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What do we do?

Web-site: www.cibse-sdg.org

Our mission is to improve the design, operation, and environmental quality of educational buildings by providing timely, unbiased impartial information on design techniques, building technologies and developing novel engineering tools to enable the industry to deliver truly sustainable educational buildings. Our vision is that educational buildings will become centres of low carbon knowledge based economies.

The CIBSE School Design Group aims to foster long-term knowledge exchange and partnership between stakeholders working on sustainable school design, construction and maintenance.

The principal terms of reference are as follows:

1. to foster knowledge exchange between all interested parties working on sustainable school design
2. to develop a strategy for healthy and sustainable school buildings
3. to encourage cooperation between different professional bodies and institutions of relevance for school design
4. to reflect on changing procurement routes and design standards
5. to identify gaps in the science of designing learning environments
6. to initiate cooperation between academia and industry to resolve the problems of relevance to the industry.

Who we are

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Secretary to CIBSE School Design Group

I am writing this editorial on Tuesday, 19th July. The Secretary of State for Education Michael Gove has just provided me with inspiration for this article by publishing an initial response to much criticised James' Review of educational standards. Only two years ago we were commenting on the Final Report by the Zero Carbon Task Force (ZCFT) which aimed to advise on how England can achieve the ambition for new school buildings to be zero carbon by 2016, to develop a roadmap to zero carbon and to make recommendations for implementing the roadmap. I thought that in the world of 'satellite navigation systems' a roadmap was just not enough. Unlike 2009 when the whole industry was daydreaming about zero carbon school design, 2011 will take us back on the planet Earth: modular teaching blocks or in plain English, portacabins. Why? One of the key announcements in the Secretary’s response is an extra £500 million to help local authorities to provide extra school places to meet extra pressures caused by increased birth rates. Let’s do some back of the envelope calculations. At the moment there are approximately 4 million pupils aged under 11 in state funded primary schools and nurseries. A few years ago DCSF predicted that this number will exceed 4.5 million by 2018 – an extra 500,000 school places. This would be roughly equivalent to additional 20,000 classes of 25 pupils or additional 1,700 average-sized primary schools in the next 8 years. This is mission impossible. To be cynical, teachers will need to firmly embed the principles of low carbon economy in the hearts and minds of future generations from well-designed portacabins. A portacabin education might become almost a norm in East London or West Midlands where the pressure caused by increased birth rates is the highest.

On a positive note we should welcome announcement that the School Building Regulations will be pared down significantly. For years, I have advocated a radical restructuring of the existing regulatory framework for schools as a way of challenging the silo mentality characterising the current decision making process for design and operation (see CIBSE School Design Group bulletin No. 3, page 31). There are currently in existence more than 30 Building Bulletins focusing on school buildings and this disparate approach to school building design needed urgent transformation. On that note I am pleased to tell you that CIBSE School Design Group is working really hard on the new CIBSE TM on Integrated School Design. Hopefully, we will manage to finish it by the end of this year. Although unusual for an editorial, I want to end this one by showing you a diagram adapted by my ex-student Greta Caruana Smith. She built on the previous work in this area and reviewed 34 school refurbishment projects across Europe and presented frequency of most common retrofit measures for school buildings. (see Figure). This figure underpins my belief that traditional energy conservation measures such as additional insulation, windows replacement, lighting improvements and upgrade of heating systems are the most common and are being perceived as the most cost effective measures.

Please note that CIBSE School Design Group is a specialist group of volunteers interested in school design. All articles were prepared by our members. The money donated by industry and academia was used to cover the costs of printing this bulletin (1,000 copies). We did our best. Enjoy.
A Word from the Chairman

It is all change in the world of schools. The Building Schools for the Future Programme has been scrapped, ‘free schools’ are to be encouraged, the James Review has been published, there are proposals to re-introduce standard designs for school buildings, and then there is the recent announcement of the demise of the Partnership for Schools. All of which has resulted in a slowdown in the rush to build thousands of new school buildings. Not only this, but there are increasing concerns about recently built schools not being fit for purpose and anecdotal evidence of overheating in classrooms. Where does this leave the CIBSE engineer?

Hopefully, this hiatus provides a period to reflect on the design and use of schools in the age of low-carbon and sustainable design, and as designers we should welcome this opportunity.

We need to learn from the experience of procuring and designing these recent schools and develop a deeper understanding of the key issues that have provided the successful buildings. Issues that may be either procedural, in what has been a quite complex and bureaucratic procurement process, or technical problems of design and operation.

The CIBSE School Design Group is aware of this opportunity, and its committee members are busy writing a technical memorandum that will fulfil two key functions. It will provide a compendium of the design standards currently contained in number of Building Bulletins and be a source of design information based on recent experience.

First, it will bring together the key design requirements for school buildings into one document — providing the basic design standards in a single point of reference and, where possible, contain guidance currently in the Building Bulletins. Where appropriate, the document will up-date existing guidance and provide reference to recent designs approaches and performance. This is an important aim if the Department for Education ceases to provide support for the bulletins.

Second, the proposed document will deal with integrated design solutions that take account of all of the single issue Building Bulletins and the conflicts between them. Design solutions that address single issues can compromise other factors in the performance of the school. Hence, the aim is to present a holistic design approach that overcomes these conflicts and responds to changing requirements in school design.

It is proposed that the guide will also emphasise the importance of the actual performance in use that arises from the design’s intent. Often the design as conceived does not deliver the performance anticipated. The reasons for this can be many and various, but particularly important issues are the requirements of the occupants and their abilities to operate and maintain the school and its services.

The clear intention is to learn from experience and provide these lessons to the CIBSE membership. If we do not take notice of this experience, we may simply return to the errors of the CLASP and SCOLA approaches to school design, but without the guiding hand of the Local Authorities. If we now turn to a more measured rate of design and construction, and possibly less complex and bureaucratic procedures, together with better design understanding, we will produce schools that are truly suitable for the future.

John Palmer, Regional Director, AECOM

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- Vertical Transportation
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Occupant Oriented Design: Professional Research into the Pragmatic Use of Data to Inform Design

Judit Kimpian
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Post Occupancy Evaluations have shown that buildings can fall substantially short of occupant expectations in terms of targeted energy performance and comfort. One reason for this is a disconnection between the design and operation of a building. The fragmented regulatory environment, squeezed procurement and commissioning often found in educational buildings can exacerbate this. An occupant orientated approach to design can help to minimise these disparities and manage expectations now and into the future.

Occupyants do unexpected things to buildings - in schools they may come and go at irregular and elongated intervals, reconfigure spaces, increase numbers, add workshops or IT suites. One teacher may prefer a darkened room with blinds down and laptops open, while another prefers a daylit space with notebooks and pens. Lack of training can lead to mis-management of control systems and simple exposed equipment can be mis-used by students.

Furthermore, when a building operates as if it was open 24 hours, energy consumption can potentially triple.

Server rooms, cafeterias, workshops and occupant comfort leads to shorter life spans - which means that the whole life value we get out of public investment in these buildings is likely to be low.

Traditionally, architects had close ties with clients and the usability of a building was an essential part of this relationship. This connection has grown more distant and the profession is losing out on feedback on how their designs have panned out in practice. At Aedas R&D, we are attempting to tackle this problem through research projects such as CarbonBuzz, Building Performance Evaluation Programme and Design for Future Climate - each using real projects and data in a pragmatic manner in order better inform the designs of the future. The projects overlap with research carried out by three UCL EngD researchers based within Aedas, as well as the practice’s design methodology.

CASE STUDY: CARBONBUZZ

We began tracking down project design predictions and performing benchmark comparisons in 2006 as part of Aedas’ internal carbon audit. Looking at 10-15 case studies, we couldn’t help noticing that compliance calculations, such as SBEM and SAP, were the only energy use analyses carried out on projects and that these had little to do with operational outcomes. These findings matched other colleagues’ experience and it soon became obvious that very little was done to verify design predictions in operation, industry-wide.

CarbonBuzz.org helps users to bridge projected emissions from design and operation. Users can upload design stage predictions, add unregulated energy use estimates and compare these with actual energy consumption data. While based on the Display Energy Certification method, CarbonBuzz goes beyond current reporting standards - it collects ‘end use’ energy details alongside electrical and fuel consumption. With good benchmarks, poorly performing buildings can be easily spotted based on just energy bills. However, without knowing where energy is used in a building, i.e. how much goes on heating, hot water, cooling, lighting, appliance loads etc, it is difficult to diagnose problems and target efforts to resolve these.

We tested our ideas with a broad group of architects and engineers and since its launch in 2008, the platform has grown to host over 250 records and over 400 member organisations. Initial analysis of the data points to significant under-performance in almost all sectors, with schools and offices being the modal sectors in terms of data collected.

CarbonBuzz is currently the only platform that allows users to monitor and benchmark building CO2 emissions online in line with the DEC methodology. With users entering more data it will supply crucial evidence and tools to reduce building carbon emissions for real.

CarbonBuzz is an RIBA CIBSE platform.


case study

end of life design construction

policy maker architect

commissioning supplier

potential issues

post occ occ

acquisition funding

operator client

design

buildings

operation

commissioning
CASE STUDY: BUILDING PERFORMANCE EVALUATION PROGRAMME

Aedas R&D, with the support of the Technology Strategy Board, is carrying out post-occupancy evaluations for eight projects, including Darwen Academy. Completed in 2010, thev Academy hosts 1200 11-16 year olds and 400 post-16 students north of Manchester. Built on a brownfield site the building brought improvements in ecology and habitats in the town centre with a sedum roof and extensive planting along playing surfaces. The building includes large, daylight, naturally ventilated atria and classrooms with single sided or mechanical ventilation. A biomass boiler aimed to deliver 80% of heating demand and 20m2 of solar water heaters contribute to the domestic water system. The compliance calculations put the building emissions at 39kg CO2/m2/year. In the first year of operation the building emitted just over double this figure with excessive electrical consumption responsible for most of this excess. This is not uncommon for schools – appliance loads have increased dramatically in education buildings and Darwen is no exception. Interviews with the building’s facilities manager confirmed that improving lighting controls and better appliance management could substantially reduce consumption. Gas consumption is also higher than expected. This is due to some storage issues with the biomass as well as security issues with night purge ventilation. The school is working with the MEP subconsultants to resolve this. Aedas R&D used CarbonBuzz to track and analyse the role of unregulated energy use in design and operation. Aedas R&D also headed a Technology Strategy Board funded project to assess the impact future climate predictions on an Academy building whilst investigating adaptation measures to increase future climate resilience. The project chosen was Harris Academy, Purley, as it was entering the detail design stages and meeting all current overheating requirements for schools, with the aim of achieving a BREEAM rating of excellent. Key aspects of the study were to work within the existing programme and engage with the design team to make recommendations that were cost and programme neutral as well as report on items that may be introduced as retrofit options in the future.

A research based thermal model of the school was built to investigate the likelihood and severity of overheating scenarios within the naturally ventilated classrooms over and above those required to meet current standards. The UKCIP02 low emissions climate change scenarios for 2020, 2050 and 2080 were selected as a best case scenario, measured against criteria used by BREEAM and BB101. In order to mitigate against the future overheating risks, design strategies were tested that aimed to reduce gains and increase natural ventilation rates. Key areas of investigation included: assessment of modelled and detailed free areas; improved glazing shading coefficients; the addition of internal blinds; and increasing thermal mass. In addition, the team re-assessed the criteria and assumptions used in the design of the building to consider potential ‘worst case’ occupancy behaviours as well as dealing with hot summers in today’s climate. This involved incorporating the impacts of increased internal heat gains of small power appliances such as laptops and assessing the building's performance under design summer year (DSY) conditions. With the project entering detail stages during our study and now currently on site, our investigation was integrated into a tight time, cost and briefing schedule. Nevertheless, the study did have a tangible impact on the project: most notably through the increase in free areas and internal thermal mass together with the remaining retrofit options for the future. By separately increasing the internal gains and using design summer year conditions, we showed that equivalent internal conditions of future climates can occur quite easily today. This was used to highlight the relative importance of designing buildings today that allow better adaptation to conditions in the future. For similar reasons, we chose to model future climate conditions under ‘low emission’ predictions as this represents a ‘best case’ scenario for the future, in a similar way that test reference years are less severe than design summer years when modelling overheating risks in today’s climate.

The results showed that where all mitigation measures were included, with no change to the assumptions, the designs met current criteria requirements up to 2020. However, where assumptions are adjusted for worst case scenarios, the likelihood of failure under current criteria is high even before future scenarios are tested. This shows some concern for current regulatory and advisory standards but that care needs to be taken to ensure the resulting models do not always point towards a mechanical cooling solution from the outset and the associated emissions.

Upon the completion of the project we hope to develop some simple checklist tools for design teams within Aedas to apply on future projects. Involvement of future climate considerations at the briefing stages of a project is key as this is when the standards for the entire project are set. This means that fundamental design decisions can be made earlier at lower cost and minimal impact on the schedule.

We have shown that future and unpredictable conditions have a very real threat to overheating within buildings that pass current criteria. Without regulatory involvement it is difficult to encourage the incorporation of adaptation measures across the range of all new school designs. However, we have demonstrated that cost effective solutions can go some way in tackling potential problems even at the later detail stages of design.

We would encourage more education buildings to consider future climate scenarios as it is these conditions that will meet the occupants of the building’s life which under current design life standards may be 60 – 100 years.
BACKGROUND
The report must be viewed as a part of an strategy for the reform of the Eng- lish state school system, initiated by Michael Gove and the Department for Education. This is intended to encour- age entrepreneurship in the sector, with good or popular schools expanding and poor or unpopular schools being allowed to wither on the vine. It will reduce the influence of local authorities on how schools are run.

Many local authorities do not welcome this removal of authority, and see it as placing a burden on them without giving them the authority to co-ordinate schools provision across their area. While notional funding is to be apportioned to Local Authorities, prioritisation will be even more difficult to resolve if there is a high proportion of Academies and Free Schools (etc) in their area.

The report also presents challenges to the government’s localism agenda that is focused on a schools market responding to local demands, but proposes a centralised procurement route with standardised designs.

There is also a change in emphasis, with capital allocated according to the fitness for purpose and condition of a school’s buildings rather than the educational need. This seems sensible, and we can only hope that this doesn’t encourage schools to neglect their buildings still further in the hope of securing funding.

It is not clear how the new market led process will deliver the additional spaces required for the 8% increase in child population between 2010 and 2020. One part of any competitive ethos is that it will be likely to deliver increased numbers of space places at a variety of schools – surely not efficient in these cash strapped times.

Other concerns include the management of the schools estate in an increasingly fragmented market – many schools do not have the resources or training to manage the performance of their buildings and their energy consumption adequately, which wastes millions of pounds every year. Removing more schools from Local Authority control could exacerbate this.

THE REPORT
Turning to the James review document itself, the main issues identified were:

1. The complexity of the capital alloca- tion process
2. The pitfalls of BSF
3. A lack of client expertise
4. The lack of co-ordination of funding processes
5. The lack of maintenance provision and data
6. The complex regulatory and planning environment for schools.

The five principal recommendations are:

1. A focus on delivering enough fit-for-purpose school places
2. Capital allocation determined by the need for places and building condition
3. New buildings to be based on standardised drawings and specifications
4. A single intelligent public sector ‘cli- ent’ responsible for design and delivery.
5. Responsible Bodies accountable for maintenance.

There is a lot of important detail missing from the report – including the following:

• What does “fit-for-purpose” mean?
• How will the need for places be co-ordinated in a fragmented schools estate?
• What will be standardised?
• What is an appropriate construction budget?
• How will the public sector “client” and “Responsible Bodies” be organised?
• How will the post occupancy evalua- tion operate? Will it only study the buildings procured through the new model?
• How do they propose that energy consumption reductions are achieved?

There is of course much that can be done to reduce cost through procurement and design, but we must ensure that “fit for purpose” buildings are adaptable, comfortable all year round, have low energy use, and do not revert to the tin sheds with narrow corridors and insufficient ventilation which have given such problems once occupied.

It is notable that the aggressive stance against the design professions taken by Michael Gove does not appear to be maintained in the James Review.

STANDARDISATION AND PREFABRICATION

While it has been portrayed in the press as “Flat Pack Schools”, standardisation does not necessarily mean prefabrication – although there can be benefits in both of these if they can be delivered for the tight budgets being discussed.

Many contractors have for some time worked with a relatively narrow range of materials, systems and design approaches and often have their own schools design manuals. The effectiveness of standardisation will ultimately depend upon what it is aiming to deliver, what is standardised and what is left to the market to resolve.

There are however conflicts between the increased drive for standardised approaches, the scale of refurbishment which is likely in many schools and the localism agenda. Also many prefabrication systems require a significant volume of production – something which is incompati- ble with the “one-off” approach to the current procurement model.

PROCUREMENT

More detail is needed on the procure- ment routes and how the move towards localism (for instance Free Schools) is reconciled with the centralised procure- ment and design standardisation.

It is instructive to contrast the aggres- sive Academies procurement route with the PFI + route used for health projects, where a contractor led team is selected before costs are considered – why should the procurement of these two different parts of our social infrastructure be so different?

RECENT PRECEDENTS – LEARN FROM THE GOOD AS WELL AS THE BAD!

There is little or no reference in the report to the large amount of good work which has been done over the last few years. While we agree that many of the schools built over the last 5-10 years are of a poor design standard, there is a large number of excellent buildings which are delivering great environments for learning. There is a lot of valuable guidance material available which is not even mentioned in the report, including:

• The DfES SSLD (Standard Specifica- tions, Layouts and Dimensions) pro- gramme
• The Zero Carbon Task Force.

CARBON

There are a few references to carbon reduction in the report but there is no plan proposed for achieving the indicated savings of 30%, and no reference made to the work of the Zero Carbon Task Force.

A report on Carbon Emissions reduction in refurbished school buildings commis- sioned by the DCfS has still not been is- sued – surely a prime example of relevant information when money is tight.

There is also no reference to handover protocols or Soft Landings which can greatly assist with carbon and building management.

OVERALL

While eagerly awaited for many months, the report was to many of us something of a let down.

Many of the points it makes were either well known (e.g. the wastage in BSF) or had been stated previously (the target- ing of funding with regard to “fit-for- purpose”).

We applaud the emphasis on simplifying many issues, whether design, funding or procurement, but need to see more detail on when and how this will be achieved.

There is insufficient definition regarding issues such as standardisation, the term “fit-for-purpose” or the future procure- ment routes and there seems to be little appetite to learn from much of the good work which was done under the last Government.

There needs to be a clearer route to achieving carbon savings (which also equate to running cost savings). The fund- ing model for investment in operational advice or new equipment is very different from that in a retail environment!

There are many gaps in the detail, particu- larly those relating to standard designs, future procurement routes, how local and national agendas can be work together efficiently, and (perhaps most crucially) the appropriate level for construction costs.

The long-awaited James Review, finally published in April this year, has been the subject of much speculation over the last few months, with leaks and rumours often making it difficult to sort the wheat from the chaff. Now it has finally emerged, it seems something of a let-down, with many questions left unanswered.

Dr. Mike Entwisle, Director, Buro Happold.

Langley Academy. Courtesy of Buro Happold.
Commissioning a new school building is a specialist procurement task best undertaken by suitably qualified professionals who are competent to undertake the role of Intelligent Client (IC). The engineering requirements of such buildings demand that Building Services Engineers (BSE) be part of that intelligent commissioning team as they understand the balance that needs to be struck between complexity and performance and critically, through working alongside project sponsors and the end users over a period of time and multiple projects understand what makes successful buildings tick from the user’s perspective.

Understanding the end users' requirements and limitations, and ensuring that the engineering solution resolves the two requires a well defined brief with a clear set of target outcomes. The client should not be telling designers how to design but should be clear on the technical objectives and outcomes for the project and how success will be measured. The focus is on setting the desired direction early and being able to communicate this in terms that the design team and constructor will grasp immediately. Ambiguities are thereby removed and unworkable deviations minimised.

An IC team understands risk, minimises cost and enhances value by setting the technical parameters at the commissioning stage, performing the role of ‘critical friend’ by reviewing engineering solutions and shares their own technical experience and knowledge with the design team. Continuous learning, through project evaluation and feedback, ensures that engineering successes are repeated and shared.

A collaborative design approach, in an environment of trust and openness, is key to achieve the client’s outcomes as well as a reasonable financial profit for the consultants and contractors. In the current austere times, designers are having to respond to local authorities need to significantly reduce costs whilst still delivering good quality solutions. The role of the IC is crucial in ensuring that the cost/quality challenges are understood by the project team and managed effectively. Over recent years, published guidance, codes of practice, statutory regulations, etc. has grown but, regretfully, this has not always been matched by an increased level of competency of the design engineer. The level of competency can vary enormously and without an IC to advise the client, and/or challenge the designer, the risk of disappointment is high.

It is essential that engineering designs are reviewed at key milestone stages to ensure compliance with the brief. The IC will review the design to ensure that it is robust, within budget, affordable to operate, is coordinated, maintainable and satisfies the carbon and energy targets. The review provides the design engineer an opportunity to demonstrate their competency and reassure the client that the end product will meet the brief objectives and is value for money. Knowing that a design solution will be subject to an independent engineering audit should also guarantee that the designer has a clear rationale for their solutions.

Modern primary or secondary schools are complex buildings with engineering and architectural challenges that can only effectively be resolved through design teams understanding their customers own challenges, limitations and expectations. The ‘Soft Landings’ framework, published by BSRIA, is a very useful tool to help deliver successful outcomes and to maintain the golden thread throughout the life of a project. An IC ensures that the golden thread is there and that the ‘batten’ is successfully passed on and not dropped!

All designers need to take time out, to view the world through the client’s end of the telescope. Engineering services installed need to be suitable for operation by the site manager (or other designated person) who may well have very limited technical or ICT knowledge, especially in primary schools. Highly sophisticated engineering solutions - that theoretically are very energy efficient and carbon friendly – may well fail to deliver their intended benefits, if in practice, they are too complex for the end user to understand and manage and/or are too costly to maintain.

Early discussions with the end user, conducted in non technical language, to understand their needs and outcomes, and to explore potential engineering solutions, will help deliver good design and achieve success. Simplicity is the key and the IC’s role is to ensure that that message is understood by the design team. For example, removing human interface etc. has grown but, regretfully, this has not always been matched by an increased level of competency of the design engineer. The level of competency can vary enormously and without an IC to advise the client, and/or challenge the designer, the risk of disappointment is high. And there is a likelihood that the system may eventually just be overridden or disconnected.

Sadly it is not unusual to learn of a school building project to be viewed as a disappointment by the end user due to a failure of the design team to understand their client’s world. A local authority, with an IC team that incorporates a professionally qualified BSE, has a far greater chance of delivering a successful outcome by ensuring that the commissioning and delivery process is competently managed with all parties interest in mind.

International studies show that productivity and learning can be increased by 10-15% when the right air quality and temperature are present. Natural Ventilation is the economically attractive and sustainable solution for a good indoor climate. Analysis has shown a CO2 saving of up to 40% compared to traditional mechanical ventilation systems.

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**FRESH AIR AND A GOOD INDOOR CLIMATE ARE IMPORTANT FOR OUR:**

- HEALTH
- PRODUCTIVITY
- LEARNING
Our EngD Centre funds and supports Research Engineers (REs) studying in areas related to the use of visualisation and imaging in engineering and design. This includes adaptive architecture and computation, construction, urban planning, Space Syntax, use of visualisation in building design and engineering, building performance simulation, use of imaging in heritage science, but we are open to all other suggestions for industrial research.

Our REs undertake a bespoke, one-year technical training course (IMRees), followed by three years’ full-time work on their sponsor’s project. Additional training is offered throughout. REs receive a tax-free stipend of approximately £18,500 per year. The EngD is open to graduates in any discipline, provided that they are articulate, well qualified and highly motivated.

Each RE is sponsored by an industrial or charitable partner. The cost of sponsorship is typically around £36,000 to £40,000 over four years, with occasional concessions offered to charitable sponsors. UCL have already secured EPSRC matching funds. REs normally divide their time between the sponsoring organisation and UCL.

The programme supports REs in a studentship mode, but it also supports current employees from industrial organisations seeking to enhance their R&D capabilities. This offers companies, including SMEs, a way to further research and development, while retaining highly sought-after staff who wish to continue their professional development.

### Table 1: Overview of test results

<table>
<thead>
<tr>
<th>School</th>
<th>No. of Tests</th>
<th>Pass Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary1</td>
<td>18</td>
<td>100%</td>
</tr>
<tr>
<td>Secondary1</td>
<td>12</td>
<td>83%</td>
</tr>
<tr>
<td>Secondary2</td>
<td>22</td>
<td>79%</td>
</tr>
<tr>
<td>Secondary3</td>
<td>17</td>
<td>73%</td>
</tr>
<tr>
<td>Secondary4</td>
<td>21</td>
<td>72%</td>
</tr>
<tr>
<td>Primary2</td>
<td>14</td>
<td>67%</td>
</tr>
</tbody>
</table>

### Table 2: Results by test type

<table>
<thead>
<tr>
<th>School</th>
<th>Airborne Sound Isolation</th>
<th>Impact Sound Isolation</th>
<th>Reverberation</th>
<th>Ambient Noise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary 1</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Secondary 1</td>
<td>100%</td>
<td>100%</td>
<td>67%</td>
<td>67%</td>
</tr>
<tr>
<td>Secondary 2</td>
<td>86%</td>
<td>82%</td>
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<td>Secondary 3</td>
<td>75%</td>
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<td>Secondary 4</td>
<td>75%</td>
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<tr>
<td>Primary 2</td>
<td>14%</td>
<td>86%</td>
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Due to the limited number of tests that were conducted at each school, it was not possible to say that these results represent the overall level of compliance at each school, and it would be speculative to suggest that these results are representative of new schools as a whole. However, the results are clearly cause for concern.

The limited length of this article does not permit a thorough analysis of the reasons for failure of each individual test. However, there were some common themes encountered in each of the schools:

- Excessive reverberation times in sports halls and open plan areas
- Poorly performing moveable partitions / operable walls
- Poorly designed and installed fixed partitions

The results showed that many of the schools failed to meet the minimum standards, and in more than one instance this meant that rooms could not be used for their intended purpose.

Large sports halls and open plan areas were the only locations where excessive reverberation times were encountered. The amount of absorption in each of the spaces was less than was required to meet the reverberation time. This could be due to poor design (bad advice from the consultant), or poor implementation (good advice from the consultant which was subse- quently ignored). In the sports halls with excessive reverberation times, the acoustic absorption was only applied to the ceiling. In these cases, the excessive reverberation time was caused by flutter echoes between opposing walls. Such adverse effects could have been predicted with a simple computer model, rather than applying standard acoustic equations (i.e. Sabine and Eyring), which are often unsuitable for these spaces.

#### Considering the Future of Acoustics in Education

Mike Wood
Research Associate Centre for Energy and the Environment, University of Exeter

Building Bulletin (BB 93) came into force in July 2003 and represented a relatively comprehensive design guide for acoustics in schools. The document was intended to provide both minimum standards and design guidance for the client and the design team. However, since it has been introduced there has been little opportunity to determine how effective it has been in ensuring a good acoustic environment in schools.

In 2010, the Centre for Energy and the Environment at the University of Exeter, in partnership with RPS Gregory, conducted a government funded study into the quality of acoustics of six newly built schools in the UK. The included two new primary schools and six new secondary schools constructed after 2003. The schools studied were flagship schools either built under the Building Schools for the Future scheme or were built using money from a Private Finance Initiative (PFI).

Tests were conducted at each school on every aspect of acoustics for which there is a set standard within BB 93. Schools were tested for airborne impact sound isolation, reverberation and indoor ambient sound levels. Due to the time constraints associated with the project, it was not possible to conduct exhaustive tests. Instead, a sample of rooms and partitions were tested according to the guidelines in BB 93. An overview of the results is shown in Table 1 below (the name of each school could not be identified for copyright reasons).

The results revealed varying levels of compliance, with some spaces performing particularly poorly. The results also varied widely between each type of test.
Operable walls also performed poorly. In most cases, the poor performance of these walls was due to either poor installation or poor maintenance. Figure 1 shows a poorly installed wall at one of the primary schools that was tested. The partition shown in figure 1 lead to sound isolation that was 10 dB below that required by BB 93.

There were also several cases where solid partitions fell short of the requirements. Figure 2 below shows a fixed partition between two music practice rooms. The detail shown in Figure 2 shows evidence of a combination of poor design and installation. Such a head detail is unlikely to provide the level of sound isolation required by music practice rooms. Due to a combination of poor design and workmanship, this partition was 20 dB short of the required sound insulation. Because of the poor sound isolation the room was being used as a store room instead of its intended use as a music practice room.

- Acoustic engineers were not consulted early enough in the project to influence important layout decisions (e.g. during RIBA stage C)
- The desire for flexibility in spaces outweighed the desire for a good quality acoustic environment (i.e. the installation of operational walls)
- Large spaces (e.g. sports halls and open plan teaching areas) were given insufficient consideration regarding adverse acoustic effects.

The original purpose of BB 93 was to assist in ensuring an appropriate acoustic environment for all pupils, and it is often forgotten that poor acoustics affects “vulnerable listeners”, such as those with hearing impairments, disproportionately. As designers, it is also important to remember that groups that are vulnerable to poor acoustics include not just those with hearing difficulties, but also children with special educational needs and pupils whose first language is not English, among others.

Given the substandard acoustic conditions that were revealed in the study, the reasons for the high rate of non-compliance were questioned. As one might expect, there is no one clear answer. However, upon studying the documentation associated with each school design, some common themes emerged:

- The desire for flexibility in spaces resulted early enough in the project to influence important layout decisions (e.g. during RIBA stage C)
- The importance of acoustics in schools, how can high acoustic standards be delivered without a legal requirements being imposed?
- Acoustic engineers were not consulted early enough in the project to influence important layout decisions (e.g. during RIBA stage C)
- The desire for flexibility in spaces outweighed the desire for a good quality acoustic environment (i.e. the installation of operational walls)
- Large spaces (e.g. sports halls and open plan teaching areas) were given insufficient consideration regarding adverse acoustic effects.

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- Large spaces (e.g. sports halls and open plan teaching areas) were given insufficient consideration regarding adverse acoustic effects.

The future of BB 93 is currently looking uncertain. BB 93 was due to be updated by the Department for Education, but plans for an update now seem to be on hold as the government are reconsidering the implementation of building standards in schools. It now seems likely that section E4 of the building regulations (which requires the acoustic design of schools to be considered) will be removed. The removal of section E4 will certainly weaken the requirement to consider acoustics in schools. Many studies show a strong correlation between poor acoustics and degraded educational outcomes. These degraded outcomes occur not just for those who have special hearing requirements but for all pupils. Given the importance of acoustics in schools, how can high acoustic standards be delivered without a legal requirements being imposed?

There are many competing requirements of school design meaning that there is a danger that the acoustic issues could be swept aside in favour of more “important” considerations. Acoustic standards are often seen as another barrier in the building regulations, but it is well understood that a good acoustic environment is essential to a successful educational environment. There is already a gap in attainment between pupils with special hearing requirements, and in poor acoustic environments this gap in attainment only widens. The responsibility involved in delivering a successful design is therefore clear.

In response to the threat to section E4, the Institute of Acoustics are producing their own guidance on school acoustics, which, in the event of the removal of section E4, will serve as a replacement to BB 93. In light of the results of the case studies, and the published literature on the effect of acoustics on education, it is incumbent on the design team both to recognise the importance of good acoustic design and to consider it as early as possible during the design process. The results of the case studies show that, even in the presence of a (fairly) comprehensive design guide such as BB 93, poor design decisions are still made. In some cases this may have been due to poor acoustic advice, but upon studying the documentation associated with each project, it was clear that the communication between the design team could have been better.

It is now more important than ever that the basic acoustic requirements are understood and communicated between the design team. Whether acoustic standards are a legal requirement or not, it is only through an integrated approach that this crucial element of school design can be reliably delivered.
Purpose of a Charette at a Generic Level, the Scope is:

1. To clarify the Client’s aspirations.
2. To provide a viability framework for client aspirations, such that values are attached to each of a range of early stage project objectives.
3. To identify strategic issues.
4. To set project objectives at a strategic level such that the various professional groups contributing to a project have clear identification of their tasks, duties and responsibilities in meeting Client objectives.
5. To identify the key integrated design issues, together with the preferred approach to a design solution.
6. To set project strategies for consideration of potential design solutions, including costs, time constraints. The object is to avoid ‘surprises’ later in the design and construction processes.
7. To review grants and aid available to the project, and take a decision on the value to the project of attempting to access such aid.
8. To identify outline solutions for key design issues, especially those aspects that have interactions across traditional design skills areas.
9. To set project strategies for consideration of potential design solutions, including costs, time constraints. The object is to avoid ‘surprises’ later in the design and construction processes.
10. To set a framework for detail level design decisions.

A ‘Design Charette’:

1. Sets quantifiable metrics to verify compliance with Client objectives.
2. Helps all design team members understand the implications of agreed project objectives – at individual profession and multi-professional activity levels.
3. Sets project strategies for consideration of potential design solutions, including costs, time constraints. The object is to avoid ‘surprises’ later in the design and construction processes.
4. Reviews grants and aid available to the project, and takes a decision on the value to the project of attempting to access such aid.
5. Identifies outline solutions for key design issues, especially those aspects that have interactions across traditional design skills areas.
6. Identifies the phasing of decisions, (eg. – decisions on heat sources are only made when daily / seasonal / peak load profiles are defined).
7. Identifies the need and available budgets for external specialist input – such as comprehensive thermal modelling to optimise summer overheating, window sizing, acoustics, ventilation and space heating requirements.

Position in the Design Progression

This suggested agenda for the ‘Client values’ charette to inform the planning application – ie. before RIBA Plan of Work Stage A. The design charette(s) are then run as early as possible so that best benefits are achieved from design integration.

Conclusions

The client values and design charettes as identified above help a project team to structure decisions. By clearly attaching values to Client aspirations, it ensures that detail decisions are made within an existing strategic framework. This minimises the need to re-visit earlier decisions, and the associated waste of project team resource. The benefit to the Client is clear identification of costs and values of various design options, including sustainability items.
The KSE approach to the "Client values" charette is to define the process with a clear vision of Client priorities. A normal approach would be to:

1. Agree the Agenda for the Charette.
2. Define the Client’s policy on Corporate Social Responsibility (CSR) or table and agree a default policy) that will be the basis of project advancement.
3. Identify the Client’s Auditor for low-carbon impact and productive workplace issues (the Auditor’s terms of reference). Define the Auditor’s terms of reference.
4. Agree the Agenda and date of the ‘Design’ charette.

Appendix 3: ‘Design’ charette: KSE requirements

The ‘KSE’ below are the minimum overall responsibilities, skills and knowledge required to be present at a 'Design' charette for it to function effectively. The KSE requirements at the 'Client values' stage do not vary significantly with project size.

1. CSR (Corporate Social Responsibility) – client-side.
2. Corporate budgets – building capital + revenue costs + plus salary costs.
3. Construction costs, fees, and operating costs.
4. Functional definition of the building.
5. Corporate priorities.
6. Operational management of staff in the building.
7. Auditor covering conformance with the building.
8. Site acquisition.
9. Building regulations requirements.
10. Energy demands.
11. Energy supply.
13. Productive workplace.
14. Waste management

Appendix 2: ‘Client Values’ Charette: Suggested agenda

The outcome of a 'Client values' charette is to provide the design process with a clear vision of Client priorities. A normal approach would be to:

1. Agree the Agenda for the Charette.
2. Define the Client’s policy on Corporate Social Responsibility (CSR) or table and agree a default policy) that will be the basis of project advancement.
3. Identify the Client’s Auditor for low-carbon impact and productive workplace issues (the Auditor’s terms of reference). Define the Auditor’s terms of reference.
4. Agree the Agenda and date of the ‘Design’ charette.

Appendix 3: ‘Design’ charette: KSE requirements

The ‘KSE’ below are the minimum overall responsibilities, skills and knowledge required to be present at a 'Design' charette for it to function effectively. Unless specifically identified, the KSE is defined for a typical 5,000m² school or office. Smaller projects – below circa. 700m² may not warrant the full extent of skills availability for all issues. Persons contributing to the charettes may cover several functions.

Listing of Functions: Design Charette - Headings

1. Auditor covering conformance with client needs.
2. Senior Responsible Owner (Client-side).
3. Site identification / site planning.
4. Building Regulations requirements.
5. Performance specification writing.
7. Building maxing and adjacencies.
8. Internal gains.
11. Air tightness.
12. Wind modelling (if needed).
15. Heating energy.
16. Hot water services.
17. Summer overheating.
18. Day-lighting and daylight modelling (including brightness management).
19. Artificial lighting.
22. Water economy.
23. Structural.
25. Fire safety.
26. Waste management.
27. DDA (Disability Discrimination Act) compliance
28. Commissioning specialist.
29. Maintenance – revenue and capital, skills requirements.
30. Whole life costing (including simulation if data is inadequate)
31. Project financing.
32. Building insurance.
33. Grants available to the project.
34. Construction costs.
35. Materials availability.
36. Payment mechanism (if appropriate).
37. Operating costs.
38. Broad aspects of sustainability.
40. Building decommissioning.
41. Construction timescale(s).

Appendix 4: ‘Design’ Charette: Suggested agenda

For most buildings projects, the charette priorities are low-carbon impact, good workplace productivity, and in broad terms – good sustainability. All, of course, within cost limits. Operating within the generic outline, a normal approach would be to:

1. Re-cap on the outcome of the ‘Client values’ charette.
2. Identify the top four integrated design areas (such as daylight displacement of paid-for artificial lighting / minimisation of space heating / control of summer overheating / source of energy for hot water service), the normal intent being to get the building as passive / minimal carbon impact as possible without compromising internal environments or service levels.
3. Set performance objectives for the top four integrated design areas, and the reporting requirements.
4. Establish priorities based on Client values, identify strategic solutions within an agreed viability framework.
5. Identify construction materials and components to achieve sustainability objectives within Client aspirations and requirements. (Includes consideration of life-cycle costs and realistic maintenance regimes).
6. Integrate external sustainability assessments such as BREEAM / LEED / Minnesota Sustainable Design Guide into the design process. Identify any seemingly perverse sustainability valuations and seek resolution.
7. Identify a person to undertake the duties of a ‘Client auditor’ as the project progresses (if not already appointed).
8. Ensure that the proposed design is consistent with all applicable regulations, can be easily set to work and commissioned, and does not incur unnecessary costs during mature operation.
9. Identify and agree key decisions, copy to all members of the procurement team. Subject to any comments received within a short time frame, those notes then form the basis for detailed design work.
10. Agree on the stages at which the ‘Auditor’ will report.
Linking Design Quality and Education

Roeler Leiringer (University of Gottenberg)
Paula Cardellino (University of Uruguay)
and Derek Clements-Croome (University of Reading)

The significance of design quality is clearly articulated in the official documentation and advice on how to achieve it is provided in abundance. However, the reports fail somewhat short in describing how design quality can be fostered to achieve educational transformation. Whilst several reports set out the attributes of a well-designed school scant attention is commonly given to the commercial context. The majority of the reports target the architectural aspects of the building design and prescribe an architectural approach towards the assessment of design quality. To a degree this could be argued to be due to the great prominence and frequency of CABE reports. However, it should be remembered that CABE was specifically commissioned by the Government to provide advice on good design in public building projects. Hence, it is not surprising that these reports and the interpretations of design quality offered within them have had a significant impact. However, the architectural biased approach seemingly underestimates the value of intangible aspects of design and chances are that the tool becomes a ‘tick in the box’ exercise.

FUNCTIONALITY AND FITNESS FOR PURPOSE

A functional school building is one that through its design addresses present and future changes in pedagogy. That the building is ‘fit for purpose’ is viewed as a crucial component of design quality and vital to the achievement of a good school building. This concept was given significant prominence in the BSF and it relates closely with the Government’s expressed policy that the investment in secondary schools is not just about providing new buildings, but also about acting as a channel for educational transformation.

FLEXIBILITY AND ADAPTABILITY

Past approaches to school design are deemed to have hindered the ability of adapting the building to future needs in education. Designing flexible environments is believed to enable the adaption and adoption of the emerging changes in education. Thus, flexible and adaptable building designs ‘future proof’ the spaces and allow for a variety of uses at different points in time. Furthermore, it is suggested that flexible or ‘agile’ designs will allow for short-term changes of layout and use, and for long-term expansion or contraction. However, the need to strike a balance between flexibility and specificity and the functional aspects of the school (teaching areas) and social spaces are also explicitly expressed.

INSPIRATIONAL, SAFE AND SECURE

Inspirational school buildings are supportive of effective teaching and learning and inspire users to learn. The ultimate aim is for spaces that foster creativity and a culture of learning. The design of learning environments that have something unique about them will make these spaces special – ‘spaces’ that become ‘places’. This is believed to be achieved through the design of environments that accommodate a wide range of experiences and activities and that include all types of learning: intellectual, physical, practical, social, emotional, spiritual and cultural. In other words, inspirational buildings support a diversity of learners and inspire not only the pupils, but also those who work and visit the school.

AESTHETICALLY PLEASING AND CONTEXTUAL FIT

A building is considered to be ‘beautiful’ when it ‘lifts the spirits’ of those who come into contact with it. An aesthetically pleasing building is portrayed as not only having the potential to create a ‘sense of place’ in the internal school environment, but also as having a positive effect on the local community. Likewise, a school that is welcoming and accessible is portrayed as having a positive impact not only on the users of the building, but also on the surrounding areas. For example, an attractive entrance and a welcoming hall contribute to a positive visual impact on the local neighbourhood. As such, contextual fit goes beyond the specific school environment and places emphasis on the interaction with and contribution to the local community and public well-being in general.

BUILD QUALITY AND SUSTAINABILITY

Build quality is a concept that speaks for itself and sustainability is a topic that cannot be meaningfully dealt with in the confines of this paper. Nevertheless, important to the argument presented here is that well designed learning environments should provide a platform for wider learning agendas ranging from the issues of citizenship and sustainability. For example, C Abe presents the sustainable character of the building, in terms of the use of natural light and ventilation, the consideration of alternative forms of energy and the choice of robust materials from sustainable sources, as a means to highlight and disseminate environmental issues.

DESIGN QUALITY IN PRACTICE

From the above analysis it is clear that several of the attributes of design quality are of a subjective nature and will be measured. In this respect, there will be many different perceptions of what the important attributes of good design are and how they are operated in practice.

“I think design quality is really interesting and generally very misunderstood. And I think CABE keep trying to describe to people what design quality is, and it keeps being misheard.” [Architect 1]

“What is good design? Obviously there are different views because there always will be in an industry, but I’m sorry to say that rock bottom Is it just do not think many people would know a good design if it hit them in the face like a wet fish. Therein lies the problem.” [Contractor 1]

FITNESS FOR PURPOSE AND EDUCATIONAL TRANSFORMATION

The foremost goal of the refurbishment and construction of new or refurbishment school projects is to achieve educational transformation and this is the principal criterion against which success will be measured. In this respect, there is unanimous agreement regarding the

...
"We have got to spend the money where it is best spent so if it needs a really welcoming opening entrance and the entrance needs to look big and really welcoming and everything else, we will spend a bit of money there but perhaps the back of the house might not be so ‘wazzy’ and when you get to class rooms at 60 sq metres a classroom there is only so much you can do with them, isn’t there, so the point is trying to design those as best you can. So it is knowing where the best place to spend the money is and perhaps where it’s not so critical to give the client at the end of the day exactly what they want.”

The character of the building

The idea that the building should be aesthetically pleasing was prevalent amongst the architects. Yet, the rest of the interviewees were less enthusiastic about this aspect of design quality and concerns were raised regarding the benefits of designing overly ‘lively’ buildings. The contractors and the consultants, in particular, considered these to cost too much and have minimal, if any, impact on learning. In their view many architects produce superficially attractive and glitzy buildings, and are lacking in their ability to relate to the physical spaces needed to deliver the educational transformation required: “You have got some quite interesting buildings. But are they good value for money - probably not. Are they architecturally pleasing - yes. But then are they overly architecturally pleasing – probably. So the client pays for that.” [Contractor 2]

It was argued that the use of images of award winning school buildings in the reports, at times, served to put excessive emphasis on the aesthetic aspects of the buildings and divert attention from education. Those involved in the programme level were, of course, not oblivious to this and they too had concerns about spending the allocated money merely on ‘landmark’ buildings. The architectural design of a building is only one aspect of the school and they were adamant about the allocated money being spent on good educational facilities. Creating a ‘sense of place’ within the school environment was acknowledged as an important aspect of design quality. The creation of this feeling of belonging within the school is, therefore, not only a building matter. Different schools, children and contexts will create a variety of conditions for this to happen.

The architects were committed to creating designs that encourage social interaction between pupils and staff. Their descriptions of how this was to be achieved within the school building tended to be quite emotive and used analogies such as ‘special spaces’ and the ‘heart of the school’. However, concerns were raised about the restrictions encountered when attempting to include special spaces into the school design:

“The vision is often an education vision, so it is very slanted towards education. They will say ‘must have sufficient social spaces’ but the problem is that nowhere in Building Bulletin 98 or 99 does it give you an area for social spaces.” [Architect 2]

“We have got to spend the money where it is best spent so if it needs a really welcoming opening entrance and the entrance needs to look big and really welcoming and everything else, we will spend a bit of money there but perhaps the back of the house might not be so ‘wazzy’ and when you get to class rooms at 60 sq metres a classroom there is only so much you can do with them, isn’t there, so the point is trying to design those as best you can. So it is knowing where the best place to spend the money is.”

necessity of understanding the educational nature of the school and the physical environment of the building. Several government bodies address the importance of considering and accommodating the new teaching and learning agendas, such as ‘every child matters’ and ‘personalised learning’ in the school design:

“I think we are aware that actually we are designing schools that are 20th century schools rather than 21st century schools in the sense that they are still largely departmentally organised and so on, rather than organised in a freer form that a personalised learning might determine.” [DBES representative]

Thus, there is a belief that the introduction and implementation of these educational approaches to various degrees are dependent on the design of school buildings. Yet, there is real concern regarding the ability of those involved in the design process to address the rapidly changing pedagogies. The ability to predict and visualise the way in which the pedagogy will change in the future is seen as a major challenge:

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USE Efficiency is a dissemination project funded by EACI (Executive Agency for Competitiveness & Innovation – Intelligent Energy Europe Programme). The Project involves 10 EU countries (9 Universities and 4 market players from Denmark, Germany and Italy). It has the aim to help students learn about energy efficiency in buildings by working within their courses to improve energy efficiency in their university buildings. Students are the main actors of the project, working and interacting with teachers and technicians.

**USE Efficiency**

*University and Students for Energy Efficiency*

Professor Maria Kolokotroni
Brunel University

**UNIVERSITIES INVOLVED HAVE SOME COMMON FEATURES:**
- Campus Universities with a variety of buildings
- Students taking courses in the built environment
- Desire to introduce energy related courses
- Willingness to use campus buildings as problem based teaching for students
- Desire to introduce energy in the built environment in a common European vocabulary based on the EPBD

They also differ in some aspects such as diversity of students and existing courses (architects, engineers), different locations in Europe (Figure 1) and a variety of campus buildings, new and old, and various existing approaches on energy management. However, these differences are built in the project to enhance student learning and students will meet in Valencia in July 2011 to work together. In this summer school, nine existing buildings (one from each university campus) will be studied where students will be able to benefit from the experience of other students in terms of discipline, climatic influences, materials, users’ behaviour and cultural issues.

During the courses, students worked on a selection of 6 buildings per university which were analysed using measurements, user feedback and available energy consumption data. Energy consumption data were analysed for all campuses by energy consultant partners, based on a method developed in a previous project (DataMine – http://www.meteo.noa.gr/datamine/). For each buildings and after appropriate weather and other correction to consumption data, a Heat and Electricity consumption index was calculated – which is the ratio of energy consumption over national benchmark consumption. Based on this, buildings were classified as indicated in Figure 2. Some results are presented in Figure 3 for heating energy and a more visual result in Figure 4 which clearly indicates which buildings would benefit from energy management systems. However, it should be stressed that comparing results from different countries and presenting them all together is done for the benefit of student learning.

**Figure 2: Heat and Electricity consumption were compared with national benchmarks and indices were derived to allow easy comparison between buildings.**

**Figure 3: Area specific final energy consumption of the selected building of all universities (Bubble size is proportional to building net floor area.)**

**Figure 4: Analysis of selected buildings based on heat and electricity index, clearly showing buildings that would benefit from refurbishment.**

More information on the project and available reports can be found in [http://www.useefficiency.eu/](http://www.useefficiency.eu/)
SØNDERSØSKOLEN
Søndersøskolen is located in Denmark and was opened in 1973. The total floor area is 12,400 m2 and the school houses approximately 800 pupils.

In the context of a major refurbishment of the school in 2007-2010 automated Natural Ventilation was established in a variety of classrooms and in the large group areas in approximately one third of the school. These classrooms also had some mechanical exhaust ventilation installed, so the natural ventilation can be assisted if the natural driving forces are not sufficient (mixed mode ventilation).

CLASSROOMS
The ventilation in the classrooms occurs through high level automatic opening windows and mechanical exhaust ventilation in the back of the room.

The amount of fresh air coming into the classrooms is limited by single-sided ventilation, as the controlled windows have the same orientation and height above the floor level. The single-sided ventilation is driven by wind and temperature differences between indoors and outdoors. The fresh air primarily flows in at the bottom of the window openings and the stale air leaves the room at the top of the window openings.

At the back of the classrooms there are extract fans to assist the natural ventilation with when required. The mechanical exhaust is controlled and activated when temperature and/or CO2 levels exceed the prescribed level and the power of the extraction is regulated according to the need.

LARGE GROUP AREAS
The ventilation principle in the large group areas is cross ventilation, as the automatically controlled windows are oriented in different directions and positioned at the same height above floor level.

The ventilation is powered primarily by the wind, which creates differences in wind pressure on the facades in which the window openings are located.

PRECISE CONTROL OF THE WINDOWS
For all projects with the WindowMaster NV Advance™ control system the wind pressure coefficients for all automatic windows is calculated by simulating pressure distributions on the entire building from a wide range of wind directions (CFD analysis). The calculated wind pressure coefficients are used as parameters in the NV Advance™ software and this ensures the precise control of the individual windows and provides a comfortable and stable indoor climate as a result.

More and more schools suffer from a poor indoor air quality (IAQ), particularly in older schools where there can be a definite lack of ventilation. It is well known amongst many researches that poor IAQ can lead to different complaints, such as odours, headaches, irritation of eyes, nose and throat, inability to concentrate and other symptoms. A good IAQ in schools is important, since a poor IAQ affects human health and wellbeing. Independent research shows that the correct ventilation can create a 15% increase in effective learning for pupils in schools (Wargocki, 2008).

Indoor Air Quality in Denmark:
Søndersøskolen
Jannick Roth (main author), Richard Arnott, Carl Sutterby
WindowMaster

More and more schools suffer from a poor indoor air quality (IAQ), particularly in older schools where there can be a definite lack of ventilation. It is well known amongst many researches that poor IAQ can lead to different complaints, such as odours, headaches, irritation of eyes, nose and throat, inability to concentrate and other symptoms. A good IAQ in schools is important, since a poor IAQ affects human health and wellbeing. Independent research shows that the correct ventilation can create a 15% increase in effective learning for pupils in schools (Wargocki, 2008).

 Incorporating natural ventilation into classrooms and large group areas through high level automatic opening windows and mechanical exhaust ventilation can significantly improve indoor air quality and learning environments in schools. The WindowMaster NV Advance™ control system enables precise control of ventilation based on wind pressure coefficients calculated through CFD analysis, ensuring a comfortable and stable indoor climate. The integration of natural ventilation with mechanical extraction can further enhance IAQ by assisting natural driving forces, creating a mixed-mode ventilation system.
In each room, close to the automatically operated windows, there is a manual keypad allowing the teachers and pupils to override the control of the windows in the façade. After a predefined period the automatic control is reactivated. The ability to override the system results in high user satisfaction.

**Danish Standards and Building Codes**

The IAQ in the school (temperature and CO2 levels) is evaluated in accordance with the Danish standards and Building codes.

In accordance to the Danish Standard "DS474" (standard for specification of the thermal indoor climate), the temperature in the occupied zone in the summer may vary from 23 to 26°C, deviations in the occupied zone in the summer are permitted in the warm periods. The thermal indoor climate), the temperature in the occupied zone in the summer may vary from 23 to 26°C, deviations in the occupied zone in the summer are permitted in the warm periods. The indoor temperature during the occupied hours in the 12 months from the 1st August 2009 has never exceeded 26°C. One of the key reasons that there are no temperatures above 26°C is the night time cooling. The automatic windows can be opened at night for specific periods to purge the rooms thus ensuring an optimum inlet temperature. This form of heating gave significant energy consumption.

By installing radiators, the school saved approximately 430,000 kWh/year in their heating energy (HVAC 1-2011). Furthermore, the new and energy efficient ventilation system saves 500,000 kWh/year, equivalent to nearly £118,000/year (HVAC 1-2011). One of the main reasons for this saving is that the mechanical ventilation system can be switched off for a large part of the year. During this time the ventilation is done through natural ventilation which has a very low operating cost.

**Energy Savings**

Besides the improved IAQ in the school the school also noted large savings in their energy consumption after the refurbishment. Heating of the rooms was previously done through air heating with the old ventilation system. The ventilation systems ran day and night during the heating season and with a high inlet temperature. This form of heating gave significant energy consumption. By installing radiators, the school saved approximately 430,000 kWh/year in their heating energy (HVAC 1-2011).

**Conclusion**

This study clearly shows the benefits of automated natural ventilation and mixed mode ventilation systems in a refurbishment of a Danish school, Søndersøskolen. Before the refurbishment the pupils and teachers were suffering from headaches and other symptoms caused by the poor IAQ. Complaints fell dramatically after the new ventilation system was introduced, and a much better IAQ has been proven by the measurements taken.

The study also revealed that the school experienced high energy savings in comparison to the old mechanical ventilation system. The mixed mode ventilation system saved 500,000 kWh/year, equivalent to nearly £118,000/year (HVAC 1-2011).

WindowMaster (www.windowmaster.com), Europe’s largest provider of natural comfort and smoke ventilation solutions, has installed its innovative indoor climate solutions for new and refurbishment projects all over Europe, and therefore if you need assistance for one of your projects please do not hesitate to contact them (info@windowmaster.co.uk).
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INTRODUCTION
The vast majority of UK school classrooms are naturally ventilated and over 1100 employ an advanced natural ventilation strategy that uses a Windcatcher®. The Windcatcher is a roof mounted device that channels air into a room under the action of wind pressure, whilst simultaneously drawing air out of the room by virtue of a low pressure region created downstream of the element. However, there is a perceived dichotomy between the requirement to provide sufficient natural ventilation and an acceptable acoustic environment. Accordingly, this article aims to do three things: firstly, to review noise levels measured in UK school classrooms and published in peer reviewed literature; secondly, to present measurements of noise levels in UK school classrooms ventilated by a Windcatcher®; and finally, to compare the two sets of data.

INDOOR ENVIRONMENTAL NOISE AND VENTILATION

The human ear is capable of responding to sound frequencies from approximately 20Hz to 20kHz, but is much more responsive to broadband noise rather than a single tone of sound (Kinsler et al., 1982). In a building, broadband noise is the combination of direct sound from a source and the reverberation of that sound. Ling (2001) shows that noise comes from three and the reverberation of that sound. Ling (2001) shows that noise comes from three.

1. External noise (entering a building through a ventilation or building void).
2. Internal noise (from ventilation systems or electronic equipment).
3. Path effects (sound transported through a building via a ventilation system or building voids).

Noise within a building is generally below 50–60 dBA and will not cause auditory damage to the ears, however the non-auditory effects are far more dangerous to health (Stansfeld & Matheson, 2003). Here, Stansfeld and Matheson link occupational and environmental noise with hypertension, and aircraft and traffic noise with psychological symptoms. Aircraft and traffic noise is associated with raised blood pressure and is also shown to impair the reading comprehension and the long term memory of children. Furthermore, it is generally accepted that noise has a detrimental effect upon the learning and attainment of primary school children, who are more susceptible than adults (Shield & Dockrell, 2003).

Therefore, the investigation of noise in schools and its effect on children is of great interest. Different types of noise (conversational babble and environmental noises for example) are shown to produce different effects on children when performing different tasks (Dockrell & Shield, 2006), while road traffic noise has a negative effect on the attention span of school children (Sanz et al., 1993). More sudden noises, such as sirens, trains, or aircraft, may affect children and teachers ‘disproportionately to their contribution to the overall noise environment of a school’ (Shield & Dockrell, 2003). It is important to note that the design of the room itself has an important influence on the noise from a ventilation system, because this affects the reverberation time and sound absorption of a classroom. These effects are not discussed here, but they are discussed in a review of literature by Shield & Dockrell (2003).

The World Health Organisation (WHO, 1999) and the American Standards Institute (ANSI, 2002) both specify ambient levels of noise for classrooms of 35dB Leq during teaching hours. In the UK, Building Bulletin 93 (BB93) (DfES, 2003) provides the regulatory framework for noise levels in schools. Upper limits are specified as Lmax, an average uninterrupted measurement of a weighted sound pressure level over 30 minutes in an unoccupied and unfurnished classroom. Here, BB93 (DfES, 2003, Table 1.1) sets the upper limit at 35dBA in a conventional classroom and 40dBA in a science and technology laboratory. BB101 (DfES, 2006) allows an additional 5dB Lmax when the pure ventilation rate of 8 l/s per person is provided by natural ventilation. For all other ventilation rates the BB93 limits apply.

Shield & Dockrell (2004) measured noise levels outside 142 urban schools in London, where 88% of the them were exposed to road traffic noise; the average external sound pressure level was calculated to be 57dB Lmax, and was 12dB above those specified by BB93. Although the measurements were only made over periods of 2 minutes, continuous monitoring over a number of hours revealed that the fluctuation of noise was minimal, and so was considered to be approximately constant. Seven of the classrooms are reported as having audible heating/ventilation noise where mean ambient levels were highest, although specific ventilation strategies are not reported. Shield and Dockrell note that the average noise levels measured in Victorian classrooms were 3.2dBA lower than the average noise level measured in modern classrooms and that the glazing type appeared to make no difference to classroom noise levels in this study, although it is acknowledged that the sample size is deemed to be too small for definitive conclusions to be made. However, Shield and Dockrell point out that ambient traffic noise is predominately made up of low frequencies that are difficult to attenuate using glazing. Most naturally ventilated (NV) school classrooms must open windows to provide fresh air, thus increasing the ingress of noise (Ling, 2001). Andersen et al. (2005) show that some types of windows, those manufactured by Velux, only need to open 2 cm (a distance determined in the laboratory) to provide sufficient ventilation while maintaining adequate sound insulation. However, the fact remains that ambient noise levels in UK classrooms are already too high and opening windows increases them. A recent study of noise levels in 12 UK school classrooms built since 2003 (see Mumvuki et al., 2009) shows that 50% of measured classrooms fail to meet government requirements, with all mechanically ventilated classrooms failing to meet the internal ambient noise criteria. Most interesting of all, the study concludes that more noise is generated internally than externally.

Noise generated by mechanical ventilation systems arises from aerodynamic turbulence caused by fans, and contractions and expansions in its duct work that may consist of branching elements, diffusers, grills, and turning vanes (Ling, 2001). Natural ventilation systems have comparably large openings that offer low resistance to the ingress of external noise. In fact, the need to provide low-resistance ducts for the free-flow of air and to reduce noise ingress is a paradox. This was found to be a problem in the Coventry University Library where occupants applied their own acoustic lining to an exposed concrete natural ventilation duct (Simons & Malaney, 2003).

The average broadband traffic noise found in urban areas is approximately 60dBA (Shield & Dockrell, 2003) and so facades and ventilation elements that are immediately adjacent to roads must attenuate this. One cost effective response is to line ducts with an absorbent material. Here, a non-peer reviewed assessment of a square Monodraught Windcatcher, of cross sectional area 0.64m², by the Building Research Establishment (BRE, 2005) shows that when it was tested in accordance with ISO 17171-1 (ISO, 1997) and ISO 140-10 (ISO, 1991) to produce a standard acoustic difference from one room to another, the addition of a 25mm open cell polyurethane foam acoustic lining to a duct (of length 1.1m) and its partition, increases the airborne sound insulation by 11dB. However, Oldham et al. (2004) show that duct lining is designed to attenuate mid and high frequencies and has mixed effects on low frequency traffic noise. A more expensive solution is to use active noise control which Oldham et al. show can attenuate lower frequencies by around 22dBA. De Salis et al. (2000) offer a note of caution because badly designed active control systems can themselves be the cause of problems. De Salis et al. suggest the use of external architectural features such as fences or earth mounds.

Dockrell & Shield (2006) advocates internal measures and suggests using ceiling tiles, carpeting and curtains, and wall covering to absorb sound. The literature shows the negative effects of noise on the occupants of buildings, with children affected more than adults. Most studies of noise in schools are for NV classrooms, however there are no in situ measurements of noise in classrooms or any other type of room ventilated by a Windcatcher®. Clearly, the need to attenuate noise through a natural ventilation system is at odds with the requirement to allow air to flow with as little resistance as possible. The consideration of both factors may lead to a compromise that could negatively affect the occupants of a room ventilated by a Windcatcher®, thus making the measurement of noise in situ highly important.
MEASURING AMBIENT NOISE

Acoustic measurements of the equivalent sound pressure level over 30 minutes ($L_{eq,30m}$) were made in twenty one classrooms of seven schools, see Table 1. Each classroom was ventilated by a roof mounted Windcatcher controlled by dampers located at the base of the connecting duct. Some ducts were lined with acoustic foam. The cross sectional area (CSA) of each Windcatcher given in Table 1 accounts for its presence.

Measurements were made using a Citrus CR262 Sound Level Meter that is accurate to ±0.5 dB and Deaf Defender software. The meter was placed in the centre of the room and measurements made with all windows closed and the Windcatcher dampers either open or closed. External $L_{eq,30m}$ was measured adjacent to the façade of the classroom within a height of between 1 and 2 m. Here, it is noted that the upper limits specified by BB93 (DfES, 2003) are for an unoccupied and unfurnished classroom, but it was not possible to test the classrooms under these circumstances because although the classrooms were unoccupied, they were not free from furnishings.

RESULTS

Ventilation systems such as a Windcatcher often generate noise or allow noise ingress, and so the contribution of the Windcatcher to the ambient noise level in each classroom is evaluated here. External ambient noise levels for each school are shown in Table 2 and the measured sound pressure level in each classroom with the Windcatcher dampers open and closed are given in Figure 1 as an average unim-
terrupted measurement of “A” weighted sound pressure level, $L_{eq,30m}$, over 30 minutes. A full table of measurements is presented in Jones (2010). In Table 2, the external sound pressure level in each classroom is shown.

By opening the Windcatcher dampers it is perhaps expected that the ambient sound pressure level measured in each classroom will increase because this exposes the large duct area that spans from the classroom to its surroundings. However, of the nineteen pairs of measurements made with the Windcatcher dampers open and closed, 10 are highest with the Windcatcher dampers open, 8 are highest with the Windcatcher dampers closed, and 1 pair is identical. Overall, the difference between the mean noise levels for dampers open and closed is 1.8 dB $L_{eq,30m}$ and so the difference between the sound pressure levels experienced in these classrooms with the Windcatchers open or closed can be considered to be negligible.

Table 1: Windcatcher parameters.

<table>
<thead>
<tr>
<th>SCHOOL PREFIX</th>
<th>NUMBER OF WINDCATCHERS</th>
<th>WINDCATCHER CSA (m²)</th>
<th>ACOUSTIC LINING (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>4</td>
<td>0.77</td>
<td>25</td>
</tr>
<tr>
<td>D</td>
<td>3</td>
<td>0.64</td>
<td>0</td>
</tr>
<tr>
<td>E</td>
<td>1</td>
<td>0.46</td>
<td>25</td>
</tr>
<tr>
<td>F</td>
<td>2</td>
<td>0.92</td>
<td>50</td>
</tr>
<tr>
<td>G</td>
<td>3</td>
<td>0.64</td>
<td>50</td>
</tr>
<tr>
<td>H</td>
<td>4</td>
<td>0.50</td>
<td>0</td>
</tr>
<tr>
<td>I</td>
<td>4</td>
<td>0.50</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 2: Measured external sound pressure level, $L_{eq,30m}$ (dBA)

School | $L_{eq,30m}$ (dBA)
--- | ---
C | 57.2
D | 44.4
E | 38.4
F | 42.9
G | 50.9
H | 53.5
I | 66.6

The remaining schools are much quieter. Those near to busy roads or motorways, while comparable, possibly because they located near to busy roads or motorways, while the remaining schools are much quieter. Figure 1 shows that for closed and open Windcatchers the ambient noise levels are below those required by BB93 (DfES, 2003) in sixteen classrooms, and exceeded in seven classrooms. The sound pressure levels range from 24.3 dB $L_{eq,30min}$ to 44.3 dB $L_{eq,30min}$ and the mean average for classrooms with an open or closed Windcatcher is 36.3 dB $L_{eq,30min}$. Here it is noted that it was not possible to take measurements in classrooms D2 and D3 with the Windcatcher dampers closed and the measurements made in classroom.

E3 have not been included because they were disturbed during the measurement. These values compare favourably to those of Mumovic et al. (2009) who measured sound pressure levels in twelve NV and MV classrooms that ranged from 24—71 dB $L_{eq,30min}$ and have a mean average of 62.4 dB $L_{eq,30min}$ and Shield & Dockrell (2004) who measured ambient sound pressure levels in 30 unoccupied classrooms reporting a mean level of 47 dB $L_{eq,30min}$.

CONCLUSIONS

These results suggest that the classrooms containing a Windcatcher generally conform to BB93, although the sample size is relatively small and so there is probably insufficient data to conclude that Windcatchers do not represent a problem when meeting noise targets in schools. Here, further testing that includes a detailed acoustic analysis of the Windcatcher using the frequency domain is probably necessary in order to draw more definitive conclusions.

REFERENCES


Figure 1: Measured internal sound pressure level, $L_{eq,30min}$ (dBA).

Filled, Windcatcher closed; clear, Windcatcher open; specified upper limit.
Time-Dependent Effects of Indoor Lighting on Well-Being and Academic Performance

K. Eren Sansal, Peter Raynham
The Bartlett, University College London

ABSTRACT
This paper briefly presents the critical findings of a study which was carried out in a junior school between October 2008 and June 2009 in order to investigate the influences of different lighting conditions on various physiological, psychological and cognitive parameters. The results of the study revealed that natural light might be a potent factor in promoting various non-visual effects in humans. Therefore, it seems reasonable to surmise that our well-being and mental functioning are likely to be contingent upon the successful incorporation of natural light into our modern urban built environment, including schools.

INTRODUCTION

PREVIOUS RESEARCH

As research evidence has accumulated regarding the impacts of affective states on cognitive processing (e.g., memory) and social behaviour (e.g., helping) in humans, a growing number of researchers have sought to determine whether indoor lighting can influence mood and cognition. Although some of the early studies report that differences in the illuminance provided and colour properties of illuminants do not have any impact, subsequent research, undertaken predominantly in controlled settings, provides inconclusive evidence that indoor lighting can alter mood and thought processes.

Present Research

Based on the previous findings, it seems reasonable to infer that our current knowledge of how changes in environmental lighting conditions alter mood and cognition is less than adequate and based mainly on short-term studies in laboratory settings. The present research, therefore, was designed to address some of the questions raised by the existing literature:

a) Although the studies on the effects of different light intensities and spectra on mood and cognition have produced equivocal results, a number of studies have demonstrated that daytime exposure to bright light and light sources rich in short wavelength light can influence the rhythms of melatonin, core temperature and cortisol in humans and have implications for sleep and daytime sleepiness, which have been shown to be associated with psychological well-being. Is there an optimal lighting condition with respect to light intensity and spectrum in order to promote physiological and psychological well-being and facilitate thinking? Is it possible that light intensity and spectrum have differential effects on separate non-visual processes?

b) It should be noted that, other than quantity and spectrum, light can also be varied in terms of timing. Is it possible that environmental lighting conditions may exert a more potent influence on physiological, psychological and cognitive processes at certain times of day (e.g., during early morning hours) and year (e.g., during winter months)?

PROCEDURE

Participants
Fifty-six fourth-grade students (30 males and 26 females), aged between eight and nine years, voluntarily participated in this field study. All participants were reported to be in good physical and psychological health and have normal, or corrected to normal, vision and normal colour vision.

Setting
During the period between 08 October 2008 and 10 June 2009, the study was carried out in four similar classrooms of a junior school in Kent, UK (Figure 1). The classrooms differed mainly in their access to natural light and in the illuminance provided. While two of the classrooms (C2 and E2) had windows only on the south wall, the other two classrooms (C1 and E1) had windows on the north and south walls, respectively. Approximately 200 lux on the horizontal working plane was provided by the electric lighting system in C1 and C2. The illuminance provided was adjusted to 500 lux in E1 and E2, and this level was increased by approximately twenty-five per cent in the morning (between 08:50 and 09:50) and in the afternoon (between 13:10 and 14:10) in E2.

Protocol and Dependent Variables

Throughout the study, five main (Table 1) and five supplementary (Table 2) data collections were executed at approximately four-week intervals in order to assess participants’ sleep quality, mood and daytime sleepiness by administering self-reports and their diurnal melatonin and cortisol concentrations by collecting saliva samples. In addition, the data regarding participants’ performance on school examinations were collected for evaluating their academic achievement.

Table 1. The daily routine of the main data collections

<table>
<thead>
<tr>
<th>Time</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:00-08:50</td>
<td>Preparations</td>
</tr>
<tr>
<td>08:50</td>
<td>The start of school day – Sleep quality assessments</td>
</tr>
<tr>
<td>09:50</td>
<td>Mood and alertness assessments + Saliva samples (cortisol + melatonin)</td>
</tr>
<tr>
<td>10:15-10:30</td>
<td>Break</td>
</tr>
<tr>
<td>11:45</td>
<td>Mood and alertness assessments + Saliva samples (cortisol)</td>
</tr>
<tr>
<td>12:00-13:10</td>
<td>Lunch</td>
</tr>
<tr>
<td>14:45</td>
<td>Mood and alertness assessments + Saliva samples (cortisol)</td>
</tr>
<tr>
<td>15:20</td>
<td>The end of school day</td>
</tr>
</tbody>
</table>

Table 2. The daily routine of the supplementary data collections

<table>
<thead>
<tr>
<th>Time</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:00-08:50</td>
<td>Preparations</td>
</tr>
<tr>
<td>08:50</td>
<td>The start of school day – Sleep quality assessments</td>
</tr>
<tr>
<td>09:50</td>
<td>Saliva samples (melatonin)</td>
</tr>
</tbody>
</table>

Figure 1. Classroom images
RESULTS

In the present context, the most critical finding is concerning the merits of natural light. It was observed that the additional windows in C2 and E2, providing both full spectrum natural light and the changing cycles of light and darkness, might have beneficial effects on sleep quality, mood and academic achievement. Participants’ ratings of their sleep quality and mood did not differ significantly among the classrooms. However, the participants, who had been allocated in C2 and E2, reported less sleep quality problems and were in a more elated mood state than the other participants throughout the study (Figure 2). Furthermore, they were marginally more successful in reading, writing and mathematics on all occasions (Figure 3).

DISCUSSION AND CONCLUSION

There is no doubt at all that, for many of us, it is a joy to feel the warmth of sun and be able to perceive the meaningful variations of daylight. Even if these were only aesthetic preferences, they would be of great value. But perhaps these are more than just simple appraisals. Based on the present results, it is viable to deduce that we may be physically and mentally attuned to natural light. Therefore, it seems reasonable to suggest that our well-being and mental functioning is likely to be contingent upon the meaningful variations of daylight. Even if these were only aesthetic preferences, they would be of great value. But perhaps these are more than just simple appraisals. Based on the present results, it is viable to deduce that we may be physically and mentally attuned to natural light. Therefore, it seems reasonable to suggest that our well-being and mental functioning is likely to be contingent upon the meaningful variations of daylight.
Delivering Low Carbon Schools in UK: Bridging a Credibility Gap

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Dr Dejan Mumovic, The Bartlett, UCL

Ten million pupils in UK spend almost 30% of their time in a classroom during school days. The indoor environment quality (IAQ) of the classroom not only affects the health and thermal comfort of pupils (Norbeck and Nordström 2003; Wargocki and Wynn 2000) but also impacts learning performance and increases absenteeism (Coley and Davies 2004; Shaughnessy et al. 2006; Bako-Biro et al. 2008). There are approximately 25,000 maintained schools in England and Wales with a total school area of 60,000,000 m2 and replacement value of £130 billion (BTI 2005). In addition to a £1.5 billion annual spend on maintenance of school buildings, the annual spend on energy in year 2006-2007 exceeded £420 million. The Climate Change Act (2008) requires the UK to reduce its greenhouse gas emissions by at least 34% below 1990 levels by 2020 and 80% by 2050 (DECC, 2008). Nationally, schools alone account for 15% of the energy in public and commercial buildings (DCSF 2009). Locally, schools in England contribute to around 40-60% of a Local Authority’s (LA) carbon emissions (Carbon Trust, 2010) and as such provide a substantial financial burden on the LA’s carbon tax payment. The Carbon Management Strategy for the School Sector sets a target of 42% reduction from the 1990 level by 2020 for the national schools estate (DFE 2010).

Three major UK studies focusing on operational performance of newly built ‘low energy’ schools have shown that new schools are failing to meet even basic criteria related to both energy consumption (Pegg et al. 2007; CarbonBuzz 2010) and provision of indoor environmental quality (Mumovic et al. 2009a). Classrooms and lecture theatres pose a great challenge to designers and engineers as they are environmentally more complex than most structures. The challenge here is not just the fact that they usually have high heat loads due to its mostly full or nearly full capacity, but also their transient nature of pupils. Further, lighting and equipments change from class to class depending on the teaching methods used. Classrooms and lecture theatres also need to perform well acoustically, both for the speech and music, and as sound amplification is generally not used, background noise control is critically important. All these factors, in addition to energy use place constraints on, for example, ventilation design, and if this is poor, it can lead to the deterioration of IAQ and thermal comfort. Although complex, achieving the balance point between indoor air quality and energy use is unfortunately just one of many socio-technical engineering challenges in school buildings. To get a bigger picture of why the ongoing efforts of UK industry to deliver low carbon school buildings conducive to learning have had little success the methodology was split into two stages:

The first stage involved an online survey conducted with 286 members of the CIBSE School Design Group (Dasgupta 2009). The study highlights numerous challenges with respect to designing low carbon schools. UK industry believes that there is shortage of skilled professionals capable to deliver low carbon school design to the required scale and standards. At present the industry does not have sufficient knowledge and skill to procure, design, construct and operate zero carbon school buildings at the scale required today.

The absence of readily available energy use data matched with descriptions of physical form, indoor environmental quality parameters, occupant use of space and behaviour affects the accuracy of predicted energy consumption at the design stage. It further prevents the development of a transparent and validated strategy for modelling energy use in school buildings which could provide indoor environmental quality parameters required to achieve a conducive learning environment.

This has been further substantiated by professional opinion regarding designing of low carbon buildings which has clearly highlighted the limitations of the current processes adopted, one of the key risks being the inability to predict the actual energy consumption of the buildings. The DSA indicates a variation between the design and use of the building for the 16 parameters examined (Refer Fig 2) can cause a discrepancy in the annual energy use ranging from -31% (underprediction) to +45% (overprediction). The survey additionally attributes this to issues such as conservative approaches of design briefs and design tools, facility management and behavioural issues of energy use.

This includes extended unoccupied hours of schools and irregularities within the BMS. The DSA points at behavioural issues to be one of the single largest contributors to discrepancies in energy performance (69%), while uncertainties in the thermal physical properties of the materials used have a negligible effect (3%). The key variables for behavioural issues include heating setpoints, heating schedules and daytime ventilation rates, while uncertainties in heat recovery efficiency and thermophysical properties of typical used materials have a much smaller influence. These discrepancies have been additionally substantiated by post occupancy evaluation studies and as a result designers and engineers are increasingly under pressure to provide accurate estimates for energy consumption in schools and supply guidance to achieve carbon reduction targets.

Overheating has a wider variation, ranging from 58% (underprediction) to 118% (overprediction) and is more dependent on use (81%) and materials (11%). This underlines the absolute reliance of naturally ventilated schools buildings on proper utilisation available ventilation systems in order to meet overheating criteria and the robustness that will this offer if accomplished. At the same time though, this dependency raises concerns about whether such designs can actually be successful.
For schools to be truly zero carbon, it is imperative that low carbon energy resources be used for energy generation. However, schools do not have a year round demand for energy and environmental conditions may not always support exploiting renewable resources. Thus in order to take maximum advantage of low carbon resources it is suggested that they be shared across local communities, especially where schools are a part of wider scale new development. However, the use of energy networks cannot be standardized for all schools. There will be a variation in the models of the rural schools from that of the urban ones. Further questions need to be answered regarding the distribution of responsibilities in terms of management and maintenance of the systems and where their budgetary responsibilities would lie. There also needs to be more research carried out to understand implementation of such systems in various contexts, which will signify the as per demands of community, planning constraints, school size, supply chain of resources and development laws. It is accepted that sharing energy would have perceivable benefits, but to realize it there needs to be a clearer frame work and defined policies to support them.

More awareness of their resources, can and whilst there is common acceptance of the complexity of designing a school, the recent paper (Clements-Croome et. al., 2010) stated that agreement regarding the importance of different components of a school building’s system and ways to prioritize between them is still to be achieved between various stakeholders. It argued that the multi purposes educational facilities and the conflicting view of design quality combine to make finding balance between ‘fitness for purpose’, ‘cost effectiveness’ and ‘buildability’ of the facility extremely difficult to achieve in practice. It appears that the engineering science of designing green buildings is remarkably underdeveloped and that a step change in the approach to the design of school buildings is urgently needed.

In classrooms, indoor environment quality performance is dependent on how the building responds to variations in internal and external conditions and on how and when the pupils and teachers respond to these variations, i.e. what adaptive actions they take and under what conditions they take them. All, survey, monitoring and modelling studies are suggesting that behavioural aspects are the most dominant factor affecting energy use in school buildings. The study clearly showed that past attempts to reduce carbon emissions from existing as well as newly built school buildings in UK have had little success. Reasons for this includes poor understanding of

• how to design, engineer and facilitate learning spaces for changing pedagogical practices to support a mass education system, and greater student diversity
• how pupils and teachers use energy in school buildings and interact with technology
• how they respond to socio-technical energy conservation initiatives
• how the overall indoor environment quality affects the learning performance of pupils and productivity of teachers

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Clements-Croome D., MacMillan S., Mumovic D. 2010. Designing Intelligent Schools, CIB World Congress, Salford, UK.


Joint CIBSE Schools Design and Natural Ventilation Group Seminar:

THE NATURAL VENTILATION OF UK SCHOOL CLASSROOMS

For those involved in the design and construction of school buildings this is a time of great change. The river of money allocated for building schools has run dry and the price of energy is increasing. Yet, there are social and moral obligations to provide school buildings that are both safe and healthy for those who are amongst the most vulnerable in our society, and that enable children to achieve their full academic potential.

The noted Egyptian architect, Hassan Fathy, said “Before investing or proposing new mechanical solutions, traditional solutions in vernacular architecture should be evaluated and then adopted or modified and developed to make them compatible with modern requirements.” It is only in recent times that we have sought to resolve the inadequacies of design by using mechanical systems where previously passive systems had sufficed. Natural ventilation is still the most common ventilation strategy used by UK buildings yet to some involved in the design and construction of buildings it remains a black art. This seminar aims to answer three key questions: (i) Is there still a case for naturally ventilating schools? (ii) What are the objective lessons that can be learned from functional schools built during the last decade? (iii) Can a compliant natural ventilation strategy ever be assured?

VENUE

4th October 2011
The Old Refectory
University College London
Wilkins Building
Gower Street
WC1E 6BT

For further details please see the CIBSE School Design Group website at www.cibse-sdg.org or contact Benjamin Jones by email at bjones@ucl.ac.uk.

This event is jointly sponsored by Monodraught, SE Controls, and WindowMaster.

SESSION A

10:00 – 11:30 hrs.
Registration in the North Cloisters

SESSION B

12:00 – 13:30 hrs.
Lessons from the post occupancy evaluation of naturally ventilated schools
1. How not to design a school
Roderick Bunn, BSRIA
2. DCLG ventilation design in Schools study
John Palmer, AECOM
3. Ventilation strategies in practice and in context
Dr. Benjamin Jones, University College London

Lunch break and networking session (13:30 – 14:30 hrs.)

SESSION C

14:30 – 16:00 hrs.
Delivering a compliant natural ventilation strategy
1. Ventilation modelling and regulatory compliance
Dr. Malcolm Cook, Loughborough University
2. The art of fine control
Carl Sutterby, WindowMaster
3. Contracting the control and ventilation strategies early
Nick Huddleston, SE Controls

4. Questions and discussion (if time and numbers permit)

SESSION OUTLINE

09:30 – 10:00 hrs.
Registration in the North Cloisters

SESSION A

10:00 – 11:30 hrs.
There case for naturally ventilating UK schools?
1. Building schools today and in the near future
Dr. Mike Entwisle, Buro Happold
2. The relationship between ventilation and academic performance
Dr. Derek Clements-Croome, Reading University
3. The case for natural ventilation in schools and the origin of the standards
Professor Martin Liddament, VEETECH

11:30 – 12:00 hrs.
Coffee break and networking session

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Professor Derek Clements-Croome is founder of the MSc Intelligent Buildings Course at the University of Reading and has carried out many research projects funded by Government. He is experienced in sustainable buildings research and education nationally and internationally. He chairs the CIBSE Natural Ventilation and Intelligent Buildings Groups and sits on the Schools Group. He is Editor for the Intelligent Buildings International Journal and is the author of more than one hundred papers and books.

Dr. Mike Entwistle is a director of Buro Happold consulting engineers. Mike has provided guidance to Partnerships for Schools and other relevant bodies, and is a leading member of the CIBSE Schools design group and the PIS Pest Occupational Group. He was a member of the DCFS Zero Carbon Schools Task Force, and the BSRIA Schools Soft Landing Group and as a CABE Schools design reviewer, was instrumental in the drafting of the sustainability criteria for the design review process. Mike has led the engineering design of over 20 schools, including primary, secondary, Academy, BSF, and Special Needs facilities.

Dr. Benjamin Jones is a Research Associate in Indoor Environment Modelling at the Bartlett School of Graduate Studies. He holds an Engineering Doctorate in Environmental Technologies from Brunel University. His research evaluated the post-occupancy performance of naturally ventilated school buildings in collaboration with Monodraught Ltd. Benjamin is a committee member of the Chartered Institute of Building Services Engineers Natural Ventilation and Schools Design Groups.

Dr. Malcolm Cook is a Reader in Building Performance Modelling at Loughborough University and works in the area of theory and practice of energy buildings. His work is published in books, journals and conference proceedings, and journal papers and has contributed to awards for innovative building design, including the RIBA presidents gold medal for practice-based architecture (2007) and the CIBSE environmental initiative of the year award (2006). Dr. Cook is secretary for the CIBSE Natural Ventilation Group and chairman of IBPSA England.

Dr. Nick Huddleston is a Business Development Manager for SE Controls. He joined SE Controls in 2006 to establish their dedicated NVS division offering the construction industry fully adaptive natural ventilation systems, which are open protocol and stand-alone, using building envelope automation. Nick has a BEng degree from Coventry Polytechnic and is studying for an MBA by distance learning at Warwick Business School and continues to champion natural ventilation both commercially and through more altruistic activities to benefit the industry as a whole.

Professor Martin Liddament has been involved in ventilation activities for over 30 years and is Managing Director of VEETECH Ltd. Martin also edits and publishes the International Journal of Ventilation. He is currently involved in writing revisions to the ventilation sections of CIBSE Guides A and B. Martin has a special interest in natural ventilation and is a member of the CIBSE Natural Ventilation Group. Prior to forming his own company he was Head of the International Energy Agency’s Air Infiltration and Ventilation Centre.

John Palmer has been involved in the research into the energy performance of school buildings since 1981. This includes both monitoring school building performance and design of low energy school buildings. He has been a principal author of numerous schools based publications including Good Practice Guides, the original Department of Education guide: Design of Sustainable Schools: Case studies, the editor of the CIBSE Journal and is the author of more than 60 conference papers and books.

Carl Sutterby is a Regional Sales Manager at WindowMaster where he provides general guidance on facade design and building suitability for natural ventilation to architects, and building and M&E consultants. His role is not product specific and requires knowledge of WindowMaster’s experience of controlling natural ventilation strategies across Europe in differing climatic conditions. Carl has worked within the construction industry for 30 years, particularly on facades and interiors concentrating on acoustic control. He is active within CIBSE in the management of committees of the Schools Design Group and the Natural Ventilation Group.

For further details please see the CIBSE School Design Group website at www.cibse-sdg.org or contact Benjamin Jones by email at bjones@ucl.ac.uk.

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The Bartlett School of Graduate Studies

is the only UK built environment department to host two research groups which have been acknowledged as “world leading” by the EPSRC via the award of Platform Funding: Space Group and Complex Built Environment Systems Group (with UCL Energy Institute). In the last Research Assessment Exercise, RAE 2008, The Bartlett was rated the best overall in the UK for research in Architecture and Built Environment.

To engage with the building design industry we are rolling out a programme of CPD education suitable for built environment professionals such as architects and engineers. This will take the form of full MSc modules accredited by professional institutions such as CIBSE, to shorter more specific half day courses on technical topics. All CPD education would draw on the experienced staff of the BSGS. For further information and pricing see the website.

CIBSE Approved CPD Modules:

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- Industrial Symbiosis
- Social Dimensions of Sustainability
- Environment Management and Sustainability
- Advanced Building Simulation
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- Built Environment: The Energy in Context
- Health and Comfort in Buildings

Approved for Completing the Educational Requirements for CEng Registration by CIBSE and the Energy Institute:

MSc in Environmental Design and Engineering
MSc in Light and Lighting

Contact: Dr Ben Croxford (b.croxford@ucl.ac.uk)
Website: www.bartlett.ucl.ac.uk/web/ben/cpd

EU Commission: Evidence Based Policy on Indoor Air Quality in Schools

Dejan Mumovic,
The Bartlett, UCL

Schools in the UK house almost 10 million pupils who spend almost 30% of their life in school buildings and about 70% of their time inside a classroom during school days. Consequently, classrooms/learning spaces are the second most important indoor environment, after children’s homes, where they are exposed to various air-borne pollutants to a much greater extent than outdoors. Children are also more vulnerable to environmental pollutants as they breathe more compared to their body weight and are less able to deal with toxic chemicals than adults. Former reviews on the subject of school environments indicate that ventilation is often inadequate in classrooms, causing increased risk for asthma and other respiratory health-related symptoms among school children. Recent studies still report extremely high CO2 levels in classrooms and ventilation rates were often found to be very low.

SINPHONIE Project (School Indoor Pollution and Health: Observatory Network in Europe) is a large research project funded by EU Commission’s Health and Consumer Protection Directorate. It aims to improve indoor air quality (IAQ) in schools by establishing IAQ benchmarks for schools and assessing effect of IAQ on health of primary school children. This project is an example of practical implementation of the EU environment and Health Action Plan 2004-2010. 25 European countries contribute to the development of European IAQ database which will be created using the same IAQ monitoring protocols in 120 countries across Europe.

UK TEAM

UCL: Dr Dejan Mumovic, Dr Kaman Lai, Professor Michael Davies, Lia Chatzidiakou, Paula Tarttelin Hernandez, Nikki D’Arcy

Reading University: Professor Derek Clements Croome
CIBSE School Design Group is a specialist group of volunteers interested in school design. All articles were prepared by CIBSE School Design Group members. Our sponsors covered the costs of printing 1,000 copies of this bulletin. The previous issues can be downloaded from our web-site.