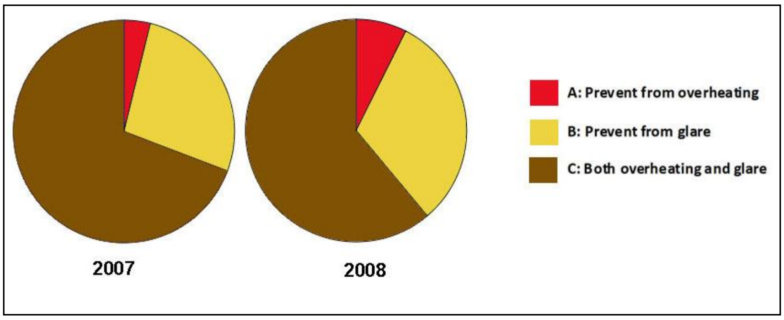

Figure 8. Reasons for putting the blind down in 110 classrooms.

In order to explore the relationship between teachers' perceptions regarding blind operation and both overheating (i.e. thermal comfort) and glare (i.e. visual comfort) as the reasons for putting the blind down, two regression analyses were carried out. The first was between the teachers' perceptions regarding the blind operation and teachers' perceptions regarding thermal comfort inside the classroom and the second was between the teachers' perceptions regarding the blind operation and teachers' perceptions regarding experiencing glare inside the classroom. The results show that there is a significant relationship between the frequency of putting a blind down and both overheating (n=110, $p= 0.003<0.05$, $R^2=0.07$) and experiencing glare (n=110, $p= 0<0.05$, $R^2= 0.14$). According the above regression analyses, experiencing overheating and glare explains 7.5% and 13% of occurrences of putting the blind down respectively.

According to the teachers of these schools, as well as overheating and glare, distractions from outside, particularly where classrooms are located on the ground floor, were also a reason for operating the blinds. Table 2 summarises some comments from the teachers from various schools explaining the reasons for blind operation.

Table 2. Reasons for blind operation according into the interviews.

Primary schools	Teachers' comments
Norwood Green	'Glare from sun on interactive white board decrease productivity, Ceiling ventilation system (Skylight) causes glare on IWB'.
Hungerford	'Cannot see the Interactive White Board. Too much glare, Too much sun light and having to have curtain all the time. Mostly the class dull'
Grove Road	'Much better in a classroom with overhead blind. During smart board work during specific times of the day, there is too much natural light to have it. (Blind down) Completely dark and optimal viewing'.
Feltham	'Can not see IWB'.
Cranford	'Light shines through the blinds making it very hot and very difficult to see the board.
Berkeley	The reason that I put the blind down is to stop parents / children peering into the classroom'.

These results suggest the three main reasons for putting blinds down are overheating, glare and distractions from outside. These findings concur with those from previous research which focused on office buildings (Inoue et al., 1988; Lindsay and Littlefair, 1992; Reinhart, 2004; Inkarojrit, 2005; Sutter et al., 2006; Sutter Y, 2006; Lindelöf and Morel, 2006; Inkarojrit, 2008; Foster and Oreszczyn, 2011).

Putting the blinds down has some consequences on the electricity consumption in schools as this encourages the occupants to keep the artificial lights on most of the time in order to provide sufficient light levels on their working plane. Images in Figure 9 were taken during a break in two of the above schools. As can be seen, during the study session the blinds had been put down and the artificial light are on.

Figure 9. Implications of putting the bind down in classrooms on the use of artificial light.

[(Left: CR primary school, Right: SG primary school)] (Taken by A. Montazami)

The level of glare from artificial light and natural light was also compared in Figure 10. The results suggest that, according to the teachers' perception, occupants mainly suffer glare from natural light rather than artificial light.

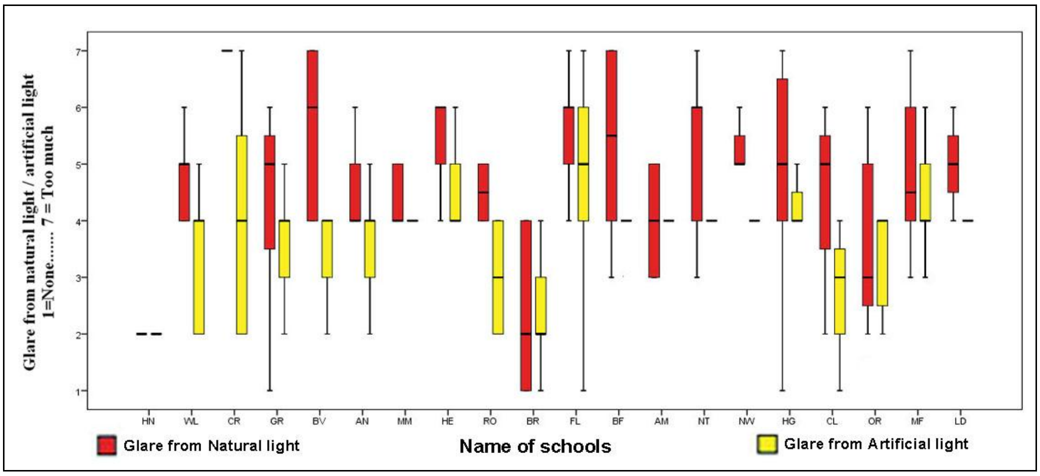

Figure 10. Glare problem as the results of natural and artificial light

The glare problem in classrooms is sometimes related to that which appears on the whiteboard or computer screen.

3.2. Occupant behaviour in controlling blinds in schools constructed in different eras

In order to understand how school design has an impact on occupant behaviour in controlling blinds, an ANOVA T-test was carried out between the teachers' behaviour in controlling blinds in the schools constructed in four different eras; Victorian, open-air, post-war and post- energy crisis. All of these schools are selected from the ones which are naturally ventilated. The results show that there is a significant difference between the occupants behaviour in controlling blinds in these 4 groups schools ($p= 0.045< 0.05$). As can be seen in Figure 11, although the frequency of putting the blinds down in all four groups is more than 4 and has a tendency to 7=Always, there is a degree of difference between them. The tendency of putting the blind down in post energy crisis schools is approximately 5 with the standard deviation of 2, while the tendency of putting the blind in Victorian, open air and post war schools is approximately 6 with the standard deviation of 1. One likely reason for such difference is due to the window areas in Victorian, open-air and post- war schools being significantly larger in comparison with schools constructed after the energy crisis in the 1970s.

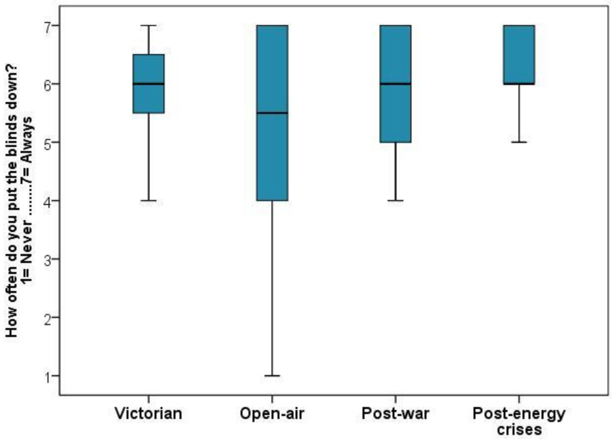

Figure 11: Occupants' behaviour in controlling blind in four groups of schools.

Victorian schools built from 1837 to 1901 have large sash windows which extend to the high ceiling (Robson, 1979). Open air schools constructed in the early part of the 20th Century (1900 – 1939), had large windows due to concerns over the spread of tuberculosis (Wilmor and Saul, 1998), In Post-war schools, constructed after World War II, large windows were employed because natural light was regarded as the main source of illumination. Indeed, guidelines created in 1945 recommended 2% day light factors with the possibility of increasing this to 5% (Stillman, 1994). In contrast, schools constructed after the energy crisis of the 1970s placed greater emphasis on reducing window size as a means of controlling heat loss (Edward, 2010).

3.3. Occupant behaviour in the usage of classroom windows

Based on the authors' observation of 20 schools that were conducted in 2005, 2007 and 2008 internal surfaces of classrooms (walls and windows) are used to display students' work and educational materials. These occupant behaviours (both teacher and students) have a negative impact on the internal environment (i.e. visual and thermal comfort). According to the study carried our by Montazami et al (2012) there is a relationship between occupant behaviour on the usage of classroom walls and the level of overheating in UK schools classrooms. As can be seen from Figures 12, a large area of the windows is covered with students' works which means teachers keep artificial lights on most of the time to compensate for the low level of natural light.

Figure 12. Classroom windows are covered with the student work and artificial lights are on.

(H.O Primary School) (Taken by A. Montazami)

It should be noted that in some cases teachers put the students' work on the window consciously. This is one of the teacher's quotes in this regard 'Although this classroom doesn't have any blinds the windows are covered with students work to prevent glare'.

Figure 13 shows windows of 9 classrooms. As can be seen, windows are covered with students' work which again has a negative impact on internal light levels.

Figure 13. Classroom windows covered with the students works (Taken by A. Montazami).

3.4. Comparing the level of control over lighting comfort to other comfort factors.

According to Nicol et al. (2012), the adaptive approach to comfort is based on the Adaptive Principle whereby ‘if a change occurs such as to produce discomfort, people react in ways which tend to restore their comfort’. Indeed, Bauman (1999) suggests that by giving occupants individual control over the environmental conditions in their workplaces, and the opportunity to adapt, designers and facility managers can help increase worker satisfaction and productivity.

In this study, teachers’ perceptions regarding thermal comfort, lighting comfort (with sources of natural and artificial light), acoustic comfort (with noise sources both outside and inside of school) and also the level of control over these comfort factors were explored on the likert scale. The internal environment was questioned through likert scale of 1= Uncomfortable-Hot/Noisy/Light dissatisfaction/ Stuffy and 7=Comfortable-Cool/ Quiet/ Light satisfaction / Freshness. The level of control was also questioned through likert scale of 1=No Control and 7= Full control.

Regression analysis was carried out between the perception of teachers over the level of control and the quality of the internal environment (Table 3). As can be seen there is a significant relationship between the levels of control and the quality of the internal environment.

Table 3. The relation between internal environment and the level of comfort

Control levels vs Internal environmnt	Thermal comfort Uncomfortable (1)...Comfortable(7) Summer	Noise from outside Noisy (1)...Quiet(7) (Source : Outside and inside school)	Overall lighting Unsatisfactory(1)...Satisfactory(7) (Source: Natural and artifitial light)	Air quality Stuffy (1)...Fresh(7)
Cooling control	P<0.05 (Significantly related)			
Noise Control		P<0.05 (Significantly related)		
Lighting control			P<0.05 (Significantly related)	
Ventilation Control				P<0.05 (Significantly related)

Figure 14 shows the levels of control and corresponding quality of the internal environment. As can be seen, the level of control over lighting comfort is higher than control over other comfort factors and also the occupants' satisfaction over lighting comfort is also higher (highlighted in red).

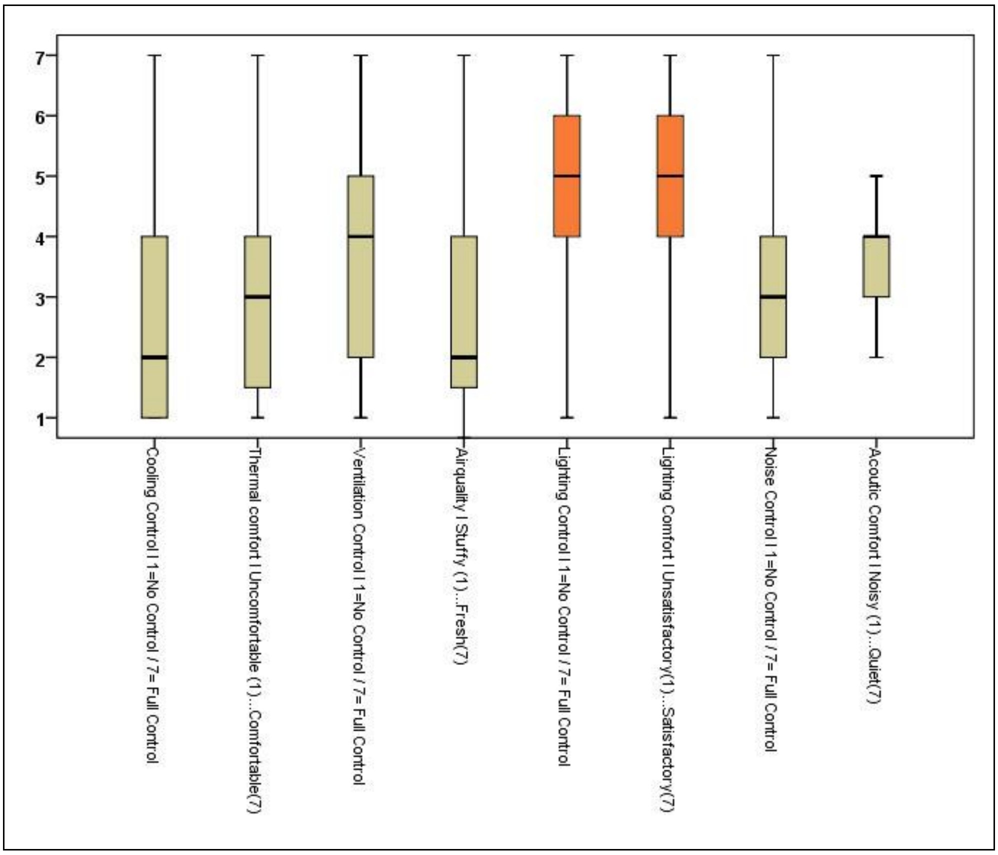

Figure 14: Level of control vs internal environment

It can be argued that although the there is a higher level of control over lighting comfort and a higher perception about the quality of visual comfort, there are some hidden implications as the result of high level of control and poor window design that should be considered. For example, occupant behaviour in putting the blind down and the resulting lower level of natural light has a negative impact on students' health/performance and a higher level of energy consumption (i.e. using more artificial light) with a concomitant rise in carbon footprint and energy costs.

Blinds are one of the components that should be considered carefully during window design. For example, in classrooms that face east and west, vertical blinds should be considered while in classrooms facing south, horizontal blinds, light shelf or overhanging window reveals are likely to be more effective. In addition, the occupants' behaviour in controlling blinds should form part of this procedure. Having horizontal blinds on east and west facing elevations or on classroom windows that face onto busy areas of a school means teachers are likely to keep them down most of the time (in order to prevent glare, overheating and also distraction) with the consequences outlined above.

4 Discussions:

This research set out to understand how teachers use devices such as blinds to control their internal environment, the potential implications of their use on light levels and consequently their likely role in the gap between predicated and actual electricity consumption.

Results suggest that the frequency of putting blinds down in 99% of classrooms was towards 'always' according to the teachers' perceptions. This study also illustrates that there is a higher tendency for putting the blinds down in Victorian, open-air, post-war schools in comparison to post-oil crisis schools due to the likelihood of the former having larger windows.

According in to this study, the main reasons for such behavior were preventing glare, reducing overheating and limiting distractions from outside. This study also illustrates that school teachers use the classroom window as a place to display students' work sometimes as a conscious decision to reduce the glare, overheating and also distractions from outside.

This study highlights that the two likely implications of putting the blinds down are a lower level of natural light inside the classrooms, which can have a negative impact on students' health and performance, and an increase in the level of electricity consumption through the use of artificial light which has a negative impact on a school's carbon foot print and costs.

Results also confirm that there is a relationship between the level of control over the internal environment and the teachers' satisfaction about the internal environment. The provision of opportunities for occupants to control their surrounding environment are clearly important. However, it is essential that occupants are also aware of the implications of their actions. It is also critical that designers understand fully the motivations of occupants to control their internal environment. The unintended consequences of operating devices such blinds that were not envisaged during the design stage, particularly the potential knock-on effects on electricity consumption, are likely to play a role in the gap between design intent and in-use energy consumption. Therefore, a systematic approach to understanding occupant requirements and behaviour, feeding back details of actual occupant behaviour and educating occupants in the implications of their actions should form part of the design process, particularly if we are to ensure effective, energy efficient teaching spaces that function as intended are delivered.

5 Conclusion:

This study highlights the need to not only understand the multi dimensional role of windows and blinds in controlling the internal environment in UK primary schools but also the implications of occupant behaviour on delivering required comfort conditions. .

In developing such an understanding the often conflicting comfort requirement need to be considered. For example, the provision of a good view to the outside without it being distracting for students; the provision of sufficient light while preventing glare; and the use of windows as a source of heat gain during winter but without introducing overheating during summer.

In future, the school design process should incorporate the occupants' needs and behaviour as an element in the design process to provide a more effective level of control. Educating occupants on the implications of their choices should form part of this process.

The proposed approach will help building designers reduce the gap between predicted and actual electricity energy consumption, particularly where this is associated with the use of artificial lighting. It will also help ensure effective and efficient teaching and learning spaces are actually delivered.

Acknowledgment:

The authors would like to express their thanks to the head teachers for their permission and support to use their schools as a case study. Special thanks also to the teachers that participated in this research.

References:

- Barbara B, Kawulich., 2005, Participant Observation as a Data Collection Method. FOS (Forum of qualitative social research) 2005: 6: No 2

- Barnitt, H. 2003, Lighting for the Future, Building Services Journal: The magazine for the CIBSE, 25, 1, 38-39.

- Bordass B, Cohen R, Field J., 2004, Energy performance of non-domestic buildings – closing the credibility gap. In: International conference on improving energy efficiency in commercial buildings. Frankfurt, Germany.

- Bordass B, Cohen R, Standeven M, Leaman A., 2001, Assessing building performance in use 3: energy performance of probe buildings. Build Res Inform;29(2):114–28.

- Building Bulletin (BB) 90, 2003, A design guide: Lighting design for schools. Department for Education and Skills (DfES). London

- Carbon trust, 2012, Schools Learning to improve energy efficiency Sector , www.carbontrust.com, UK

- CHPS-The Collaborative for high performance school, "Lighting comfort" (n.d.,), Available from : http://www.chps.net/ (Accessed 2006).

- CIBSE KS6, 2006, Comfort. Chartered Institution of Building Services Engineers. London.

- CIBSE TM 37, 2006. Design for improved solar shading control. Chartered Institution of Building Services Engineers. London

- Demanuele C, Tweddell T, Davies M., 2010, Bridging the gap between predicted and actual energy performance in schools. World renewable energy congress XI. 25–30 September, Abu Dhabi, UAE.

- Demanuele, C., Tweddell, T. & Davies, M., 2010. Bridging the gap between predicted and actual energy performance in schools. , (September), pp.1–6.

- Dunn, R., Kiimsky, J., Murray, J., Quimm, P. 1985. Light up their lives: A review of research on the effects of lighting on children achievement and behaviour. The Reading Teacher (39) 19, pp. 863-869.

- Dutton S, Shao L., 2010. Window opening behaviour in a naturally ventilatedschool. In: Presented at the IBPSA conference

- Edwards, B. 2010, Rough guide to sustainability: a design primer, London: RIBA Publishing

- Foster M, Oreszczyn T., 2001. Occupant control of passive systems: the use of venetian blinds. Building and Environment 2001;36:149-55.

- Fred S. Bauman, P.E., 1999. Giving Occupants What They Want: Guidelines for Implementing Personal Environmental Control in Your Building, Presented at World Workplace 99, October 3-5, 1999, Los Angeles, CA, and published in the Proceedings. [Online] Available at: http://www.cbe.berkeley.edu/research/pdf_files/FBau_WorldWk1999.pdf [Accessed Sept 2013].

- Global Action Plan. UK Schools Carbon Footprint Scoping Study. Stockholm Environment Institute; 2006. p. 1–76.

- HM Government. Climate Change Act 2008 (c. 27). 2008.

- Inkarojrit V, 2008. Monitoring and modelling of manually-controlled Venetian blinds in private offices: a pilot study. Journal of Building Performance Simulation 2008;1:75-89
- Inkarojrit V., 2005. Balancing comfort: occupants' control of window blinds in
- Inoue T, Kawase T, Ibamoto T, Takakusa S, Matsuo Y. 1988, The development of an optimal control system for window shading devices based on investigations
- Kawulich, B., 2005. Participant Observation as a Data Collection Method. FOS (Forum of qualitative social research) 2005; 6: No 2; Available from http://www.qualitative-research.net/ (Accessed 2013)
- Lindelöf D, Morel N., 2006. A field investigation of the intermediate light switching by users. Energy and Buildings 2006; 38:790-801
- Lindsay C, Littlefair P., 1992. Occupant use of venetian blinds in offices, vol. 233; 1992. p. 92. PD. in office buildings. ASHRAE Transactions; 94:1034-49.
- Menezes, A.C, 2012. Predicted vs. actual energy performance of non-domestic buildings: Using post-occupancy evaluation data to reduce the performance gap. *Applied Energy*, 97, pp.355–364. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0306261911007811 [Accessed November 9, 2013].
- Montazami, A., Nicol, F. and Gaterell. M (2014), The effect of thermal mass on thermal performance in UK primary school classrooms, Energy and Buildings, (Under review)
- Montazami, A., and Nicol, F. (2013) 'overheating in schools: comparing existing and new guidelines'. Journal of Building Research and Information, 41, 3, 317-331.
- Nicol, JF, Humphreys MA and Roaf, SC, (2012) Adaptive thermal comfort: principles and practice, London Earthscan/Routledge March 2012
- Ott, J., 1976, Influence of fluorescent lights on hyperactivity and learning disabilities. Journal of Learning Disabilities, 9(7), 22-27.
  private offices. Citeseer
- Stillman CG, Castle Cleary R. The modern school, 75. London: The Architectural Press; 1949.
- Reinhart CF., 2004. Lightswitch-2002: a model for manual and automated control of electric lighting and blinds. Solar Energy; 77:15-28.
- Robson, E.R,. 1874. Schools Architecture, Murray, (Reprinted 1979): Leicester University Press.
- Sutter Y, Dumortier D, Fontoynont M., 2006. The use of shading systems in VDU task offices: a pilot study. Energy and Buildings; 38:780-9.

- Taylor, A., Gousie, G., 1988, The Ecology of Learning Environments for Children. Educational facility planner, 26 (4). http://www.coe.uga.edu/sdpl/researchabstracts/visual.html.

- Usable Buildings Trust (UBT). <http:// www.usablebuildings.co.uk/Pages/UBProbePublications1.html> [accessed 17.11.11].

- Walden.R, 2008. Building school for the future - Design Proposals from Architectural Psychology, Hogrefe and Huber. Germany.

- Wilmot, F. and Saul, P., (1998) Breath of fresh air- Birmingham's Open-air Schools 1911- 1970, Phillimore; 1998.