PROGRESSING PRACTICES OF SUSTAINABLE SCHOOL DESIGN

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ABSTRACT

This article discusses a survey of contemporary practices of sustainable school design. It reveals a trend that relies on technological fixes and outlines barriers to this, primarily related to lack of awareness of benefits, and a limited perception centring on the process of pre-design, design and construction but ignoring the use phase. To overcome the barriers, this article argues that a paradigm shift is required, embracing the creation of sustainable systems through a holistic approach to education, so that design operates and interacts with other disciplines. The suggestions provided could also be used to improve sustainable architectural practices in general.

KEYWORDS

sustainable school design, sustainable architecture, paradigm shift

A RECENT TREND IN SUSTAINABLE SCHOOL DESIGN

Sustainable or green design is a relatively new concept that is rapidly gaining favour in school design and planning. Schools that apply the concept in this way are often referred to as sustainable schools. The term '*sustainable schools*' (SBE, 2003; Gaia Architects and Gaia Research, 2005; DfES, 2006; Ford, 2007; Shum Miller, 2008) has also been used in parallel with other terms, such as '*high-performance schools*' (Eley, 2006; http://www.chps.net; http://www.sbicouncil.org) and '*green schools*' (Kats, Perlman, and Jamadagni, 2005; Committee to Review and Assess the Health and Productivity Benefits of Green Schools, 2006). According to an online survey among professionals involved in school establishment in the US by the Reed Research Group (2004), more than 80% of the 437 participants were at least somewhat familiar with the terms '*high performance/ sustainable/ green schools*'.

Although many schools have applied sustainable design principles in their projects, it appears that there is no consensus definition of the characteristics of such schools. Based on a survey of contemporary practices of sustainable school design, mainly in developed countries, nine common key issues of concern in designing sustainable schools emerge. These are a healthy learning environment, energy use, water use and management, material selection, construction and waste management, site selection and development, accessibility and transport options, participatory systems in designing, commissioning and maintenance, and using the school as a learning tool.

A healthy learning environment, something considered a basic criterion of school design from the early 20th century onwards, has recently emerged as one of the most common criteria for sustainable school design. Among all the issues related to health conditions, air quality and lighting are the most frequently mentioned priorities in this context. This is because these two issues have a high impact on the use of energy, commonly considered an environmental issue and one that affects operation costs, while the others, such as acoustics, thermal comfort, physical comfort and safety, mainly relate to user satisfaction with less effect on running costs.

Another fundamental issue for sustainable school design is energy use. The primary concern is how a school can reduce its energy use, while aiming to rely on renewable energy is usually secondary. Most energy conservation techniques in schools

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are focused on the major consumers of energy in this building type, which are lighting, heating, air-conditioning, domestic hot water, ventilation, and mechanical and electrical equipment. Using high-efficiency lamps, fixtures, appliances, and solar domestic hot water heating, improving the building envelope, including windows, and designing efficient distribution systems are common strategies, while employing alternative sources of energy is comparatively rare.

Unlike energy use that is commonly considered in a broad way, related to the limits of non-renewable energy sources and their effects on the earth's atmosphere, water use and management in schools can reduce overflow and show the closed-cycle of water systems within the school site. In fact, the issue also affects the broader scale, in terms of the limits of fresh water availability and quality of the bio-ecological watershed. Compared to the idea of energy conservation and other health issues, inclusion of water use and management is relatively new and has only really been part of practice since the mid 1990s. The common strategies include preservation of green areas, reduction of paved areas, construction of a wetland, specifying a green roof, installing low-consumption lavatories, showers and plumbing fixtures and sensor-operated systems, harvesting rainwater from the building roof for irrigation or toilet flushing, and recycling grey water.

Although the selection of materials has a long history in school design related to creating the school image and sometimes stimulating the children's sense of touching and seeing, concerns about how it affects the environment and human health and how it can enhance connection to local culture are comparatively new ideas. Many projects (e.g. Kingsmead Primary School, Cheshire, the Willow School at Gladstone, New Jersey, and the Handmade Schools in Rudrapur, Bangladesh) have specified reused/reusable or recycled/recyclable materials, locally or sustainably sourced materials, and low or no VOC emission material finishes or natural materials. Material selection also links to the issue of construction and management, particularly in terms of methods of disposal and waste construction material management. To reduce negative impacts on the environment and human life, cautious selection of modes of construction, provision for future change and deconstruction, and careful supervision have become common strategies related to material selection and construction and waste management. Although appropriate construction and waste management processes can have a great effect on environmental impacts, they are seldom mentioned. Perhaps, this is because selection of an efficient process requires experience and collaboration between designers, contractors, project managers and consultants, which sometimes leads to undesirable consequences like creating extra jobs and needing more time, as well as arguments between the professions. From another point of view, being involved in these processes can also contribute to partnerships for sustainable practices and enhance the knowledge, skills and experience of each stakeholder.

Site selection and site development to enhance close relationships between school and community and support communal activities is another old concept that has been revisited and promoted. This idea supports sustainable practices in promotion of local community participation and social equity in accessing services and education. Moreover, site selection and development are also associated with impact on the environment. Frequently recommended actions to address this are; renovating or locating a school on a brownfield site to minimise reduction of productive land and potentially upgrade or revitalise the local community; enhancement and preservation of natural environments on school sites, and limiting disturbance during construction, for example by preventing contaminating substances leaching into the ground; selection of structures and modes of construction that will have less environmental effect on the school site; and limiting the construction zone.

Typical concerns about accessibility and transport revolve around having an appropriate distance between home and school and safety in travelling and using transport. In designing sustainable schools, provision of modes of transport that use less energy and produce less CO_2 emissions is crucial in reducing environmental impacts. Such design should encourage walking, cycling and public transport, by providing safe pedestrian paths and bicycle ways, bicycle storage and showers for bicycle commuters, and convenient, pedestrian friendly connec-

tions to mass transit. Using alternative modes such as solar electric service vehicles and buses is also an alternative.

Involvement of people outside the educational or design profession in decision making throughout the planning and design process has gradually become part of school design since the middle of the 20th century, but is more frequently found from 1990 onwards (Sanoff, 2000; Hubner et al., 2005; Koralek and Mitchell, 2005). Its main purpose is to ensure users and the community benefit from the use of the school. The participatory process can extend to the monitoring and maintenance process, which can encourage improvement in user performance to achieve the sustainable condition. This also creates a sense of belonging, and carefulness and responsibility in the use of the building components and systems. Particularly for children, involvement in design, operation and maintenance of the buildings is also crucial in gaining participatory and collaborative skills and learning how to interact properly with their surrounding environments.

Basically, the whole school should be used as a tool to promote sustainability. Although a school can be used for teaching about sustainability, its goal should be the encouragement of environmentally friendly attitudes and behaviours. Providing spaces and school components that facilitate education for sustainability is a primary tool for learning about the relationship between natural and human-created systems. It appears that the strategies and techniques of all the examples previously mentioned could be used as learning tools. While the environmental and social impacts of each transport system and the benefits of suitable modes could be a subject of study, to encourage sustainable modes of transport, safe, pleasant, and accessible paths for walking, biking and linking to public transport also need to be provided (e.g. Bradley Stoke Community School, South Gloucestershire). Separate bins and recycling stations should be provided to promote consciousness of waste management (e.g. Durant Road Middle School at Raleigh, North Carolina). Wherever possible, rainwater collectors and renewable energy generators should be installed and used for education about alternative solutions to conserve natural resources. Monitoring equipment installed in the school and building systems can be exposed to provide an opportunity for them to be used for educational purposes (e.g. Roy Lee Walker Elementary School, Mckinney, Texas and Sidwell Friends Middle School, Washington, DC). These environmentally friendly systems and monitoring equipment will help to make the building interaction with human behaviour visible and easy to comprehend. School grounds should be designed to enhance natural habitats, and for outdoor education, nature study, and other educational programmes (e.g. the Edible Schoolyard programme at Martin Luther King Jr. Middle School in Berkeley, California).

Apart from the physical environment, having a participatory process in design, commissioning and maintenance by itself can also be considered as using the school as a learning tool to educate users, local people, and larger communities (e.g. the primary school at Gando Village, Burkina Faso, and the Druk White Lotus School, Ladakh, Tibet). In this regard, the fundamental key to success is perceiving architecture as a continuing process from design to end use rather than the product of design and construction. Participants who are part of the process can learn more about the built environment and how to behave appropriately to support good connections with their environment. They can also practice citizenship skills, including inclusive participation, civic engagement, team dynamics, group facilitation and use of democratic networks. They may be able to apply these skills and knowledge into projects and situations. Additionally, the experience of one school can also be a learning experience for other schools and later developed into an appropriate implementation that fits specific conditions. Learning networks and publications can help to transfer information. All these together will enhance the ability to create holistic solutions and to negotiate rationally between the ecological, social and economic goals of school design.

LIMITATIONS, DEFICIENCIES AND BARRIERS TO THE CURRENT TREND

Many strategies and techniques for sustainable school design become significant principles of good practice, but, based on current experiences, there are many barriers and room for further development of

design and performance. It appears that a majority of schools in use are not applying strategies and techniques for sustainable schools. This is mainly because most schools were designed and built before this trend became widely acknowledged. Barriers also result from the fact that exemplars of sustainable school design put a weight on physical development of a new project, rather than the improvement of existing schools, and such development requires intense financial support, which may make it hard to apply in other situations. Although the number of schools applying sustainable criteria in their design and performance has been increasing, sadly, many people are still sceptical about the trend and consider it somewhat experimental, rather than a proven necessity, particularly those who have not worked with green educational facilities (Turner Green Building, n.d.).

In fact, sustainable school design usually includes various principles and features which allow a school to be constructed and operated in ways that maximise the quality of the built environment and minimise negative impacts on the environment. These principles and features commonly support social perspectives related to sustainability by creation of a sense of community within schools, provision of facilities and services responding to the needs of the community, encouragement of stakeholder involvement and collaboration, and being part of promotion of sustainable attitudes and actions (Shum Miller, 2008). In terms of economic aspects, although, when only the initial cost is considered, the sustainable building construction is often found to be more expensive than conventional practice, when the operation and maintenance costs are included with other financial benefits, such as reduction in health costs and improvement in teacher retention, sustainable buildings cost less than ordinary ones (Kats, 2006).

It is obvious that the benefits of sustainable school design are usually greater than for conventional schools, but, unfortunately, most people still misjudge the approach and lack awareness of its benefits. For example, according to the survey by Turner Construction (n.d.), 67% of executives from organisations involved with K-12 facilities believed that lack of awareness of benefits was an extremely significant obstacle and 53% said these benefits were still difficult to quantify. Those executives involved in the survey also considered that high construction costs (74%), short-term budget horizons (57%), and a feeling that the payback period is too long (50%) were severely significant adverse factors for green school construction. The same study also stated that most educational institutions either did not consider long-term costs or were unimaginatively focused on initial construction costs. Only half of the executives said their K-12 school districts typically considered total life-cycle costs for a new construction project, and only 7% of this group said whole life costs were seen as most important, while the other 51% of the group said the greatest emphasis was still placed on initial costs.

According to a Capital E Report on the financial costs and benefits of 30 green American schools when compared to conventional schools, green schools had an average cost premium 1.65% higher, but they used an average 33.4% less energy and 32.1% less water than conventional design (Kats, Perlman, and Jamadagni, 2005). As Kats (2006) has estimated, the financial savings of a green school per ft^2 are about 70 USD (753.50 USD/m^2), more

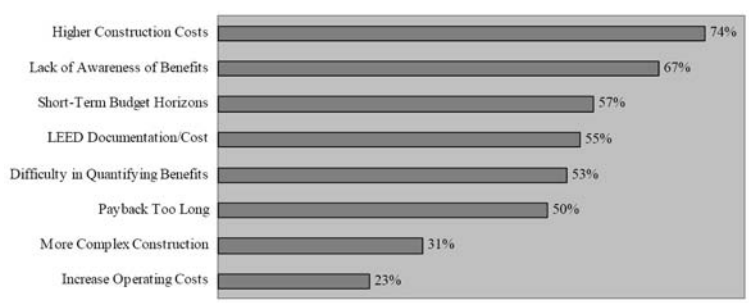

FIGURE 1. Percent of executives from organizations involved with K-12 Facilities rating factors as a very or extremely significant obstacle.
Source: Turner Construction (n.d., p. 9).

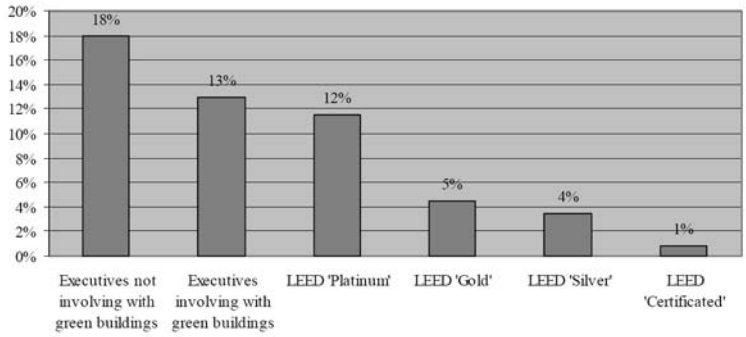

FIGURE 2. Average additional cost estimates from executives at organizations involved and not involved with green buildings and average additional costs to meet LEED standards from four US studies.
Source: Turner Construction (n.d., p. 16–17).

than 20 times higher than the cost of greening the school (2% more, or 3 USD/ft^2, 32.30 USD/m^2, than conventional schools). This includes 49 USD of increased earnings, 9 USD for energy costs, 8 USD for lowered health costs, and 6 USD for teacher retention and employment impact. In terms of additional costs for green building, based on four US LEED cost comparison studies, the average estimated cost premiums were 0.8%, 3.5%, 4.5%, and 11.5% for a LEED '*Certificated*,' '*Silver*,' '*Gold*,' and '*Platinum*' certification, respectively (Turner Green Building, n.d.). Comparing these average cost increases to Kats' estimate, the financial benefits of sustainable school design are still higher, even when using the cost premium rate for a LEED '*Platinum*' certification (11.5% more, or 16.5 USD/ft^2, 177.60 USD/m^2, than conventional schools) in the calculation. Regrettably, based on the Turner Green Building report, executives who were involved and not involved with green building estimated the increase in construction cost at 13% and 18% respectively, both still higher than the studies mentioned above where sustainable features were incoporated (Turner Green Building, n.d.).

To a certain extent, transferring social and environmental benefits to financial benefits or points can help people to recognise the benefits of sustainable school design much more easily. However, economic benefits and the points gained from rating systems, all of which were developed relatively recently, seldom present the real benefits that society and the environment will obtain from particular sustainable strategies and techniques. For instance, criteria and points given for energy consumption in all rating systems still focus on levels of energy use, which sometimes give more advantage to projects making a small contribution to reducing energy consumption and discourage projects aiming to be energy producers.[3] In BREEAM Schools, a project can gain up to 15 credits in the section related to percentage improvement above the CO_2 emission requirement as set out in the Building Regulations, but it appears that as the building moves towards being zero CO_2, it becomes very much harder to gain an extra credit (BREEAM, 2006). In LEED for schools, although the percentage improvement over the baseline required for one extra credit for optimizing energy performance is constant at 3.5%, only improvements between 14–42% for new buildings and 7–35% for existing building renovation are mentioned. Any performance above that range will only score maximum points (10 points), which is the same as a building that improves energy use by 42% and 35% in each case (USGBC, 2007). Similarly, the percentage reduction in total net energy required to achieve one extra credit for CHPS criterion for superior energy performance is fixed at 2% and the percentage reduction in energy use that will be counted is between 12–36% (up to 13 points), without no mention of percentage reduction over this range (CHPS, 2006). In terms of on-site renewable energy, a project can get up to 3 points, if it demonstrates percentage offsetting energy produced

[3]As rating systems are normally in a process of continual development, some data for these analyses may have changed or improved, which could affect the results. However, this remains an example of the fact rating systems had deficiencies in representing the real benefits obtained from sustainable design strategies and techniques.

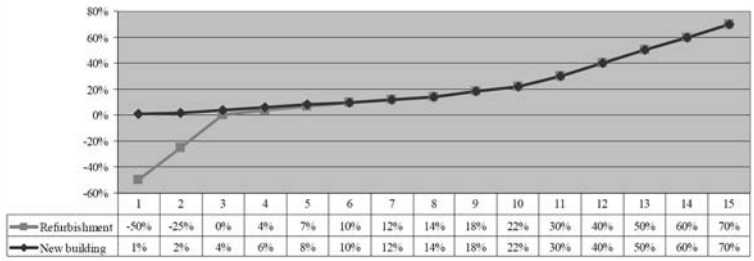

FIGURE 3. The progression in credit achievements for energy performance in the BREEAM Schools rating systems, where the building demonstrates a percentage improvement above the target CO_2 emissions as set out in the Building Regulations.
Source: (BREEAM, 2006).

Note: Credits can be awarded based on the percentage improvement in the assessed design's predicted Building CO2 Emission Rate (BER) over the Target CO2 Emission Rate (TER), as defined in the Building Regulations (Approved Document Part L2A *New Buildings other than dwelling* 2006). The percetages required to achieve one extra credit are often constant in ranges. For instance, for a new construction, it required 1% improvement for 2nd credit, 2% improvement for 3rd–8th credits, 4% improvement for 9th–10th credits, 8% improvement for 11th credit, and 10% improvement for 12th–15th credits.

from on-site renewable energy systems between 2.5–12.5% in LEED for Schools and 5–15% for CHPS (CHPS, 2006; USGBC, 2007). However, the provision of on-site renewable energy systems that contribute more than 12.5% and 15% in each case is again not mentioned. To encourage the development and use of grid-sourced, renewable energy on a net zero pollution basis in LEED for Schools one point can be awarded for provision of at least 35% of the building's electricity from renewable sources by engaging in at least a two-year green energy contract (USGBC, 2007). However, this credit does not refer to on-site renewable energy. Thus, a project that produces 100% on-site renewable energy may not get a point from this credit, if it has no contract to use renewable energy electricity from the grid.

Due to economic constraints, ignorance, or the lack of skill and awareness, many projects do not embrace all the issues related to sustainable design and consequently apply limited strategies and techniques. Implementation is frequently confined to the favourite issues of healthy learning environment and energy use. Even in the case of energy efficiency, one of the most popular criteria of sustainable school design that is widely adopted and comparatively well developed, there is still deficiency in current practices. Although the ultimate goal for a sustainable school is zero energy use, energy use totally based on renewable sources, or even being able to provide energy from a sustainable source for their local community, almost all schools that have been called '*sustainable*' have achieved energy use reductions of only 50–75% compared to conventional school buildings, and their energy sources are mainly non-renewable. For example, Sidwell Friends Middle School used 65 kWh/m^2, with 1.90 kWh/m^2 of on-site renewable energy production, which is only 3% of total energy use (2% less than originally expected, because of the higher rate of energy use) (AIA, 2007). Oakgrove Secondary School, Milton Keynes, which achieved an '*excellent*' rating under the BREEAM environmental assessment scheme, has an energy use of 75.6 kWh/m^2 or about 75% below the majority of secondary school buildings in England (307 kWh/m^2). This actual energy use is about twice the design estimate of 38 kWh/m^2 (DfES, 2006: 65). The award-winning Kingsmead Primary School used 179 kWh/m^2 or around 55% of the energy used in conventional primary schools (313 kWh/m^2), with only 4 kWh/m^2 produced from PV panels (DfES, 2006: 17). In England during 2000–2001, the top 25 percent of primary schools used 146 kWh/m^2 and produced 36.6 kg CO_2/m^2, values which are around half of those of the majority, while the top 10 percent reduced energy by two-thirds (90 kWh/m^2 and 25.9 kg CO_2/m^2)[4] (DfES, 2001). These examples show a conspicuous gap between the ultimate goal and current pragmatic results.

[4]The 90 percent of 12,416 primary schools use 313 kWh/m^2 and produce 75.8 kg CO_2/m^2. This CO_2 emission is calculated by assuming 0.19 kg CO_2/kWh of energy from gas and 0.43 kg CO_2/kWh of energy from electricity (DfES, 2001).

Although several sustainable school projects show the use of schools as learning tools to create change in attitudes and behaviours, the idea appears as a secondary consideration. Sustainable school design, based on contemporary definitions, usually focuses on the development of the physical features of schools. These external factors, it is hoped, will change attitudes and behaviours, while involvement with activities designed to promote an internal change in attitudes is often overlooked. Much equipment and many systems are installed based on the assumption that people will behave as they used to do and will not change the attitudes and behaviours that frequently support unsustainable patterns of living. For example, many American schools have installed fully controlled HVAC systems, even though they are located in areas where the normal climate is suitable for natural ventilation. Schools that agreed to reduce energy consumption and promote sustainability by reducing the use of air conditioners have been sometimes forced to install them later, because of parental beliefs that a good school should have such facilities (Katrina Shum Miller, personal communication, September 23, 2008).

Actually, how people use their schools directly affects the in-use results of sustainable school design. Without proper behaviour, many sustainable features will not be used in the way designed. For instance, provision of convenient connections to mass transit or pedestrian friendly walkways to the school cannot decrease its effect on the environment, unless the school members think about the effect of their travel and are ready to change their behaviours to use alternative modes of transport to the private car. In the UK, although energy conservation strategies, such as passive solar design and selection of energy efficient systems and appliances, have been incorporated in many sustainable schools, such schools have reported that their energy consumption is higher than expected. This is because of the increased use of electrical equipment and, in several cases, because lights and some electrical equipment have been left running unnecessarily (DfES, 2006). Because of limited budgets, providing energy from renewable sources without an attempt to change behaviours is seemingly an impossible task for most schools.

In addition, the current practices of sustainable school design, particularly in Western countries, present a limited perception of sustainable schools. Practices of sustainable school design commonly centre on an attempt to make the school building more sustainable and sustainable schools are often considered the result of sustainable design. Unlike sustainable schools built in developing countries, such as the Handmade School in Rudrapur, Bangladesh and Gando Primary School, that usually concentrate on improving of basic education and maximising the use of simple technology and basic climatic design under a limited budget for construction and maintenance, sustainable school designs in Western countries frequently relate to improvement of school performance and integration of new and high technologies. The focus is mainly on design techniques and strategies largely related to the physical elements of sustainable schools. Even some sustainable school projects in developing countries, like the Druk White Lotus School, illustrate this Western approach in part. Thus, from the Western point of view, it would be unusual for a school in the West that accommodates simple sustainable strategies like those implemented in sustainable schools in developing countries to be recognised as a model for sustainable schools.

Moreover, the focus of stakeholders involved with sustainable school design is primarily on the process of pre-design, design and construction. This helps to explain the focus on sustainable features and equipment. Participation of end-users and their actions after post-occupancy, such as maintenance, operation and the use of schools as learning tools appear to be secondary concerns. Criteria of most rating systems for school design, such as BREEAM Schools, CHPS, and LEED for Schools, are reflections of this approach. They usually place emphasis on design and construction. Additionally, most rating systems only give a few points for end user participation and actual use of the schools. For instance, from over 50 credit references in BREEAM Schools, four credit references are directly related to consultations with the building users and commissioning after occupancy, and only one credit refers to the provisional use of building and landscape to facilitate environmental issues within the school curriculum (BREEAM, 2006). Similarly, from the 79 and 85 possible points available in LEED for Schools and CHPS, respectively, only one point is given

to the use of the school as a teaching tool (CHPS, 2006; USGBC, 2007).

It appears that the dominant Western view of sustainable school design tends to form opinions on the general characteristics of sustainable schools. As happened in history and is still happening, ideas and exemplary practices are transferred from one place to another, meaning this perception may become widely accepted and adopted, even in developing countries. Without the realisation that sustainable solutions are contextual and dynamic, many educationalists and school designers may use the same perception and characteristics to form a standard for sustainable school design. Particularly, in cases where the move in architecture towards high sustainable technology is seemingly problematic, due to the limitation of accessibility and financial support, this will create a sense of deprivation and dissatisfaction and become an obstacle to the development of schools.

CHALLENGES AND SUGGESTIONS FOR PROGRESSING SUSTAINABLE SCHOOL DESIGN

Under the current circumstance, enhancing awareness of the benefits is a primary approach for helping to lessen economic misunderstandings as well as increasing the demand for sustainable design. Since the benefits do not suddenly appear after the construction is finished, but gradually appear when schools are used, a greater understanding of long-term benefits and whole life costs as well as benefits that are not just economic is desperately required. To encourage an awareness of benefits, particularly those that are harder to cost, direct experience and publications about improvement to health and learning conditions in sustainable schools and the true costs and benefits of green facilities should be promoted. The more people engage in sustainable design, the more they realise the benefits and will approve such design strategies. Based on the Turner Construction survey, for instance, an involvement with sustainable school design influenced perception of the participants about green construction. While 24% of executives who only worked with traditional approaches believed green facilities to be a proven approach, with 41% considering it an experimental approach, 54% of those who had worked with green K-12 facilities considered green construction a proven approach and only 26% thought it was neither proven nor experimental (Turner Green Building, n.d.).

Although rating systems are very helpful in promoting sustainable school design, rather than tying design decisions to costs or the creation of leadership, a change of attitudes and practices in sustainable design that leads to caring about the well-being of society and environment are essential. As Coldham (cited in Kennedy, 2007) commented, a rating system that considers how green a project is by its point system causes many planners, builders and their clients, to concentrate more on accumulating points instead of creating the most environmentally friendly facility. He also suggested that it might be better for the environment that builders and designers sometimes abandon the opportunity to get points for some features and focus on elements that will provide a greener facility. While consciousness and understanding of the issues are required, knowledge and skills to solve the problems and develop further techniques are also critical.

Because of the inevitable interconnection between each strategy and technique, some techniques used for one approach can possibly support or interfere with the achievement of others. Besides improving the implementation of a particular design technique and strategy, many components and techniques should be considered for simultaneous use. Rather than only following a basic rule of thumb, they should be thoroughly and carefully analysed and implemented and developed related to a particular situation. For example, the idea of using recycled materials that has become a common strategy should be used with care, since it is usually only suitable in particular situations and may not guarantee better benefits to the environment. It is necessary to consider the energy used to transport building materials, local conditions, and other possible sustainable options. Where, as in the Handmade School in Rudrapur nearly all building materials (in this case bamboo, brick, straw, loam and earth plaster) are locally available and are mainly used in their natural state, a school can use less energy to produce and transport building materials. This creates less

impact on the environment in terms of treatment of waste in construction, maintenance and demolition processes, although only new materials are used.

Besides improving design strategies and techniques, shifting the paradigm of sustainable design is crucial. The perception of sustainable design must move from a narrow viewpoint that centres on use of sustainable strategies and techniques during design and construction to a bigger picture that embraces the creation of sustainable systems through a complete sustainable design process. Based on this, sustainable school design should be seen as a continual process that does not end when construction of the school is complete or is limited to the physical features of the built environment, but that carries on after users occupy the schools. It must also connect to the social and environmental systems enclosing the schools. It should encompass how users operate the schools, how they learn from their experiences within the schools, and how they change their attitudes and behaviours towards sustainability. Constructive experiences of sustainable design, which people can gain through direct contact, learning and critical thinking about information from second-hand experiences (e.g. publications, media and personal communication) and participation in sustainable design processes, can educate people about sustainability and sustainable practices, make them aware, and move them to behave responsibly and sustainably (Chansomsak and Vale, 2008; Chansomsak, 2009). Knowledge, experiences and skills that users learn and practice through educational and everyday life activities in schools can also be a lesson for their actions outside schools. This may extend their perceptions of appropriate design and contribute to continual change of their attitudes and behaviour towards sustainability.

To ensure and prolong efficient use of sustainable features, sustainable design requires constant sustainable management and users that behave sustainably. In schools, actual users have to change their behaviour through operation of the facilities supplied and designed to support and promote sustainable manners. For example, rather than just specifying energy efficient systems and appliances or water conserving taps, intelligent use of the systems and equipment is required. This will mean switching off lights when daylight is adequate, setting standby modes for computers, printers and photocopiers, shutting down and unplugging electrical equipment when no longer in use, turning off taps, and managing to use potable water only when it is necessary. All these will help the school to succeed in its aim to reduce energy and water use. Cutting down the demands may lead to being self-sufficient in terms of the flow of resources in the school site, such as on-site energy production and water collecting. It also raises the possibility of installing smaller systems in future renovation or modernisation, which consequently lessens the need for the resources and energy used to produce such a system. With support from sustainable design solutions, sustainable education and other sustainable activities could occur more effectively in schools.

Another advantage of attitude and behaviour changes is that they require smaller budgets and fewer resources, but frequently create significant positive effects on sustainability. They can, additionally, be adopted and practised straight away with no need to wait for sufficient money for investing in change to the physical environment. Thus, this strategy is suitable for every school condition. This is very valuable in some situations, as in most developing countries, where changing the architecture is difficult, due to limited financial support and access to sustainable technology. Here, change in attitudes and behaviours may be a solution. Moreover, the change to attitudes and behaviours is also flexible and easy to modify if the situation changes. Unlike built environments that cannot be changed either promptly or frequently, sustainable behaviours are more easily adjusted to different traditional values and culture (e.g. diverse beliefs, religions, and social norms) or a new approach (e.g. new educational approaches and new teaching methods).

In addition, revision of the sustainable design concept suggests that sustainable design is a subsystem of a whole system of sustainable practices. It overlaps and interconnects with other subsystems, such as sustainable education, greening the building industry, environmental economy, greening politics and sustainable society. Accordingly, sustainable design demands involvement of many stakeholders and interdisciplinary integration. In

the case of schools, educationalists, educational district officers, architects, engineers, specialists, project managers, builders, community members, users, building managers and caretakers can share their knowledge and expertise to solve problems and create sustainable conditions. In the process of sharing, participants learn and hone the skills needed for sustainable practices, including the ability to create sustainable design, the ability to understand the circumstances of projects, activities and the community, knowledge gathering skills, skills of communication and collaboration, and adaptation skills. Sustainable approaches in local politics frequently lead to codes or policies that require, demand, or support sustainable school practices. Innovations in the building industry towards sustainability, such as eco-labelling of materials and products, environmental regulations, as well as environmental design and operational directives and standards, can guide sustainable practices and reinforce participation of various stakeholders in the process. Moreover, continual study, research and development in architectural and other green related fields assists in enhancing the quality of sustainable architecture, as well as promoting attitudes to and understanding of the importance and impact of sustainable school design.

CONCLUSION

Even though the examples given above are primarily based on the experiences of school facilities, similar problems and limitations can often be found in other building types. In the 2005 Turner Construction survey, the opinions of 665 executives involved with commercial, industrial, retail, residential, and other types of facilities on obstacles to green construction are similar to those of the 205 executives involved with educational facilities (Turner Green Building, n.d.). Factors related to cost, such as high construction costs and short-term budget horizons, were pinpointed as important barriers, along with the lack of awareness of benefits. Concurrently, rating systems, such as LEED and BREEAM, are also used for other building types. All basic principles and criteria are mostly the same, though the details of evaluation are somewhat different. Accordingly, the barriers facing sustainable school design, as well as ways to tackle them, form examples and lessons for sustainable design in general.

In conclusion, progressing practices of sustainable design is not only a job for architectural professionals, but it requires the understanding and participation of users and the public at large. Besides improving current practices, change of participants' attitudes and actions towards sustainability is a key issue for development. This on-going process of development and paradigm shift needs support from the sustainable practices of other professionals from various disciplines. These simultaneous and never ending processes will maintain the sustainability conditions of sustainable schools and other sustainable design solutions, and make sustainable design a prominent part of sustainable systems.

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