


# Building Intelligence

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# Executive summary

Our educational infrastructure was to a large extent built in the early decades of the 20th century or in the era following World War II, and it is not well adapted to the requirements of modern schooling. Refurbishing these environments brings a wide range of benefits, including the reduced absence of teachers and pupils for health reasons, substantial savings in energy costs and an improved environmental profile. Above all, modern, dynamic control of the indoor environment and better school security have been shown to improve academic results in terms of both knowledge retention and work effectiveness.

# Improving education through the educational environment

When 16-year-old Susan rides off to school in the morning for a day of history, mathematics and English classes, what she actually learns will be defined by a wide range of variables. Her own motivation and abilities, her teachers' and her school's methodologies and the other educational resources she can draw on (family, libraries, etc.) are all important factors in the pedagogical mix. In addition, modern research points to another factor that steers her intellectual development: the school's physical environment.

Over the centuries, teaching environments and school buildings have varied greatly – from one point in time to another, from one culture to another, from one political system to another. From Plato's Akademia outside Athens to today's advanced learning establishments, school buildings as such have evolved to be better adapted to the needs of the modern curriculum.

Many of our schools had their cornerstones laid in the late 19th or early 20th centuries, or they stem from the baby boom years that followed World War II. Clearly, these buildings were constructed according to other standards than those that govern the modern educational system. And as concerns mount over the inadequacies of the school environment, politicians and school authorities are increasing their efforts to modernise school buildings. Initiatives such as "Schools of the Future" in the UK and various programmes within the EU and US are examples of such political drives.

Currently, as part of the vast stimulus packages presented by governments worldwide to counter the recessionary effects of the 2008 financial crisis, funds are being made more readily available for such initiatives and such investments. The OECD recently stated that:<sup>1</sup>

- Countries are using public sector building and civil engineering construction, including education buildings, as one of the means to stimulate their economies.
- Education clearly benefits, and the crisis is providing an opportunity for governments and education authorities to address such issues as modernisation, earthquake-proofing and the environmental performance of buildings.

In the US, the American Recovery and Reinvestment Act of 2009 (ARRA) states that funds may be used "for modernization, renovation, or repair of public school facilities and institutions of higher education facilities."

With both the will to improve the educational environment and the increasing availability of funds in place, it is important to look at which are the key issues, where the most effective improvements lie and what tools and systems are available to bring about change.

<sup>1</sup> OECD/CELE 2009



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# Where the opportunities lie

Many of the programmes for the improvement of education buildings focus on a number of key issues. These include:

- Health
- Energy savings
- Pedagogical results
- Environmental impact
- Security

## Health

Health is of course a basic concern when creating an educational environment. Millions of students and teachers spend a significant portion of their days in public and private school buildings. Many of these buildings are old and in poor condition, and they may have environmental characteristics that inhibit learning and pose increased risks to the health of children and staff.

School buildings are prone to a variety of indoor environmental problems that may result in symptoms of illness among teachers, staff and students. In addition to having very high occupant densities, they are in many instances poorly maintained. The three major risk factors for school-building-related health complaints are inadequate ventilation, surface dust / inadequate cleaning and mould.<sup>2</sup>

While there are many factors that come into play in assuring a healthy school environment, indoor air quality (IAQ) is therefore a key component. Poor IAQ is a known contributor to a number of significant health problems. In addition to increasing the rate of transmission for infectious diseases such as colds, influenza and tuberculosis, it has a role in asthma, which affects more than 5% - 10% of the school population.<sup>2</sup>

The management of indoor air quality can significantly reduce the health hazards created by inadequate HVAC function. Improved airflow control can be provided without energy penalties, simply by gaining more precise control over ventilation rates. A dynamic, continuously adjusting system will provide the greatest health benefits and flexibility.

## Energy Savings

One aspect of improving schools and the performance of students is the amount of resources channelled into the teaching itself as opposed to other support functions. The potential for energy savings in schools creates an important opportunity to reallocate funds to the teaching staff and to other more active teaching resources.

Many schools were built in an era of cheap energy, when concern over energy costs was not among the central design criteria. As a result, these schools today are often energy inefficient. This inefficiency is due in some part to structural issues (building construction), but a greater portion can be attributed to the inefficient control of energy usage. Areas of energy use in schools today include:

- Lighting
- Fans, pumps and controls
- Cooling
- Heating
- Hot water

The use of school premises is highly irregular, both in terms of the school year and in terms of the school day. Some classrooms may be used intensively, whereas others may be used more sporadically. The flow of students and teaching staff through the premises puts irregular demands on a school's HVAC systems. Traditionally these have been met by maintaining a static level of heating, AC and ventilation over time. However, modern systems with integrated control solutions permit highly dynamic control of the indoor climate, in which the levels are tuned to coincide with actual room usage. Even a room's lighting can be steered according to its occupancy, and sensor control can be used to synchronise the

management of heating/AC and ventilation, for example by preventing an increase in heating when a window is opened.

Intelligent control of the energy consumption in schools has been shown to provide substantial savings in energy costs. Studies exhibit varying results depending on the site, but savings in the range of 15% – 30% are common. According to the Sustainable Buildings Industry Council, school districts can save 30% – 40% on utility costs each year for new schools and 20% – 30% for renovated schools, simply by applying sustainable, high-performance, energy-efficient design and construction concepts that improve classroom comfort.<sup>3</sup>

As one example, Strandskolan elementary school in Malmö, Sweden lowered its consumption to 55 kWh by installing an integrated building management system. The average for schools in the city is 120 kWh, and the difference translates into savings that can be redirected into Strandskolan's teaching resources.

## Pedagogical Results

Not only does improved HVAC and energy management in schools safeguard health and save on costs, research shows that an improved indoor environment also leads to a clear improvement in pedagogical results. A recent study published by the Technical University of Denmark<sup>4</sup> shows a correlation between variations in airflow and temperature control and a student's academic performance. In experiments conducted both summer and winter at an elementary school in Denmark, pupils were given normal schoolwork in mathematics and language training (reading and comprehension). Clear improvements in pupil performance were registered, with top levels showing a 35% improvement and average levels a 15% improvement.

<sup>3</sup>[www.greenbuildingnews.com](http://www.greenbuildingnews.com)

<sup>4</sup>indoor environment and learning in schools. DTU 2009

Other studies confirm these results. The University of Reading has measured work rate improvements of 7% in addition and subtraction with an improved indoor environment. In a Milwaukee research programme, Myhrvold et al reports a significant relationship between a facility's condition and student achievement in mathematics, science, language and social studies.<sup>5</sup>

The clear relationship between student performance and an improved indoor environment is an important incentive for reviewing the current indoor environment in schools in order to support better learning. Learning, after all, is what school is all about.

## Environmental impact

Environmental concerns form much of today's political agenda, with municipalities around the world setting objectives for environmental protection. Reduction objectives for carbon emissions have been defined by most governments and municipalities, with aggressive objectives in the 2015 – 2020 horizon. The city of Paris has set the ambitious objectives of reducing greenhouse gas emissions over 2004 levels by 30% as of 2020 and 75% as of 2050. Frankfurt am Main has special programmes for CO<sub>2</sub> reduction in schools, which achieved reductions of up to 10,000 tons between 1997 and 2007 and which are still ongoing.

Building energy often represents a large part of the overall energy consumption: values between 25% and 40%<sup>6</sup> of all energy are calculated for the building sector within the OECD. And municipal buildings, with many schools among them, are thus a prime target for environmental efforts.

Creating a "green" school implies a wide range of activities, touching on everything from construction aspects to a well-managed recycling programme. Again, an intelligent

building management system helps to achieve the environmental objectives through intelligent resource management such as dynamic control of lighting, heating and ventilation. The reduced energy consumption attained by such means can considerably diminish the environmental footprint of any educational institution.

## Security

Naturally, academic performance also depends on a student's ability to focus on his or her studies. Disruptions, and even worse a feeling of insecurity, distract from the most well-intended pedagogy. In a study commissioned by Schneider Electric, a large number of teachers in the UK responded to questions about security issues in their schools. Of these, 51% stated that the levels of indiscipline and crime in schools interfered with pupils' ability to learn. Another 33% said that it sometimes did.

Creating a tranquil, calm and secure environment in schools is an important and perpetual issue, and most of the answer lies in people and processes such as anti-bullying initiatives. But technology can also lend a helping hand, especially when it comes to criminality and the damage or destruction of property. Access control and surveillance systems can both monitor and deter. And entrance systems can log a pupil's presence in the school, a feature appreciated by parents for the feeling of safety and security it provides.

A study<sup>7</sup> among teachers, students and parents in Sweden showed a high degree of acceptance for such solutions in schools. Of the students and parents surveyed, 70% or more would accept security solutions in schools (including CCTV) and over 80% said that such systems would decrease property damage, theft and violence.

<sup>5</sup> CEFPI 2000

<sup>6</sup> Environmentally sustainable buildings, OECD 2003

<sup>7</sup> SSF 2009 (in Swedish)

# Conclusion

As we look to the future and the formative years of coming generations, a holistic approach to the educational environment must be taken – one that comprises teaching curricula and pedagogies but also the learning environment as such. By building the smarter schools of the future today, we can profit from short-term gains in cost and resource allocations while building a wholesome future for our children in the long term. A future that stimulates their knowledge and abilities, as well as one that safeguards their health and the environment of the world they live in.

## School architecture

Interest in and concern for the educational environment is nothing new. Already in 1809, Joseph Lancaster published a pioneering work regarding Hints and Directions for Building, Fitting Up, and Arranging School Rooms. Views on how best to build the educational institutions of the 19th and 20th centuries varied with the times, with the school buildings reflecting the thoughts and views of each period. The 19th century saw the emergence of public schooling, with the increased focus on broad education that came with increasing wealth and democratisation. As public schooling grew in scope, the need for appropriate educational facilities arose. Whereas the school buildings of the early 19th century were ad hoc solutions – often comprising existing facilities in churches or public buildings, teachers' homes or simple wooden buildings with a single classroom, those of the second part of the century followed trends of increased standardisation, as well as increasing focus on the school as a symbol of the new society. European laws defined in the period 1860 – 1880 regulated school space and hygiene requirements, while school architecture, especially in urban areas, became more elaborate or at times even monumental.

Some late examples of such schools include am Elisabethplatz in Munich (Theodor Fischer, 1900–1901), the school on the rue Rouelle in Paris (Louis Bonnier, 1908–1911) and Letten in Zurich (Adolf and Heinrich Bram, 1912–1915).

In the 20th century, growing concern over health and hygiene (stemming from the rise of tuberculosis) redefined the requirements placed on schools. This was also the age of le Corbusier, who called for “a new spirit”, a house “like a receptacle for light and sun.” Larger windows, improved ventilation and recreational areas became the defining guidelines.

The New Education movement let the pedagogical requirements define the school environment: the development of group activities and the improvement of the students' sense of initiative and autonomy required more open and flexible school buildings. Pavilion schools, one-story schools for easy outdoor access, were examples of the era.

After World War II, the baby boom of the late 1940s put new demands on capacity. Many of our schools today date back to this period and require adaptation to meet today's demands on school architecture, such as flexibility in floor plans and the ability to function as multi-purpose buildings (community centres). Not least, lighting and ventilation continue to be focal points for creating effective and safe educational environments.

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