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Educational Buildings as Educational Buildings: Can sustainable architecture help support sustainability in the curriculum?

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Abstract: This paper explores whether the architectural design of educational buildings - by incorporating an expression of the sustainable design - helps to educate users towards adoption of sustainable practices. Utilising observational studies from primary schools incorporating sustainable design measures, the research explored their impact on the curriculum.
School buildings accommodate the educational process but design briefs do not require that buildings educate their users. The paper demonstrated that sustainable features of the buildings were not well integrated into the curriculum and that one explanation was the lack of interpretation incorporated into the architecture to support teachers lacking an appreciation of sustainable built environments as part of a global ecosystem. Primary schools tend to deliver environmental education focussed on nature study and outdoor education rather than sustainable development.
Sustainable buildings often exhibit a performance gap for which building occupants and operators may be a contributory factor. Education within the curriculum and embedding knowledge in the architecture may reduce the gap and development of such an approach could benefit other buildings.
A 'Designed-In' approach is recommended, to make conspicuous the building design, attitudes and behaviours, offering future generations understanding of the impacts of built environments and personal actions on a sustainable future.

Keywords: Schools, Sustainable Architecture, Environmental Education.

Introduction

Orr (1999) suggests that in not making explicit to its users its location, materials and their origin, manufacturing methods and ultimately disposal, energy use, or communicating the consequence of individual action (or sustainability), buildings tacitly communicate that these things are unimportant. Orr (1999) argues that this approach makes the disconnect between user and building normal. Primary schools have longevity of purpose within the community they serve which may make the incorporation of sustainable architecture a potentially cost effective option thus reducing such disconnects. However, many Primary School buildings are managed and operated by non-specialists, i.e. head-teacher, governors, caretaker, and other personnel who will change on a regular basis. There is therefore potential for the original intention of the design and its critical features to be lost in multiple hand-overs, contributing to the gap between the predicted and recorded performance and the disconnect between building and user. Currently there appears to be little guidance available to educational institutions, from government bodies or others, in relation to building-focused environmental education. Such education could be used to raise awareness that the built environment is part of the ecology in which we live and therefore a

key factor in sustainability.

This paper sought to determine if schools which had sustainable architectural features expressed such features within the design in a manner which could be used to educate/guide users towards sustainable practices by demonstrating the effect of individual or localised actions. Through the use of case studies supported by interviews and questionnaires, the research explored the users' awareness of the sustainable features incorporated in the design. Furthermore, the research sought to understand if, and to what extent, such features are used within the curriculum. Given the case studies used each had an expressed sustainability agenda the research examined whether the features were interpreted into the curriculum and whether their correct or preferred operation was expressed in the architecture as a practical manual for optimised energy performance or a didactic for environmental education.

Literature Review

De Botton (2006) believes that the built environment and, in particular, the buildings we use or inhabit are important in influencing who we are. If only by virtue of the amount of time spent there during a highly formative period of our lives, one of the most influential buildings must be schools (Dudek, 2000; Woolner, 2010). The determinative period during primary education is recognised by government to inculcate, through the English National Curriculum, societal qualities such as 'spiritual, moral, cultural, mental and physical development' as well as preparing pupils 'for the opportunities, responsibilities and experiences of later life' (HM Government/Department for Education, 2015). However, the National Curriculum Primary School Framework contains no statutory requirement for delivering Environmental Education [EE] or Education for Sustainable Development [ESD]. Nonetheless, learning about the environment is recognised in most primary schools as contributing to its qualitative social requirements. Most schools provide evidence of some commitment to environmental awareness, often delivered in extra-curricular activities, guided or sponsored by external organisations.

The author reviewed the logos, imagery and stated aims of non-governmental educational organisations delivering guidance to schools on EE/ESD found that the subject matter is apparently most concerned with nature and the natural environment. Arguably, the unconscious message to children, parents and teachers may be interpreted as learning about the environment and sustainability can only happen externally and may achieve little to instil the idea that a major factor in maintaining the natural environment is through sustainable and environmentally-aware built environments, and our own behaviour within. As argued by Orr (1999) "The curriculum embedded within any building instructs us as fully and as powerfully as any course taught in it". He goes on to comment "the typical campus is regarded mostly as a place where learning occurs but is itself believed to be the source of no useful learning". This presents both a challenge to, and opportunity for architectural design.

The schools studied for this research used the term 'environmental education' as opposed to 'education for sustainable development' although the two terms are often used interchangeably. The former phrase, as commonly understood, refers to nature and the natural/physical environment, whilst the latter is seen as having anthropological references but is unwieldy in its phraseology and opaque in meaning to the 'person-in-the-street'. The UN identifies characteristics of ESD for "culturally appropriate implementation, which includes the environmental, social, cultural and economic dimensions of sustainability in a

manner which is locally relevant but acknowledges that fulfilling local needs has global effects and consequences" (UNESCO, 2016). Arguably, these wider cultural and social aims/ characteristics of ESD are not clearly expressed by the organisations which promote environmental learning. The remit, overlap and specificity of EE & ESD are the subject of ongoing discussions (Sterling, 2001; Orr, 1999; Edwards, 2006) which makes delivery of a consistent message problematic for teachers already delivering a demanding curriculum (Palmer, 1998). Whilst teaching theories advise of the importance of interactive and personal learning experiences, the potential of the school buildings to provide learners with knowledge appears underexploited (Cox, 2004; Palmer, 1998) .

Dudek (2000), noting that the design of school buildings is highly specialised, acknowledges the role of the interior environment to create healthy, comfortable buildings. Dudek (2000) also notes the potential of environmental psychology to further aid the development of learning through the comprehension of space, but notes "the incongruity of policy which fails to recognise architectural quality as a resource in the manner of pencils and paper". The superimposition of learning philosophy on the architectural process, by those whose expertise lies in designing buildings (rather than education) might be regarded as beyond the design brief. However, learning theory suggests that knowledge comes either from experience whether deliberately manipulated and reinforced by reward or sanction (behaviourist), or from understanding of the experience gained through exploration, experimentation and application of previous knowledge (constructivist) (Cox, 2004). Both theories indicate that schools' architecture has an imperative to educate its users.

The influence of the users on sustainable building design is limited by their comprehension of building physics beyond explanations provided by the design team. Kernohan et al (1992) identified that the users and providers are culturally separate, holding different goals, values and expectations. This misalignment of the users and providers described is known to affect design outcomes and their efficient operation.

Semiotics is the study of non-verbal communication: the human ability to draw meaning from inanimate objects through line, shape, or colour, font, etc., uniquely informed by culture and experience. Norman (2013) suggests that the communication of inanimate objects is not merely a signifier of their function but should instruct on their operation. He identifies that, in an era of complex technology, good design should incorporate 'understanding' which is the ability of the object/product/building to communicate its intended use and how it should be operated and 'discoverability' which is the ability of the object/product/building to communicate what actions are possible, where and how they should be performed. Such principles for good design have informed recent research which identifies the potential for consumer products such as kettles and cars to promote pro-environmental behaviour (Lilley, 2009). On the precept that the use phase is most significant in terms of environmental impact, Lockton et al (2008; 2010) have expanded on the need to 'design-in' communication which encourages sustainable behaviour into objects and environments. This approach is branded as 'Design with Intent' [DwI], using the features of a system to guide, shape or regulate the ways in which interaction occurs, and that this is a result of the specific intention of the designer. As noted by Lockton et al. (2008) 'DwI' strategies to promote sustainable behaviours have their origins in product design but could be extended to building design. Wever et al. (2008) identify four key strategies:

- 'Functionality matching' which attempts to eliminate mismatching between delivered

functionalities and desired functionality;

- 'Eco- feedback' –users are provided with direct information on the impact of actions;
- 'Scripting' where the product incorporates design which either makes sustainable behaviour easy or instigates obstacles to unsustainable behaviour;
- 'Forced functionality' which designs-in intelligence that automatically adapts to circumstances or incorporates strong obstacles to prevent unwanted actions'?

Whilst the incorporation of pedagogy in schools' architecture is recommended by notable authors writing in this field, (Orr, 1999; Dudek, 2000; Cannon Design, et al., 2010) limited examples in practice exist which suggests that such systematic design is uncommon. Furthermore, whilst there exists a solid literature base on technical aspects of sustainable school design there is a scarcity of research which links environmental education with sustainable buildings (Cole, 2013; Schiller, 2016). Two studies which attempt to correlate sustainable school design with pro-environmental behaviour found that there was an identifiable link between sustainably designed schools and childrens' pro-environmental attitudes. Both conclude that the building itself has a role influencing the attitudes of the users. Izadpanahi et al (2015) identified that the building (albeit marginally) as more influential than the attitudes of the teachers. In support of this, Cole (2014) suggests that it is the physical environment of the institution which sets the expectations for sustainable actions by users within the school building. Neither paper suggests that the physical construction of the schools were designed to communicate or instruct users on their sustainable credentials, therefore their effect on the users may be coincidental. It was also noted that teachers' attitudes at sustainably designed schools were more pro-environmental than those at conventionally designed schools, arguably this could harness sustainability in school design and mediate pupils' environmental attitude. Overall, it can be argued that there is a need to better understand how specific architectural features can influence of environmental awareness, attitude and behaviour change and how this can be harnessed.

METHODOLOGY

Case studies were selected as a qualitative method which allowed the observation of naturally occurring behaviours and balanced the individualistic nature of the subjects with the need to draw normative conclusions (Thomas, 2010). An informal approach using observational visits and informal interviews was identified as appropriate to explore the relationship between the building and its users. A questionnaire was used to more formally indicate sustainable attitudes and behaviours of those associated with the school. The case study schools are all located within the Southend-on-Sea Unitary Authority and were selected in reply to invitations to all Essex based schools with a BREEAM rating of 'Very Good' or above. Three schools, the details of which are noted in table 1, were taken forward for the research included in this paper.

	School A	School B	School C
Opened	2012	1949	1912
Location	Suburban / Coastal	Suburban	Suburban
Configuration	Open plan classrooms Raised, multiple storeys.	Traditional classrooms Single storey	Mainly single storey Traditional classrooms
Construction	Steel frame with block	Solid brickwork, profiled	Solid brickwork, timber

	infill, insulating ceramic & laminate facing panels		sheet roof, replacement double-glazed units		windows with secondary glazing, slate roofs.	
Buildings Regulation	Complies		Exceeds / Exemplar		Exceeds / Exemplar	
Lighting	Sensing LED		Sensing LED		Sensing LED	
Heating	Gas Boiler		Biomass Boiler		Biomass Boiler	
Cooling	Automated natural ventilation		Natural ventilation		Natural Ventilation with HR	
Renewables	Solar Panels		Solar Panels		Solar Panels	
Sustainability features	South-facing glazed areas Water saving fittings		Insulation upgrade Southerly glazed spaces		Insulation upgrade Rainwater harvesting Water-saving fittings	
Energy Use & emissions*	m^2	pupil	m^2	pupil	m^2	pupil
kWh	49.11	336	36.80	170	71.89	189
$kgCO_2$	11.37	77.86	8.52	39.42	39.42	62.31
User participation	YES		NO		YES	
Notes	More ambitious sustainable features omitted in budget cuts.		Project aimed at reduction of carbon emissions & energy use, with research and exemplar elements.		Phased refurbishment with zero-carbon target completed in 2013, with research and exemplar elements.	

* Energy use calculated by comparison of ECON 73 & Warwickshire County Council benchmark values and asserted reductions in energy use and CO_2 emissions

Table 1: Description of the Case Study Schools

The literature review identified modes for inbuilt interpretation or guidance (Wever, et al., 2008; Lockton, et al., 2008; Lilley, 2009; Lockton, et al., 2010) and the observational visits sought evidence of the strategies described above to determine whether sustainable design features were embedded within the building either for use within the curriculum or to instruct as their optimum performance.

FINDINGS

The observational visits did not elicit overwhelming evidence of the use of the building within the curriculum. Aligning with the findings of the literature review environmental education was focused on environments external to the buildings. Whilst there were anecdotal instances where the building/s had been used as the subject of study in the maths and science curricula, there was a lack of evidence within the buildings to suggest that this was systematically intended or embedded by the architects. In discussing this point one head-teacher acknowledged that the pupils who benefitted most from the building projects are those who were at school during the design phase of the projects when the ambitions of the project enthuse staff and pupils alike, and as such are translated widely into many areas of the curriculum.

Consideration of learning theory and the four design strategies (Wever, et al., 2008) were applied during visits to the case study schools. This approach identified that most of the sustainable features incorporated within the design of the school projects considered rely on 'forced functionality' to operate as predicted by the design proposal. Features such as solar PV panels, insulation, double glazing, and biomass boilers are non-dynamic and function without interaction with the community or individuals they serve. The purpose of automatic features, e.g. automatically operated windows, motion sensor lighting, remain opaque to most users of the school, and without explanation or interpretation can prove

irrational, irritating or distracting. Whilst such features serve the energy performance model, learning opportunities to construct understanding cannot take place.

'Eco feedback' is provided in the form of smart meters which report energy generated from Solar PV panels, but for the most part the information lacks context or connectedness, e.g. what is the relationship between $kgCO_2$ and trees in a child's mind? Consideration of education theory (Cox, 2004) would suggest that eco-feedback provides the best opportunities for both behaviourist and constructivist learning perspectives.

'Scripting' guides sustainable use by making it easy to use products or systems correctly. All the schools exhibit some examples of scripting but these exist mainly in aspects of the control systems for heating and lighting which are aimed at ease of use for those with responsibility for such systems, rather than the pupil or classroom teacher.

The subject of using the building as a resource for environment educational was informally discussed with some classroom teachers. Despite strong environmental agendas, teachers admitted that it had not really occurred to them, perhaps due to the assumed 'natural sciences' remit of environmental education. Suggesting that the built environment has a crucial role in sustainable development, teachers in Schools A and C saw that it could be important but felt they did not understand the sustainable features sufficiently to deliver teaching on the subject. One teacher perceived the encroachment of the built environment on nature as an imperative reason for children to experience it before further impairment or disappearance.

In considering the design of the schools and their usability as an educational resource in light of user centred design strategies, where the design of a product is adapted to the actual use by the intended users, there exists a mismatch between the delivered and the desired functionality (Lockton, et al., 2008; Lilley, 2009; Wever, et al., 2008). All the buildings studied appear to perform well as spaces in which education takes place which is the briefed and 'delivered functionality'. The lack of interpretation of the features and operation of the buildings suggests that design briefs did not include the 'desired' functions of encouragement of individual sustainable behaviour, learning from the building or enablement of the users in their efficient operation. This lack of communication to enable users to 'understand' or 'discover' (Norman, 2013) the correct use of the building and its technology may contribute to the energy/emissions performance gap.

Staff at all the schools recognised the enthusiasm of their pupils towards the environment and sustainability. The head-teacher at School A had identified the commitment of school pupils towards sustainability as 'non-negotiable' in the design of the building. Pupils at School C had likewise been included as part of the design process.

DISCUSSION

The introduction of user-centred design which demonstrates the effects which individuals or small groups can have on environmental issues has the potential to continuously engage pupils in design and operation of the building. There is scope for scripting within individual classrooms such as the use of photo-electric cells or thermostats connected to classroom smart screens to suggest appropriate sustainable actions for which specific environmental or other benefits might be highlighted; the effect of the selected action might then be reported through eco-feedback and/or 'rewards' received for pro-environmental behaviour. If functionality matching can be regarded as the creation of a design proposal which meets both the stated aims of the brief as well as the inherent objectives of its users, building designers are failing in providing buildings in which such goals can be met (Dudek, 2000;

Wever, et al., 2008). An understanding of how buildings can speak to their users to effect behaviour adaptation is required to make schools a truly fundamental medium for change.

The education and experience of teachers tends to support knowledge of the natural world, through their own educational experience in the study of subjects within the natural and physical sciences, humanities and the arts, such as biology, geography and art for example. However, the design of buildings is seen as advanced and specialist, studied at tertiary level beyond mandatory education. Our comprehension of the natural environment is intuitive, whilst understanding of the built environment is perceived as esoteric.

CONCLUSION

The research used design strategies developed for use in product design to determine whether the architecture of sustainably designed schools includes appropriate interpretation which educates the user in sustainable behaviours or guides them in the use of building towards optimal performance. The research found that whilst all the schools had perceivable sustainable agendas and delivered environmental education they were focussed on experiences in natural environments and recycling/reuse activities or rather than the impact of the built environment.

Notwithstanding the high commitment to sustainability in the ethos of the schools, the design of the buildings and its services, there are few indicators which show architectural provision within the building for its users to recognise and understand its construction, operation and performance or the facilitation of opportunities to engage in behaviour which can be seen to affect the building performance. All lack organised activities and/or resources to exploit elements of the building and its construction methods and materials which provide practical experiences within the buildings which link to the curriculum and especially STEM subjects (science, technology, engineering and mathematics, important to National technical capability); that the building itself can provide education rather than merely house it.

The conclusion of this paper, therefore must be, that sustainably-designed school buildings are not presently useful in changing attitudes or behaviours as the sustainable features are not readable by the children and, in general, teachers do not have the specialist knowledge nor access to resources with which to interpret the building for educative purposes within an environmental context. The inclusion of permanently embedded detailing or interpretation at the design stage (as is now relatively common in product design) intended to engage users and deliver a rationale for its form and operation meet requirements for ‘discoverability’ and ‘understanding’ which is the basis of Lockton’s ‘Design with Intent’. In the same manner that there is a moral and economic onus on architects to design buildings which not only meet legislation but are environmentally responsible, there should be (and most certainly in buildings designed for education) a requirement for the same to be interpreted within the architecture and services, designed to make explicit the necessity of the built environment, its contribution to the global ecosystem and the behaviour of the individual within, towards a balanced and therefore sustainable ecology.

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