

The Impact of School Environments:

A literature review

Produced for the Design Council

Steve Higgins

Elaine Hall

Kate Wall

Pam Woolner

Caroline McCaughey

The Centre for Learning and Teaching

School of Education, Communication and Language Science

University of Newcastle



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Foreword

‘The science of designing learning environments is currently remarkably under-developed’, argued architect and CABI Commissioner Emeritus the late Richard Feilden in 2004. In a similar vein, Professor Stephen Heppell argued at the expert seminar held to inform this literature review that ‘whereas, traditionally, we have designed for productivity, processing large numbers of children through the effective use of buildings, designing a room for learning is very complex. No one knows how to prevent ‘learning-loss’ when you design a room “pedagogically”, whereas we know lots about designing for minimum heat loss’.

The first thing that will strike you as you read this literature review is the relative paucity of research on effective learning environments. Not only is the evidence incomplete, particularly in areas such as the systems and processes and communications approaches that schools need to underpin their physical environment, but the research that has been done seems to be largely predicated on a traditional view of ‘chalk and talk’ learning in standardised ‘one size fits all’ institutions.

The danger with this as we set out on the government’s massive and exciting school building programme is that we will use evidence from the past to inform a very similar future, when what is needed is a new approach and new solutions for school design to reflect the changing needs of learning in the 21st century. As Professor David Hopkins, the Education Minister’s Chief Advisor on School Standards, argued at the same seminar: ‘Schools today have the responsibility for personalised learning and its design.’

The government’s emphasis on personalised learning reflects a much broader and subtler view of learning than the ‘chalk and talk’ alternative. As globalisation and societal changes transform the world we live in, the demands placed on learners and our education system are changing to reflect this, for example through ever-rising participation rates post-16, the 14-19 reforms and the Extended Schools thrust to engage whole communities in lifelong learning and wider services. At the same time our understanding of learning itself is changing. Research on learning styles, formative assessment, multiple and emotional intelligences, constructivism and so on have combined with the rapid development of technology-enabled, peer-to-peer and self-directed learning to facilitate very different approaches to the 30-students-in-rows model. But despite these changes, we do not yet have a robust research base for integrated and personalised learning environments.

The second striking finding from this review is that it is the extent to which, and the ways in which, school users are engaged in the school design process that determines the success or failure of the resulting design. The message is clear. School designs cannot be imposed nor bought off-the-shelf. Success lies in users being able to articulate a distinctive vision for their school and then working with designers and architects to create integrated solutions. The open-plan classroom movement showed that purely physical design solutions that are not owned by their users or supported with effective systems and behaviour change will not work.

Thirdly, as the review’s researchers conclude, in a changing world no design solution will last forever, so the process of user involvement must be continually refreshed and iterated to support ongoing change. This approach has the added benefit of sustaining the meta-cognitive and motivational power of user involvement in creating the environment over time. It therefore seems a hugely significant lesson for the school building programme to take on board.

So what should be the research agenda going forward? It seems that we need two types of research. On the one hand, a system-wide action research approach that inspires and enables every school in the country to take ownership of the design process and learn systematically from its own experience as we go through the capital programme. On the other, a more focussed research exercise to systematically probe some of the biggest and most fundamental questions for a personalised system, not least the nature of an effective design process within the capital programme itself. Without such an understanding the danger is that wider policy imperatives will leave us with another generation of schools fit for the past, rather than the future.

Finally, I am extremely grateful to the team at Newcastle University's Centre for Learning and Teaching for conducting this review and to CfBt for sponsoring it. I hope you will find it useful.

A handwritten signature in dark ink, reading 'T. M. Greany'.

Toby Greany
Campaign Leader – Learning Environments
Design Council

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Introduction

This review was commissioned by the Design Council to inform its Learning Environments Campaign and sponsored by CfBT Research and Development¹.

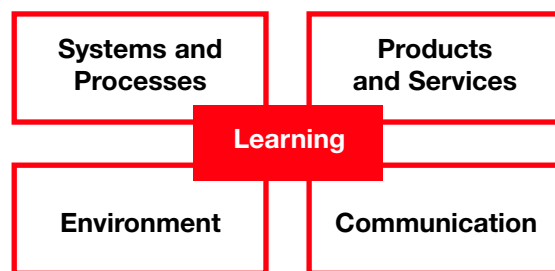
The primary objective of the Learning Environments Campaign is to challenge those involved in the leadership, design, planning, resourcing and management of Britain's schools to provide innovative and effective learning environments.

The overarching brief for the literature review contained the following questions:

- What makes a good school (physical) learning environment?
- What impact do (physical) school learning environments have on student behaviour, motivation, learning and achievement?
- Which components/elements of school learning environments make the most difference to pupil behaviour, motivation, learning and achievement, and why?
- What evidence exists to indicate the relative balance between the physical environment and the emotional and cognitive environments on pupil behaviour, motivation, learning and achievement?

The Newcastle review used the conceptual framework of interacting elements drawn up by the Design Council (Figure 1) as the framework for its review.

Figure 1: Project design themes



This grid divides the complex environments and interactions within schools into different areas which can be the focus of a design-led approach to change. In the grid, learning is shown at the centre, indicating that improved pupil and school-level learning is seen as an outcome both of changes to the school's 'systems and processes' (including through an adoption of the design approach), and through changes to its environment, communications approach or to products and/or services. Placing learning as the 'bridging element' also implies that changes to one area, for example the environment, are likely to be associated with changes in communication or systems and processes.

As part of the review process CfBT also sponsored a high-level seminar held by the Learning Environments Campaign where 60 delegates heard from leading policy makers and academics and relayed their thinking to the review team. A second parallel 'grey' review was also carried out by the Newcastle team and sponsored by CfBT to research 12 case studies of innovative practice in the design of school learning environments from around the world. These case studies will be published as part of www.designmyschool.com, a new website commissioned by the Learning Environments Campaign and being developed by Ultralab to help schools improve their environments.

¹While CfBT has funded this literature review, the contents of this report do not necessarily reflect the views of CfBT.

Executive Summary

This review explores the impact of learning environments on students' achievement, engagement, affective state, attendance and well-being. It draws on a body of literature which is mainly based in the USA and the UK. Our analysis of the range of evidence leads us to make the following principal points.

It is extremely difficult to come to firm conclusions about the impact of learning environments because of the multi-faceted nature of environments and the subsequent diverse and disconnected nature of the research literature.

The empirical research that exists on the impacts of environment on teaching and learning tends to focus much more upon some elements (for example, noise) and to fail to synthesise understandings (for example the implications of noise and temperature research tend to conflict). Cultural and geographical differences also highlight the importance of sensitivity to context. For these reasons it is very difficult to make judgements about which areas are 'worth' focussing on.

There is clear evidence that extremes of environmental elements (for example, poor ventilation or excessive noise) have negative effects on students and teachers and that improving these elements has significant benefits. However, once school environments come up to minimum standards, the evidence of effect is less clear-cut. Our evaluation suggests that the nature of the improvements made in schools may have less to do with the specific element chosen for change than with how the process of change is managed.

There appears to be a strong link between effective engagement with staff, students and other users of school buildings and the success of environmental change in having an impact on behaviour, well-being or attainment. The ownership of innovation, in contrast to the externally imposed solution, appears to tap directly into motivational aspects which are key factors in maximising the impact of change. Changing the environment is 'worth doing' if it is done as a design process.

The causal chain between environmental change and changes in students' attitudes, behaviours and achievements is a fairly complex one taking in issues of;

- Choice and autonomy in consultation processes
- Increased self-worth and morale for staff and students based on the investment of time and money in their ideas and their working space
- The 'fitness for purpose' of innovations for particular contexts
- The process of trialling, testing and embedding new practices shaped by environmental change.

These organic, locally governed processes of change and engagement are also necessarily dependent on a process of renewal: as staff and students move on, it is necessary to engage new cohorts in improving the environment in order to continue to reap the benefits.

It is important, therefore to beware of 'architectural determinism', of plans for renewal and development which do not allow for both local variation and ownership, and of programmes which do not budget for an ongoing investment in, and iteration of, school environments.

The following summaries are taken from the four chapters of the review to provide an overview of findings.

Systems and processes

- Different users have different perceptions and needs, which often differ from the architect's perspective.

- Genuine involvement of users empowers individuals, produces greater satisfaction and should improve the design.
- Teachers' attitudes and behaviour are vitally important to the use made of space.
- While there can be a dynamic relationship between environment and behaviour, it is not automatic.
- Environmental perceptions are not, unless prompted, often at the forefront of teachers' planning.
- Staff morale is a crucial aspect of the learning environment.

School built environment

- There is strong, consistent evidence for the effect of basic physical variables (air quality, temperature, noise) on learning.
- Once minimal standards are attained, evidence of the effect of changing basic physical variables is less significant.
- There is conflicting evidence, but forceful opinions, on the effects of lighting and colour.
- Other physical characteristics affect student perceptions and behaviour, but it is difficult to draw definite, general conclusions.
- The interactions of different elements are as important as the consideration of single elements.

Physical environment in the classroom

- Much of what is known about student comfort, particularly in terms of furniture, has yet to be translated into actual school environments.
- Since different room arrangements serve different purposes, it is necessary for classrooms to have some degree of flexibility.
- Some improvements to environment may save time, which is then available for learning.
- 'Ownership' of space and equipment by both teachers and students is important.
- Ownership and engagement are ongoing elements, so there has to be a balance (in display of student work, for example), between permanent and fresh elements.
- Some physical elements in the classroom improve comfort, well-being and probably attitude - and so, perhaps, improve achievement.

Products and services

- Catering is important to children and may be linked to learning.
- Schools have a role both in the meals and snacks provided and with regard to the information about healthy living provided to students and their families.
- Extending schools into the community is considered desirable and seems beneficial.
- For schools, there are system and process issues relating to teachers having a role 'beyond the classroom'.
- Community involvement is seen as both cause and effect of an improved school and can complement other initiatives.

Communication

- Effective communication is part of involving users and extending schools into the community.
- Good communication within a school seems to be part of creating an environment that is conducive to success.
- Schools as communicators in the community have dual, not necessarily compatible roles: presenting themselves positively and promoting links with, and understanding among, with parents.
- Navigation is improved by landmarks and distinctiveness.

Method of review

Searching

This review began by searching databases using relevant search terms (see Table 1). This produced a large number of articles and books, which were briefly considered for relevance and reduced to a smaller number that could be read in full. As well as papers providing references back to earlier work, the citations of a number of notable articles were also traced forwards to more recent research.

The field of school learning environments draws on a number of disciplines, from the purely educational to psychology, environmental and buildings design and ergonomics, to name but a few. It has been necessary to merge these fields for this review and sometimes this has proved difficult, as different disciplines have a variety of paradigms for research and reporting. However, we have maintained a strategy of giving the greatest prominence to recent, relevant research which has a clearly reported empirical base.

Our current database of relevant material now contains more than 200 references, ranging from many published in the last three years to those from as early as 1911. Much of the literature comes from the UK and the US, though we have also drawn upon some influential European literature.

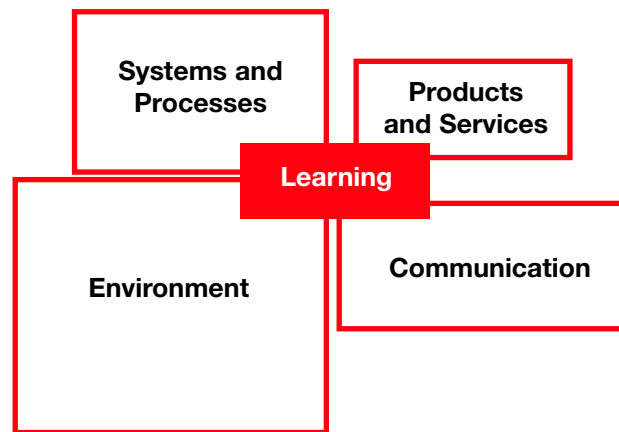
Table 1: The search strategy and results

Academic Searches							
	Articles First	ECO	World Cat	Web of Science	BIDS	BEI	ERIC
physical learning environment	16	143	317	321	7	13	
school building							51
noise + education / teaching / school	91	73	1400	305	2	18	
temperature + education / teaching / school / classroom	146	110	2499	271	3	3	
light + education	396	1113	3535	42	149	9	
light + classroom	29	113	328	14	11	3	
colour + education/ classroom	33	94	1873	108	10	36	24
colour + learning / mood / motivation	2	11	0				
effect of colour	13	1					
decoration + learning	1						

Mapping the field

It became clear immediately that there has been more research in some areas than in others, with the result that we will have far more to say about issues relating to the environment and the effect on learning, than about products and services (see Figure 2).

Figure 2: The design quadrants in proportion to representation in the literature



It has been pointed out that typical school buildings and classroom layouts vary between countries in ways that are related to understandings and philosophies of education as well as to material resources (Alexander, 2000). From a study of 30 primary schools in five countries, Alexander reports some interesting consistencies such as the much more elaborate displays of children's finished work in the American and British schools (op.cit.,p.184); the arrangement of the children in rows of individuals in India, rows of pairs in Russia and around work 'centres' in the USA (p.333-334); and the contrast of 'a great deal of light' in all the Russian classrooms with some British and American classrooms 'so inadequately fenestrated that they required artificial light throughout the day'. (p.185).

However, research specifically concerned with the effect of the learning environment on students tends to be carried out in Western Europe and, particularly, in the USA. Although certain regions have produced notable contributions relating to particular aspects (eg, Germany and Scandinavia on air quality, Britain on external noise) it is in the USA that the general issue of the learning environment has been most thoroughly addressed. Clark comments that, 'As yet, no equivalent body of research to that in the US exists in the UK'. (2002, p.8). Although some issues highlighted by American work, such as desk arrangement or external noise, have been further developed by British research, other areas which have been extensively studied in the USA, such as school size, appear to be considered less relevant to the British situation.

There were some aspects of the original research brief which are not covered in this review, simply because the academic literature does not provide sufficient evidence. These include the variable impacts of environmental factors on students of different ages, the extent to which changes in behaviour (teacher or student) persist over time and issues relating to the procurement of new school environments and the cost-benefit analyses that are associated with this process.

Overall, the review looks at the effects of changes in the learning environment on teachers and learners but, in order to come to terms with the complexity of learning environments, we have found it necessary to explore more systematically the different potential impacts that change might have.

Each section of the review that follows will therefore begin with a summary table which indicates the evidence of effect in terms of the following five categories:

- Attainment: improvements in curriculum attainment measured by standardised tests or exams, or as monitored by teacher observation.
- Engagement: improvements in levels of attention, more on-task behaviours observed, decrease in distracted or disruptive behaviour.
- Affect: improvements in self-esteem for teachers and learners, increased academic self-concept, improvements in mood and motivation.
- Attendance: fewer instances of lateness or absenteeism.
- Well-being: impacts on the physical self, relating to discomfort as well as minor and major ailments.

System and processes

Summary table 1: Systems and processes

Design process		Roles and functions of staff
Attainment		Considering users' needs satisfaction and / or better buildings
Engagement	Mediated through morale and reduction of non-achievement behaviours?	Not simply determined by physical environment
Affect	Empowering teachers Different users have different perceptions	Staff morale: Key? Mediating? Self-fulfilling?
Attendance		
Well-being		

Design process

Apart from occasional large projects (eg, 21st Century Schools, CABA/RIBA, 2004; CABA client guide, 2002), there is not much evidence of design and/or architectural ideas directly or radically affecting many schools. At any one time, of course, the majority of schools will be housed in older buildings that will tend not to embody current design ideas. Furthermore, although the recent building bulletins produced by the DfES allow or even promote more imaginative school building, it seems likely that many of the new buildings that schools are being encouraged to plan and build will end up being much like those which came before. Seaborne (1971) demonstrates that although there have been changes in school architecture, these have often been slow. Seaborne and Lowe describe how the enthusiasm for 'open plan' primary schools was diluted so that even many newly built schools in the 1960s 'are probably best regarded as "semi-open"'. (1977, p 177). Jamieson et al (2000) argue that this conservatism is due to the lack of participation of users in the design of educational facilities. This issue of the involvement of users will be revisited below.

There are a number of instruments to assess school design that are intended to inspire and measure change (eg, The Construction Industry Council's Design Quality Indicator), to allow comparisons to be made between schools (Tanner, 1999) or to facilitate a greater understanding among users of their environment (Sanoff et al, 2001). The idea that considering, and trying to affect, the nature of the school environment is empowering is referred to by a number of writers. David (1975) argues that users are generally empowered by understanding and altering their environments, whilst the intention of empowering teachers, in particular, by helping them to learn about, and alter, their classrooms motivates Sandra Horne-Martin (eg, 1999; 2002).

In addition, architects and others have noted that the involvement of users should improve the design Dudek (2000) and Clark (2002) recommend the genuine involvement of students and teachers in the design process. At the time of experimentation with open-plan education, a contemporary book (IDEA, 1970) argued that all staff need to be involved to understand the potential of the space, while 'there must be extensive involvement of the parents in the planning

as well as in the implementation of the programs; otherwise, the new school is doomed before it is even opened'. (p.20).

Rivlin and Wolfe are especially positive about the ideas and vision of children. They describe an occasion where not involving pupils in a classroom innovation fatally undermined it (the loft structure that 'suddenly appeared', 1985, p.200) and, furthermore, regard the involvement of children in design projects as important in overcoming the conservatism of many adults. It has been argued (Asprino et al, 1981; Moore, 1979) that, because lay and expert perceptions and opinions about architecture vary, it is necessary to involve ordinary users. Sundstrom (1987) reports some findings of increased satisfaction with environments designed through user involvement, and points out that this satisfaction could be due to the involvement itself, the resulting building actually being better, or perhaps both.

However, he is quite cautious about representing such involvement as a panacea and clearly there are ways and degrees of involvement, to which Clark (2002) alludes. Arnstein (1979, cited by Hart, 1987) used a typology to describe how people might be involved in the planning and operation of public programmes. This views participation as ranging from 'manipulation', where ideas are basically imposed on users, through 'informing' and 'consultation', which can be of limited worth if done in isolation, to the genuine participation of 'partnership' and 'citizen control'. Such a one-dimensional typology could be further developed by considering who is consulted at each level of participation, and this seems particularly relevant to school design, where there are distinct groups of users. Therefore, we have developed a typology of design and consultation (see Figure 3) to help in the process of evaluating how consulting about innovation interacts with levels of involvement to produce qualitatively different experiences for key participants.

Figure 3: Typology of design and consultation

People involved in consultation						
Levels of		Externally imposed new design	School managers involved	All staff involved	All staff and students	Staff, students and community
	Initial consultation					
	Testing and trialling					
	Re-design / embedding					
	Post-hoc evaluation					

Many researchers have developed questions and rating scales to measure users' opinions and perceptions. These could be used to involve school users in a design process and they have allowed a bank of knowledge to accumulate about the concerns of particular users. However, concerns are sometimes voiced about problems of subjective responses failing to match up with objective measures (Evans & Stecker, 2004; Salame & Wittersheim, 1978; Knez & Hygge, 2002). Evans & Stecker caution that 'suboptimal environmental conditions may harm individuals without causing negative subjective awareness'. (2004, p.162). Meanwhile, Gifford is of the

opinion that 'it should not be necessary to demonstrate that something in the environment fries our brains or causes insanity before it is replaced'. (2002, p.311). Taken together, these two arguments imply that users' perceptions should be seen as a sufficient, but not a necessary, indication of problems or benefits of a particular environment.

There has been plenty of subjective evidence collected, albeit for a variety of purposes. The opinions of teachers (Schapiro, 2001; Cooper, 1985), children (Burke & Grosvenor, 2003; Cohen & Trostle, 1990) and school principals (Tanner and Langford, 2002) have been individually addressed. Some work has suggested that the main concerns of the various users of a school may differ (Fraser, 1984; Maxwell, 2000; Ornstein, 1997), although there are also commonalities (Maxwell, 2000; Douglas & Gifford, 2001). Sometimes such questioning of users has been part of planning and improving a school environment. Berry (2002) used this element to both inform and assess the school improvement that he reports, and in another study a rating scale was developed but the funding was not available for the development part of the project (Maxwell, 2000).

Roles and functions of staff

The importance of how a school is generally run and of its overall ethos is suggested by many authors. Rutter (1979) found that a broadly 'academic' ethos seemed to promote academic achievement. On a practical level, Buckley et al. (2004) found that their 'overall compliance rating', which evaluates how well schools comply with health and safety requirements, such as organising fire safety, security, maintenance, etc., did contribute to the prediction of school averages on standardised achievement tests. The importance of the general school style and ethos is suggested by Tanner's (2000) observation that 'overall impression' was one of only four elements of his school design scale which on their own correlated significantly with academic achievement.

Other writers have argued that teachers' beliefs and perceptions are crucial (Deemer, 2004) and that many effects of the environment are likely to be mediated through morale within the school (Schneider, 2003; Clark, 2002). Cooper asked primary school teachers about their school buildings and argues that 'whether physical environments are themselves capable of disabling education, teachers' belief in their capacity to do so could prove self-fulfilling. For it could act to lower their morale and motivation, so eroding their commitment to teaching'. (1985, p.267-8). PricewaterhouseCoopers (2000) consider staff morale to be of key importance while Berry (2002) found there were improvements in attitude among all users after a school was physically improved. Such improvements can be seen as resulting from the physical changes to the environment which then contribute to the overall learning environment experienced by everybody.

Another interaction between users and the physical environment occurs in the use teachers make of their environment and how it affects their behaviour. Horne-Martin (2002) argues that style of teaching and room organisation are linked, although it is not clear which is cause and which is effect. There is evidence (Ahrentzen & Evans, 1984) that more open classrooms do have some direct effect on how teachers teach, but Rivlin and Rothenberg (1976) found that this was not as dramatic as might be expected: despite being encouraged by the policies of the school and the layout of the classroom to be more flexible and less traditional, many of the teachers they studied stayed in one place, essentially 'taught from the front' and did not move the furniture.

In general, as Weinstein and David point out, 'open-space, in and of itself, does not have a universal effect' (1987, p.12), while Canter and Donald argue that in studies comparing open and traditional environments "the essential element was the school's educational philosophy and physical layout, not merely the physical layout on its own". (1987, p.1292).

Figure 4: Picture taken from *The Open Plan School* (IDEA, 1970), perhaps indicative of the difficulties of open-plan education where 'classes shared little beyond the vast open area and high noise level'. (Rivlin & Wolfe, 1985, p.177).



Some writers see observations about behaviour in open-plan settings as linked to the more general issue of architectural determinism. Cooper, himself architecturally trained, warns that 'Those who offer guidance on the planning of buildings tend to assume that there is some necessary relationship between the design of a building and the behaviour of those who occupy it' (1981, p.125), a position which he goes on to reject comprehensively. Away from the research on school environment, it has been found (Brennan et al., 2002) that open-plan offices do not necessarily have the expected effect on staff behaviour of increased socialising. Findings like these, and some of those of Horne (1999), imply that human beings tend to resort to simply coping with the given environment rather than actively managing it and this may be related to users not being involved in the design process and thus not 'owning' their space.

Section Summary: Systems and processes

- Different users have different perceptions and needs, which often differ from the architect's perspective.
- Genuine involvement of users empowers individuals, produces greater satisfaction and should improve the design.
- Teachers' attitudes and behaviour are vitally important to the use made of space.
- While there can be a dynamic relationship between environment and behaviour, it is not automatic.
- Environmental perceptions are not, unless prompted, often at the forefront of teachers' planning.
- Staff morale is a crucial aspect of the learning environment.

The school built environment

Summary table 2: School environment

	Temperature/ air quality	Noise	Light	Colour	Other school build features
Attainment	Poor internal air quality – low attainment	Reading scores, pre-reading skills, general attainment	Link claimed		Outdoor spaces, pathways; What is 'good enough'?
Engagement	Air conditioning noise may distract	Attention and distraction; Time lost through noise interruption; Internal noise			
Affect		Annoyance; Learned helplessness		Children want colour; High hopes but no coherence	Conflicting evidence on ceiling height
Attendance	Conflicting evidence				
Well-being	Asthma; aller- gens; poor ventilation – build up of pollutants, CO ₂ , etc.	Some suggestion of other physical effects (e.g. raised blood pressure)	Eyestrain, headaches, fatigue; Perhaps weight gain, dental cavities		

It is possible to consider the fundamental aspects of the physical environment, such as heating, lighting and acoustics, as well as the overall design of the school, which will encompass these aspects. Since some of these physical 'basics' have been researched in isolation, it seems reasonable to look at them first in this manner. Many reviews of the effect of the physical school environment on learning (eg, Fisher, 2001; Earthman, 2004; Schneider, 2002; Clark, 2002; Weinstein, 1979; Gump, 1987) consider previous research in a similar way and point out that some of the more definite conclusions within this area can be drawn about the effects of these underlying physical characteristics (Schneider, 2002). However, it is important to remember that all these features contribute to the educational environment and, in addition to concerns about possible interactions (occasionally addressed, e.g. by Hygge & Knez, 2001), there is the problem that recommendations regarding certain physical factors may, and often do, conflict with each other.

Temperature and air quality

Earthman (2004) rates temperature, heating and air quality as the most important individual elements for student achievement. Two studies (Young et al, 2003; Buckley et al, 2004) mention the importance of these issues in reports which address the needs of particular US states' schools, while Fisher (2001) and Schneider (2002) similarly rate these factors as likely to affect student behaviour and outcomes.

Figure 5: An open-air school (From Seaborne and Lowe, 1977)



Within the studies there are some reasonably clear findings but also some disagreement. Much of the earlier work, in the USA, emphasised comfortable temperatures and, therefore, given the climates of some of the districts studied, advocated an increased use of air conditioning. There has been questioning of some of the assumptions made about maximum comfortable temperatures (Wong & Khoo, 2003) and about the necessity of using air conditioning to achieve ventilation (Khedari et al., 2000; Grams et al., 2003). Furthermore, it is notable that air conditioning, ventilation and heating systems are found to contribute quite distinctly to the level of classroom noise (Shield & Dockrell, 2004). This is considered too noisy by many researchers in that area and suggests the potential for conflict between demands for certain physical elements to be prioritised over others.

However, the importance of ventilation in educational establishments continues to be emphasised (Kimmel et al, 2000; Khattar et al, 2003), while the inadequacies of indoor air in schools continue to be reported (Lee & Chang, 2000; Kimmel et al, 2000; Khattar et al, 2003) and linked to ill-health (Ahman et al, 2000). Smedje and Norback (2001) argue that since irritants and allergens collect in dust, it might be advisable to avoid particular sorts of 'fleecy' furnishings and open shelving and to increase the frequency of cleaning. It is evident that the demands of clean air might come in to conflict with the teacher's desire to provide a comfortable, cosy and welcoming classroom.

Most of these studies work on the basis that air-related health problems are self-evidently problematic, but the study of Rosen and Richardson (1999) went further by linking poor air quality to absenteeism. They found that reducing the number of particles in the air, and so

improving air quality, in a nursery school resulted in reduced child absence. Clearly this has implications for learning and academic achievement. In contrast, the Heschong Mahone Group report (2003) argues that operable windows and air conditioning have no effect on absenteeism.

Noise

There is considerable literature considering the effect of noise on human functioning, quite a lot of it relating to children learning in noisy environments. This can be seen as developing from laboratory- based cognitive psychology experiments (eg, Salame & Wittershiem, 1978), which attempted to understand the effect of noise on cognitive functioning through examining performance of narrow tasks, often involving memory. However, even these experiments, in situations which are considerably more restricted than in a classroom, allow for some argument about the precise cognitive mechanisms for the results they obtained (Poulton, 1978). However, they do advocate explanatory elements that recur in the 'real world' literature, such as noise annoyance, distraction and direct masking of cognitive processes, as well as revealing a general tendency for noise to be disruptive, therefore impairing performance. Cohen et al. (1980) argue for combining field and laboratory methodologies when considering the effect of raised levels of ambient noise on children and they conclude that there are consistencies in the findings of the two approaches.

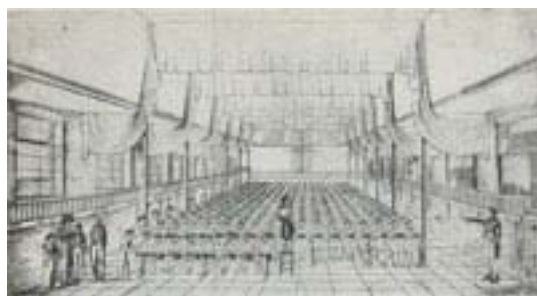
The research into the effect of living or learning in noisy surroundings was initially driven by concerns about exposure to chronic external noise, such as that due to aircraft or road traffic. In a review of the area, Stansfeld and Matheson discuss the possibility of health and psychological problems and conclude that: 'The evidence for effects of environmental noise on health is strongest for annoyance, sleep and cognitive performance in adults and children.' (2003, p.253). Cohen et al (1980) found evidence of raised blood pressure and signs of learned helplessness due to noise, although these problems have not been found by other studies (such as Haines et al, 2001a). A more reliable finding is that chronic noise exposure impairs cognitive functioning and a number of studies have discovered noise-related reading problems (Haines et al, 2001b; Evans & Maxwell, 1997), deficiencies in pre-reading skills (Maxwell & Evans, 2000) and more general cognitive deficits (Lercher et al, 2003). As a result, reviews of the consequences of aspects of the physical environment tend to conclude that acoustics and noise are important factors in a school environment (Fisher, 2001; Schneider, 2002; Earthman, 2004). Schneider comments that in general the research is 'consistent and convincing: good acoustics are fundamental to good academic performance'. (2002, p.6).

There has been some discussion about the mechanism for the widely reported reading deficits. It has been observed that teachers pausing during bursts of external noise leads to an effective reduction in teaching time (Weinstein, 1979), which has been put as high as an 11% loss in teaching time (Rivlin & Weinstein, 1984). Although there is interest in noise annoyance (Boman & Enmarker, 2004; Kjellberg et al, 1996) and links to mood (Lundquist et al, 2002, 2003), it seems there is also a more direct cognitive mechanism (Haines et al, 2001a). Hygge (2003) reports that various noises (recordings of aeroplanes, road traffic and trains) appear to interfere with the encoding stage of memory and that this is not mediated by distraction or mood. Evans and Maxwell (1997) argue that the reading deficits result from problems with language acquisition and, specifically, with speech perception. A related suggestion is that, in general, impairment in performance is partly explained by the interference of any noise with inner speech (Poulton, 1978), while Knez and Hygge (2002) found that irrelevant speech is a particularly distracting noise.

All this evidence fuels concern that many have about internal or ambient noise levels in classrooms, even where there is not particularly loud external noise. Shield and Dockrell (2004) found that

external noise levels did not generally affect levels of classroom noise, which were mainly dependent on internal factors such as the nature of the classroom activity, number of children etc. It must be noted, though, that they measured the noise levels with the classroom windows closed, and that when the children were engaged in silent reading the external noises became more significant and possibly distracting. However, they found that background noise in unoccupied classrooms was above guideline levels.

Figure 6 and 7: Sound dampening, 1831 (above from Seaborne, 1971, plate 120) and 2000 (below from Maxwell & Evans, 2000, p.94)



Other researchers have drawn attention to these problems of inadequate acoustics (Addison et al, 1999; Lundquist et al, 2002) and proposed various solutions such as increased carpeting (Tanner & Langford, 2002), sound amplification systems (McSporran et al, 1997) and ceiling hangings to dampen reverberation (Maxwell & Evans, 2000). As Seaborne (1971) describes, this last solution was in use in the 1830s! (These are illustrated in Figures 6 and 7).

Another line of research interest relates subjective perceptions of noise and noise annoyance to objective measures of noise. Dockrell and Shield (2004) conclude that the judgements of both adults and children correlate well with background noise, while noise annoyance is more related to peaks of noise and some noises are perceived as more annoying than others. Other researchers (Stansfeld & Matheson, 2003; Kjellberg et al, 1996) have noted that factors such as predictability, control and judged necessity influence how annoying people find particular noises. However, there are limits to the judgements about the effect of noise with several studies finding that participants can be apparently mistaken about the effect of the noise situation on their performance (Salame & Wittersheim, 1978; Knez & Hygge, 2002). In addition, there are some limited suggestions that some individuals might be more sensitive to noise than others (Belojevic et al, 2001; Zimmer & Ellermeier, 1999).

Lighting

There is a considerable amount of literature relating to lighting in the classroom. There is research relating to different kinds of lighting, from daylight to artificial, and there is a disagreement among researchers on which form of lighting is the most suitable for the classroom. In relation to student achievement it is argued that day lighting offers the most positive effect (Earthman, 2004; Heschong Mahone Group, 2003) as daylight produces biological effects on the human body (Wurtman, 1975). However, having solely a daylight source in the classroom is not practical or possible. Benya suggested that for 'lighting to be effective, daylight must be supplemented by automatically controlled electric lighting that dims in response to daylight levels'. (2001, p.1). Barnitt (2003) suggests that good lighting can only be achieved by a combination of direct and indirect lighting.

There are different kinds of indoor lighting and differences in the intensity depending on colour temperatures. Jago & Tanner argue that 'the visual environment affects a learner's ability to perceive visual stimuli and affects his/her mental attitude, and thus, performance' (1999). Knez (1995) found evidence that lighting conditions that induced negative affect reduced performance, and therefore, lighting conditions that induced positive affect improved performance. Veitch (1997), however, argued that lighting has no effect on mood or performance. In another study, Knez studied the effect of lighting and gender and found that females were more perceptive to light than males. Furthermore, Knez (2001) found that males and females performed differently in different kinds of lighting. Differences in performance and mood under different kinds of lighting in relation to gender and age were studied by Knez and Kers (2000).

Another line of research that relates to lighting is concerned with health issues. The most common complaints of inappropriate lighting are headaches, eyestrain and fatigue. To overcome these complaints, Karpen (1993) suggests the use of full spectrum polarised lighting as it is glare-free and flicker-free. As there is an increased use of computers in schools the idea of creating glare free lighting is important (Barnitt, 2003). However, concerns about glare and suggestions for overcoming it are not new: Donovan (1921) includes advice about the alignment of desks and the use of blinds.

One way of determining the health of students is to examine absenteeism. The Heschong Mahone Group (2003) argues that physical classroom characteristics, including lighting, do not affect student attendance, while other researchers, for example, Hathaway (1990) argue that there is a correlation between absenteeism and lighting. Hathaway goes further on the aspects of lighting than other researchers, linking lighting to incidence of dental cavities and gains in height and weight.

Colour

Engelbrecht argues that we have a basic, biological reaction to colour and that 'the psychological reaction to colour does not preclude the basic biological reaction that stems from human evolution'. (2003). Colour transmitted through the eye is argued to affect mood, mental clarity and energy levels. Camgöz et al. (2003) suggest that bright colours on any colour background attract an individual's attention. It has been asserted that when an individual sees a colour or thinks of a colour, certain reactions take place in the mind. However, the effects of such reactions and the possibility of consistencies between people are much more debatable.

Depending on the age of children, different colours are considered stimulating; younger children prefer bright colours and patterns while adolescents prefer more subdued colours (Engelbrecht, 2003). However, Pile (1997) suggests strong, warm colours for young children, and warns against the use of intense primary colours. Different preferences for particular colours have been found between males and females (Rosenstein, 1985; Read et al., 1999; Khouw, 1995) with Radeloff

(1990) suggesting that males prefer bright colours while females prefer soft colours. Yet, conversely, Ou et al. (2004 a,b,c) argue there is no difference in colour preference between males and females. However, Sundstrom (1986) points out that those experiments that determine people's colour preferences generally involve small patches of colour that are viewed for a short period. He argues that the findings do not show what colours people prefer their offices (or their classrooms!) to be painted.

Figure 8: Colour has been shown to be one of the pupils' priorities (from Burke and Grosvenor, 2003).



Plate 4 The sweet school (Rebecca, 8, Coventry)

Yet there are some suggestions that the colour of surroundings might have a distinct impact on mood and behaviour, perhaps sometimes, Sundstrom (1987) suggests, through changing perceptions of room temperature or size. Read et al (1999) consider that both colour and ceiling height affects children's cooperative behaviour. Engelbrecht argues that the colour of walls in the classroom affects productivity and accuracy while Brubaker (1998) argues that cool colours permit concentration. Bross & Jackson (1981) carried out a study on girls in grades 7-9 which found that the participants made fewer errors when working in cubicles painted in their preferred colour, while time to complete tasks changed minimally. Hamid & Newport (1989) carried out a study with pre-school children and concluded that the children demonstrated more physical strength and positive mood in a pink-coloured room than in a blue-coloured room. However, the results obtained from this study contrast with the effect that pink is supposed to have on adults (Schauss, 1985). Schauss argues that pink is a tranquilising colour that saps energy and so may be used to prevent individuals from becoming aggressive. Russell and Snodgrass (1987) note the use of 'a shade of hot pink' in several American detention centres, based on this belief.

In relation to education facilities, Maxwell (2000) found that children thought colour was important and that they thought the colour of the walls in their school was uninviting and boring. However, in this study Maxwell also found that teachers and parents were not concerned by the colour of the walls. Burke and Grosvenor (2003) further emphasise children's preference

for colour. In their book *The School I'd Like*, many children mentioned colours and lots of colours (see Figure 8). One 15-year-old student described her school as 'a giant magnolia prison' and said, 'I want colours'. A common complaint in the classroom is eye fatigue and in order to relieve it, Engelbrecht suggests that the end wall of the classroom behind the teacher should be a different colour from the other walls. This idea is also offered by Pile (1997) and Brubaker (1998), with the other walls being a neutral colour.

To conclude, however, it might be sensible to bear in mind the comment made by Sundstrom (1987) about colour in the workplace: 'Color is one of the least studied aspects of the physical environment, but it nevertheless remains the topic of some of the most optimistic claims about morale and efficiency'. (p.751).

Other design issues

A major design issue of the last few decades has been that of open-plan schools but, as other writers have argued (Gump, 1987; David, 1975; Proshansky & Wolfe, 1975), the resulting environment should be understood far more in terms of the interaction of social and physical elements than other physical factors. For this reason, the general issue of open-plan schools has been discussed in the section on roles and functions of staff, while details of classroom layout revealed by studies of open-plan classrooms will be included in later sections dealing with the physical environment of the classroom.

Other issues in the design and layout of the whole school are mentioned in the literature but have not been so exhaustively researched as the above elements. Ahrentzen & Evans (1984) found that higher ceilings in classrooms produce decreased perceptions by both teachers and children of crowding, with the height of the classroom ceiling correlating significantly with teacher satisfaction with the room. However, higher ceilings may cause other problems. Read et al (1999) found that ceiling height affected co-operative behaviour among pre-school children, with the children displaying higher levels of cooperative behaviour in classrooms with lower ceilings. Earthman argues that a particular problem with older schools is that their high ceilings 'may negate the benefit of better lighting' (2004, p.20), while higher ceilings can also increase acoustic problems due to reverberation.

Tanner (2000) provides a number of suggestions of elements of school design which might be particularly important. Among the four features of his school design assessment scale which correlate with student achievement, are 'pathways' and 'positive outdoor spaces'. The former refers to buildings and ground which encourage ease of movement, presumably avoiding feelings of crowding. With reference to the latter factor, Tanner is convinced of the benefit of well designed and maintained outdoor spaces and his findings do suggest that they might contribute to student academic performance. Certainly outdoor areas are noticed: Maxwell's (2000) student respondents criticised the rather inadequate outdoor area at their school.

Section Summary: School built environment

- There is strong, consistent evidence for the effect of basic physical variables (air quality, temperature, noise) on learning.
- Once minimal standards are attained, evidence of the effect of changing basic physical variables is less significant.
- There is conflicting evidence, but forceful opinions, on the effects of lighting and colour.
- Other physical characteristics affect student perceptions and behaviour, but it is difficult to draw definite, general conclusions.
- The interactions of different elements are as important as the consideration of single elements.

The physical environment of the classroom

Summary table 3: Physical environment

	Furniture and equipment	Arrangement and layout	Display and storage	ict
Attainment	Comfort– better attitude – attainment	Arrangement affects young children’s learning; Time on-task changes, which should affect attainment		Key predictor of performance (one study)
Engagement	Comfortable children more on-task; Might need guidance with use of ergonomic furniture	Rows and time on-task; Action zone; Horseshoe arrangement– more questions	Accessibility–more learning time	
Affect	Dislike of standard furniture; Preferences for ergonomic furniture expressed	Rows–fewer negative interactions with teacher–improved attitude; Beautiful room_ more positive attitude, more student participation	Accessibility–more learning time	
Attendance				
Well-being	Back ache (though other factors involved)		Display and open shelving linked to dust and allergens	Lighting and ergonomic problems with work spaces

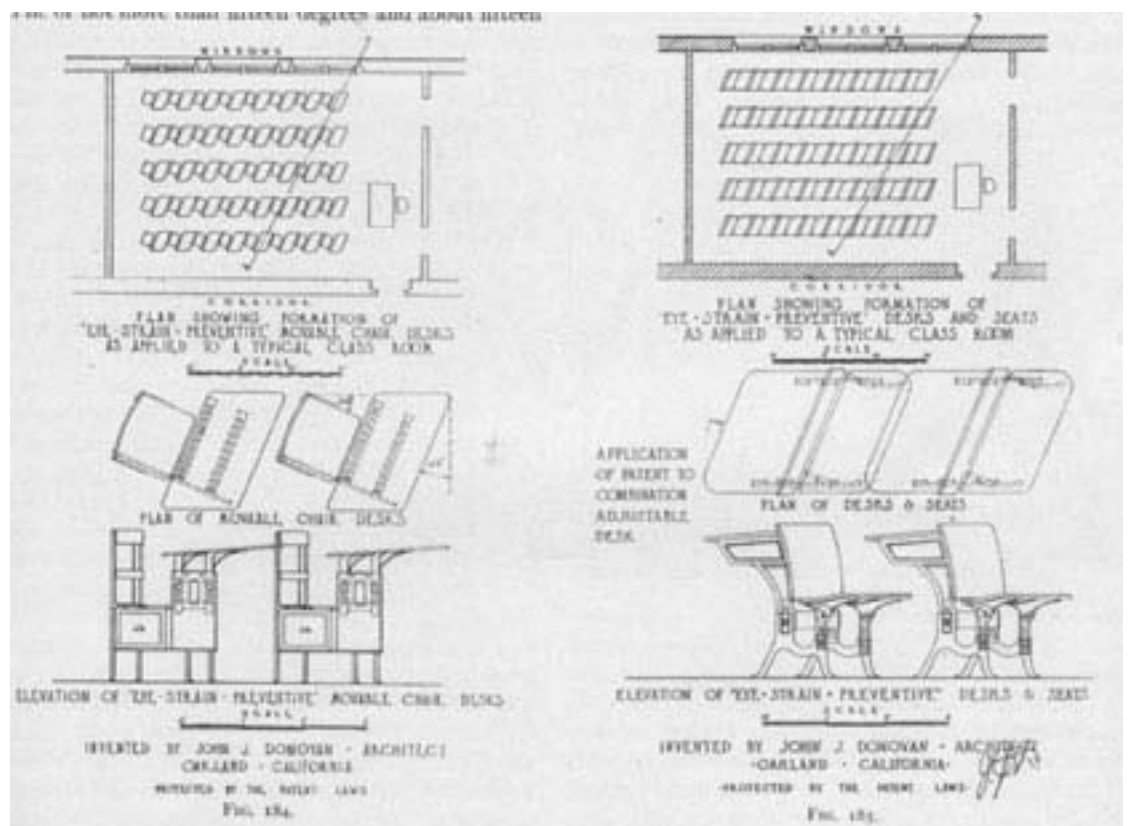
Although Talton and Simpson (1987) comment that ‘The classroom is the basic structural unit of our educational system’, the nature of the classroom is clearly affected by the school design and objectives adopted at the school level. Moos’ (1979) model of the learning environment includes ‘school context’ as a factor affecting ‘classroom climate’, but he argues that the classroom is the appropriate level to observe and evaluate. There is reason to expect the classroom environment to affect behaviour: Maslow and Mintz (1956) found that participants in an ‘ugly’ room made significantly less positive judgements about photographs than did the participants doing the same task in a ‘beautiful’ room. In an American college in the 1970s, Sommer and Olsen (1980) found that a renovated room, including soft furnishings and designed to be more friendly and attractive, seemed to increase student participation. They report that student participation rates in discussions and in asking questions during classes were ‘two or three times as high’ (op.cit, p.13) as in comparable classes taught in traditional rooms.

However, it is difficult to extrapolate from these observations to identify requirements for a school classroom. Rutter’s (1979) pupil conditions scale attempted to measure student working conditions and was positively related to exam success. In Heshong’s (2003) study, teachers were reported to desire more space, a good location and quiet environment, and have lots of storage and water in the classroom. Teachers preferred classrooms with windows, daylight and views, but these were not a top priority. It is worth noting that much research on open offices suggests that employees find them unsatisfactory (Brennan et al., 2002), which might be relevant given that in many ways a secondary school classroom resembles an open office, in particular the lack of personal, or personalised, space.

Furniture and equipment

The examination of ergonomic seating and positioning has been well researched in the workplace, but it has tended to be ignored in classrooms (Yeats, 1997). However, some children contributing to *The School I'd Like* (Burke & Grosvenor, 2003) mentioned inadequate furniture and there is some literature relating to classroom furniture (eg, Aagaard-Hansen and Storr-Pauben, 1995; Marschell et al, 1995). Given the difference in size between school children, adjustable furniture might seem sensible (suggested by Zandvliet & Straker, 2001) and in fact has been advocated for some time: Donovan (1921) has a design for an adjustable desk and seat (Figure 9). However, any observation in schools demonstrates the failure of such ideas to become accepted wisdom. here is the potential for this to change if, as has been suggested, adjustability forms part of the European Standard on School Furniture which is due to be published at the end of 2004.

Figure 9: Design for adjustable seating (Donovan, 1921)



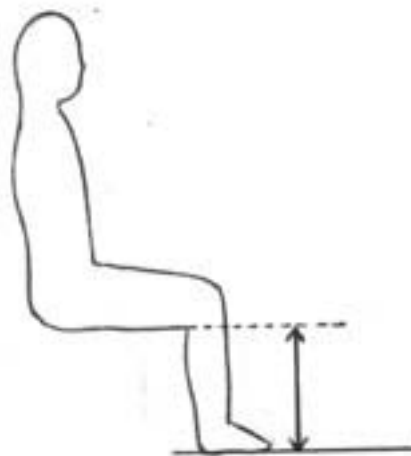
Knight and Noyes performed a study on classroom furniture in relation to children's behaviour and sitting positions between traditional classroom furniture and ergonomically designed furniture. They found that children showed a 'significant improvement in on-task behaviour and a marked change in sitting positions following the introduction of the newly designed furniture' (1999, p.747). In relation to sitting positions, Linton et al (1994) did not observe any different sitting positions in the children in their study when using ergonomically designed furniture. The children did comment that the ergonomically designed furniture was more comfortable, as did children in a further study conducted by Troussier (1999). Linton et al.(1994), however, suggest that students need guidance on proper use of ergonomically designed furniture.

Troussier (1999) also investigated levels of back pain when children use traditional classroom furniture and ergonomically designed furniture; however, it was concluded that there was no significant difference in prevalence of back pain. It has been argued that back pain does exist among school children (Murphy et al, 2004) but some researchers emphasise that back pain is not solely due to inappropriate classroom furniture but that other factors are relevant (Troussier et al, 1994; Grimmer & Williams, 2000). A major factor that has been highlighted is gender (Parcells et al, 1999), with girls more likely to experience back pain than boys. Milanese & Grimmer (2004) argue that the taller the student, the more likely they are to experience back pain.

From the literature that has been reviewed for this report, it can be concluded that, overall, there is preference for the ergonomically designed furniture in the studies (Troussier, 1999; Marschell et al, 1995; Panagiotopoulou et al, 2004; Yeats, 1997).

Molenbroek et al, (2003) argued that the design of classroom furniture should be based on the student's popliteal height (see Figure 10) rather than body height. A study which used this idea and took anthropometric measurements of students' body dimensions (Parcells et al, 1999) concluded that there was a substantial degree of mismatch between student's body dimensions and furniture that they use. Such a mismatch was also found by Panagiotopoulou et al (2004).

Figure 10: Diagram showing popliteal height



A further issue that relates to physical discomfort, and which could be solved through design, is that of students carrying books and equipment. Periodically, concerns are raised about students carrying too much and sometimes lockers are installed to minimise the problem.

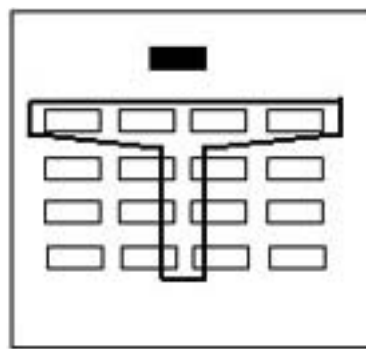
Interestingly, this is another argument with a long history: Rivlin and Wolfe (1985, p.123) relate how it became an issue in the New York mayoral elections of 1917.

Arrangement and layout

One of the more basic variables that can be altered in the classroom is the arrangement of the students' desks and chairs, and this issue has been quite well researched and debated by educationalists. Rows of desks are considered to be appropriate to individual work and increase time on-task (Galton et al, 1999). The research which specifically compares rows and tables (Wheldall et al, 1981; Wheldall & Lam, 1987; Hastings, 1995) suggests that less attentive and

less successful pupils are particularly affected by the desk arrangement, with their on-task behaviour increasing very significantly when seated in rows instead of at tables. It is pointed out by these authors that the vital mediating element between the physical environment and improved classroom climate could be the reduction in negative interactions between teacher and student, since the student in the rows arrangement is able to concentrate and so provokes fewer admonishments. This plausible chain of events has relevance for any alteration to the physical environment.

Figure 11: Action zone radiates away from the teacher.



Within the rows arrangement, there seem to be differences in student involvement dependent on position, with an ‘action zone’ of increased involvement across the front and down the middle of the room. There is some discussion about whether this is more accurately characterised as a ‘T’ shape or as a triangle (Marx et al, 2000) but there is agreement about the existence of such a zone (see Figure 11 above). This is observed even with the random allocation of seats (Gump, 1987; Weinstein, 1979) and Moore and Glynn (1984) found evidence that the differences originate in the questioning and attentiveness of the teacher rather than the students’ behaviour.

To allow for the possibility of group work, primary school children are mostly sat around tables, although McNamara and Waugh comment that ‘group size often seems to be determined by the furniture and its arrangement’ rather than by ‘educational or pedagogical considerations’. (1993, p.44). They go on to recommend a ‘horseshoe’ formation where students can see each other and the teacher. This arrangement is also commended by Galton et al (1999) and Alexander (1992). Although Horne-Martin (2002) argues that it is a very controlling and teacher-dominated approach, Marx et al. (2000) found that more questions are asked by children when seated in this arrangement than when they are in rows.

Considering the classroom arrangement more generally, Nash (1981) found that the thoughtful organisation of an infant classroom to fulfil educational aims instead of for organisational convenience, facilitated learning and enhanced cognitive development. In a similar study, Moore (1986) argues that the arrangement of pre-school environments seems to affect behaviour. Loughlin and Suina argue that the arrangement and positioning of material is a ‘tool to support the learning process’. (1982, p.xv).

Especially within more open classrooms, concerns about privacy are sometimes voiced by children (Rivlin & Rothenberg, 1976). Ahrentzen & Evans (1984) argue that teachers could help by arranging furniture to produce private areas. However, they also found that an increased number of such places in a classroom seemed to coincide with the children being less satisfied with provision of privacy.

Display and Storage

Loughlin and Suina (1982) discuss how the storage and arrangement of materials can be underestimated, but argue that the methods used affect how, and whether, items get used and are returned afterwards. It is argued that accessible, well thought out storage leads to more time spent learning (Gump, 1987; Loughlin & Suina, 1982). It must be noted, however, that the tendency to provide lots of accessible storage and plenty of display space (advocated by eg, McGonigal, 1999) may conflict with demands for better indoor air quality since such fixtures will harbour dust. Nonetheless there is generally a feeling that display of children's work is beneficial, with all users of the school studied by Maxwell (2000) agreeing that display of students' work made the school more welcoming. Although Alexander does question the wisdom of displays being pursued as 'ends in themselves' (1992, p.38), and Dudek (2000), with an architect's eye, sees the display of children's work as making the visual aspect 'cluttered', other writers argue that they increase feelings of ownership and involvement, leading to improved motivation (Killeen et al, 2003).

There are various ways of displaying students' work. McGonigal (1999) advocates giving each individual a personal space, while Killeen et al, (2003) argue for the importance of permanence, with children's artwork actually incorporated into the fabric of the school. They found that in a school which achieved this through extensive tiled murals, children were considerably more positive about the school, compared to pupils in a control school. However, this study only shows a correlation, not a causal link, between inclusive artwork and positive attitude. Interestingly, Maxwell's (2000) study demonstrates that perception of the adequacy of display may vary between school users. She found that although the parents, teachers and students all appeared to appreciate the display of work, the adults thought the school achieved this while the students were less satisfied.

Figure 12: Display and storage are important considerations in schools (photo from Dudek, Architecture of Schools, 2000)



ICT

One of the four key predictors of student performance in the building assessment scale of Tanner (2000) was availability of technology for teachers.

Computers in the classroom are a powerful educational tool and their use is becoming more widely available in schools. However, the suggestion that, as currently used, computers might be interfering with such learning is made in a recent report by Fuchs and Woessmann (2004). It is important, therefore, that computers 'do not override the important sociocultural, psychological and physiological human factors related to teaching and learning'. (Zandvliet & Straker, 2001, p.839). They identify problems associated with computer use, which include lighting and problems with individual workspaces, and argue that ergonomically designed furniture in the computer classroom has a positive influence on the learning environment. It was found that these factors affected learning behaviour and cooperation, perhaps ultimately impacting on achievement.

There are important organisational and pedagogical considerations relating to the siting of computers and other ICT equipment within a classroom (Higgins and Hall, 2002), which suggest that the introduction of ICT must be 'owned' by the teacher and embedded within existing pedagogy. The contrast from early years settings between the 'box in the corner' on which children occasionally took turns and a computer in use in a role-play area for contextualised tasks is a telling one in this context. The introduction of interactive whiteboards (IWBs) is likely to have a substantial impact on teaching and learning environments in UK schools given the scale of the investment of over £50million between 2003-05, but while the advantages of the technology have been welcomed, there have been questions raised on two levels. In the first instance, IWBs have often been installed without reference to pedagogical considerations, making access, visibility and interactivity difficult (Lee, 2004). The second concern relates to the extent to which teachers are changing their approaches to teaching and learning to reflect the potential of the new technology, or are simply 'bolting on' a slightly more impressive display format to their existing delivery (Smith et al, in progress).

Section Summary: Physical environment in the classroom

- Much of what is known about student comfort, particularly in terms of furniture, has yet to be translated into actual school environments.
- Since different room arrangements serve different purposes, it is necessary for classrooms to have some degree of flexibility.
- Some improvements to environment may save time, which is then available for learning.
- 'Ownership' of space and equipment by both teachers and students is important.
- Ownership and engagement are ongoing elements, so there has to be a balance (in display of student work, for example), between permanent and fresh elements.
- Some physical elements in the classroom improve comfort, well-being and probably attitude - and so, perhaps, improve achievement.

Products and services

Summary table 4: Products and services

	Catering	Community involvement
Attainment	Healthy diet linked to cognitive functioning	
Engagement		
Affect	Considered important by children	May enhance social cohesion
Attendance		
Well-being		

Catering

Children contributing to The School I'd Like (Burke & Grosvenor, 2003) referred to the need for a dedicated canteen, greater variety of food, more time to eat and access to water. However, catering does not seem to be investigated frequently and the reason for this is suggested by Maxwell's (2000) finding that it was only the children who mentioned wanting a cafeteria in the school. Perhaps catering is an element that seems more important to the student users than to parents, teachers or school designers.

There is a gap of 20% between pupils who are entitled to school meals and the number of pupils who actually have them (Harvey, 2001). The reason for this needs to be addressed and school meals need to be more attractive to students. The Minimum Nutritional Standards which came into effect in April 2001 state that menus on offer in schools should offer a balance and variety. The facility for drinking water in schools should also be more available. Walters & Cram (2002) argue that fresh, clean drinking water is essential to maintain good health, especially in children. Harvey (2001) states that there are no drinking water facilities in almost 20% of schools.

Obesity is a major problem that is affecting more and more children. In order to overcome this problem, it has been argued that schools should address this problem by offering health education to both parents and students in an attempt to change their eating habits (Southern, 2004). Southern argues that schools should stock their vending machines with healthy options and provide daily physical education for all students.

The Healthy Schools Initiative (see Figure 13) is a scheme that encourages schools to adopt a whole-school approach to healthy eating and health promotion. It is important for the pupils to be involved in this scheme in order for it to work and this could be achieved through the medium of a SNAG (School Nutrition Action Group), made up of pupils, teachers and caterers. As well as the health benefits of eating healthily, Harvey has suggested that 'Increasing evidence is showing very positive links between children who are well nourished and improvements in teaching and learning; pupil attendance and behaviour; and marketing of the school in the community'. (2001, p.302). This link between good nutrition and cognitive ability has also been suggested by other researchers (Blades, 2001; Colquhoun et al, 2001).

Figure 13: The Healthy Schools Initiative aims to get children to think about what they are eating in schools (image from http://www.lifebytes.gov.uk/eating/eat_balance.html)



Community involvement, adult education and extra-curricular activities

These issues are linked by the idea of the school extending its function within the local community. That this is considered desirable is shown by a number of studies, which use observation of such community involvement as indicators of an improved school. Berry (2002) notes increased parental involvement and extra-curricular activities as evidence of the improvement observed in the school he studied and Bosch (2003) finds support for using extra-curricular activities as one indicator of school success. Moore and Lackney (1993) note the inefficiency of school buildings being closed much of the time while Clark (2002) argues that as well as making more efficient use of buildings, community involvement should benefit the school by enhancing social cohesion and reducing vandalism.

The Extended Schools initiative proposed by the DfES is about supporting schools that provide services and activities beyond the school day, to help meet the needs of the students, their families and the wider community. Craig et al. argue that 'to work successfully, extended schools have to become open institutions, alive and responsive to priorities, cultures and resources that lie

beyond the school gate”. (2004, p.5). The idea behind extended schools is that teachers, parents and professionals work together as co-workers. The extended school facility encourages parents and local people to become involved in their children’s education and offers them the opportunity to enrol on adult education courses themselves. The Extended Schools initiative offers different services from childcare to ICT access.

Recent reviews of the literature on extended schools note the diversity of provision (Wilkins et al, 2003; Cummings et al, 2003), although Wilkins et al comment that British initiatives tend to be more educationally focused while American projects emphasise the socio-economic aspect (p.3). The recent evaluation of Cummings et al concludes that extended schools “impacted on pupils, families and communities in a range of ways and generated positive outcomes for these groups”, but warns that such projects need good management, resources and planning. Additionally, this report suggests extended schools seem likely to interact with other initiatives, and this could ‘bring about a series of changes and ultimately generate ...ambitious outcomes’. (p.v).

Section Summary: Products and services

- Catering is important to children and may be linked to learning.
- Schools have a role both in the meals and snacks provided and with regard to the information about healthy living provided to students and their families.
- Extending schools into the community is considered desirable and seems beneficial.
- For schools, there are system and process issues relating to teachers having a role ‘beyond the classroom’.
- Community involvement is seen as both cause and effect of an improved school and can complement other initiatives.

Communication

Summary table 5: Communication

	Catering	Community involvement	
Attainment		Contribution suggested	
Engagement			
Affect	Link made by several authors		Getting lost is annoying and can be avoided
Attendance			
Well-being			

Within school

There is such a complex and extensive network of communication within a school, and within each learning situation, that analysis is difficult. While much literature in education and psychology addresses communication, this does not often refer to the relationship with the physical environment. On the other hand, research into the influence of the environment, while encompassing communication, does not always refer to it explicitly. Where it does, such work has tended to be included in previous sections. For example, there has previously been discussion of classroom decoration and arrangement, as well as the teacher's position within the layout for teacher-to-student and student-to-student interactions.

However, it seems appropriate here to highlight some general ideas. It is assumed to be important (by eg, Galton et al, 1999, p.40) that teachers are able to communicate effectively with pupils, although it is sometimes less certain how this should be defined. Moos's evaluation of classroom environment addresses this since subscales relating to teacher behaviour and classroom management (1979, p.141), such as 'teacher support' and 'rule clarity', clearly involve communication. A study of disruptive behaviour in a particular school (Badger, 1992) found that both pupils and teachers often explained problem behaviour in terms of failures of communication, with teachers advocating more discussion and improved relationships as ways to improve the situation.

In addition to student-to-teacher communication, other writers emphasise a desire to increase productive interactions between students (e.g. Zandvliet and Straker, 2001, p.842), which children themselves are reported to value (Ultralab, 2004, p.12). Such interactions, and so communication, will be influential in ratings using Moos's classroom environment evaluation, since they are important components of the 'involvement' and 'affiliation' subscales (1979, p.141). A final sort of communication within schools is that between members of the complete school staff, and its importance is suggested by the findings of Buckley et al (2004).

The contribution of effective staff communication to student performance is suggested by the inclusion in the rating scale of planning elements such as 'emergency preparedness', which would seem to rely on good communication. Communication is part of the community involvement issue, discussed above, but seems rarely to be specifically investigated. It has

been previously noted that the needs and perceptions of different users in relation to building design do vary. It could be suggested that improved communication has a role to play in understanding and accommodating these competing priorities.

It can be concluded then that communication between all parties is an important aspect of the success of a school. Furthermore, it is recognised that both the physical environment and organisational structures can influence communication. However, it is difficult to be precise, because of the complexity of the system, and important to avoid determinism, since people can, and do, resist the suggestions of their environment. On the one hand, for example, horseshoe arrangements of desks generally seem to increase pupil questions (Marx et al, 2000) and open-plan classrooms have been reported to facilitate teacher-to-teacher interactions and 'social support' (Ahrentzen and Evans, 1984, p.449). Yet, in contrast, Horne (1999) found a predominance of less interactional, more teacher-centred teaching in schools in Brazil 'regardless of the seating arrangements'. (1999, p.201).

Beyond the school

Another aspect of communication is that which goes on with parties outside the school. Effective communication has been highlighted as key to the improvement of schools in developing countries (Dalin et al, 1994), though in this case it is communication with government and other authorities which is being suggested. More generally, communication with those beyond the school building is an issue referred to in the education literature, but again without necessarily examining the setting that may facilitate it. For instance, in his study of disruptive behaviour, Badger (1992) found that teachers often mentioned that there was a need to improve relationships with parents, while others (eg, IDEA, 1970) argue for the importance of involving parents and the wider community in school design.

Such intentions clearly involve more communication and are involved in the general issue of the school's place in the wider community, which has already been considered. However, sometimes the relationship with the community is approached specifically by considering the impression of the school that is being communicated to the community. Schools sometimes create new identities, featuring redesigned uniforms, logos, websites and sometimes even new names. These re-branding exercises are generally perceived as successful by those involved, but they are rarely rigorously evaluated and there can be problems in sustaining the effects.

Signage

There are reasons to consider clear signage to be important and some indications of how to achieve this (Evans, 1980). Furthermore, a 'clear organisation (and) an easily legible plan' is considered an important design principle (CABE, 2002, p.8). However, there is a lack of research specifically into school signage and navigation.

Some work in developmental psychology, which might be seen as relevant has considered how children build up cognitive maps, finding that young children seem to be more dependent on functional definitions of places (eg, 'the road to the sweet shop') and so learn more about their surroundings through functional use rather than mere observation (Heft & Wohlwill, 1987).

The limited work that has considered signage in contexts other than schools has generally been more practical and designer-led, rather than experimental. However, some consistencies do emerge with implications for signage in school buildings. It is pointed out (Canter, 1984; Garling et al, 1986) that signage is often required because other design elements are inadequate. These writers argue that buildings can be planned to be more navigable, through the use of salient features and landmarks and a high level of differentiation between different parts, together with less 'complexity' (Garling et al, 1986) or, perhaps more precisely, a design that

can be transformed into the ‘relatively simple geometric forms’ favoured by humans’ mental maps (Canter, 1984).

Section Summary: Communication

- Effective communication is part of involving users and extending schools into the community.
- Good communication within a school seems to be part of creating an environment that is conducive to success.
- Schools as communicators in the community have dual, not necessarily compatible roles: presenting themselves positively and promoting links with, and understanding among, with parents.
- Navigation is improved by landmarks and distinctiveness.

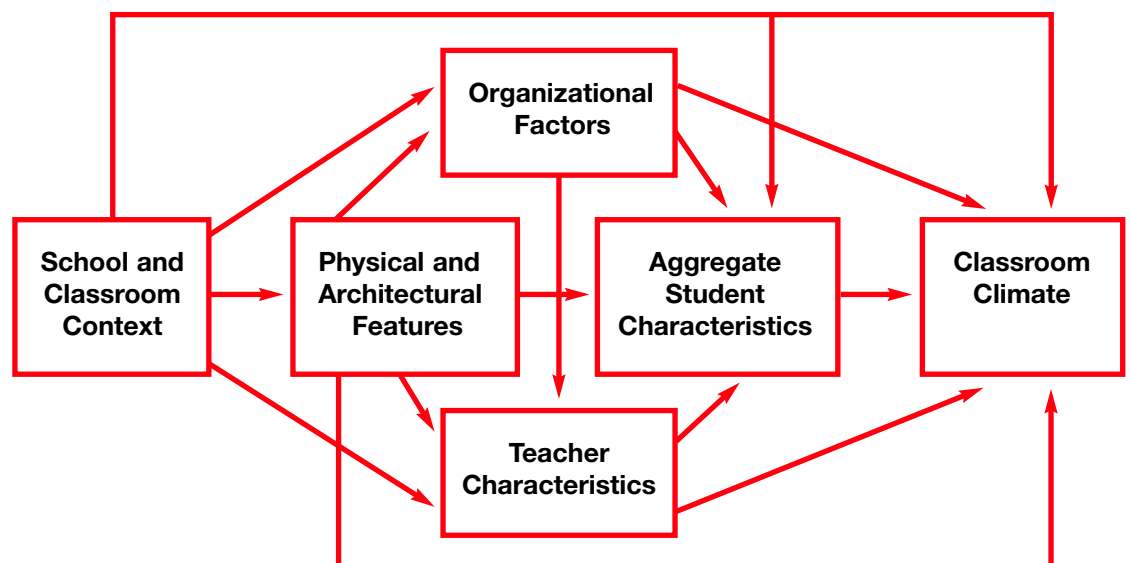
Conclusions and recommendations from the literature review

Our exploration of the impacts of changes in the physical environment on cognitive and affective measures must be based on an understanding of the complexity of schools. Schools are systems in which the environment is just one of many interacting pedagogical, socio-cultural, curricular, motivational and socio-economic factors.

When considering the literature, the underlying issue is the question of just how the environment is supposed to have effects on its users. Clearly this is not a simple matter of architectural determinism. The experiences of open-plan schools and offices demonstrate this and the active role of human beings is emphasised by environmental psychologists (eg, Gifford, 2002). So the relationship between people and their environment must be complex and therefore any outcomes from a change in setting are likely to be produced through an involved chain of events. It is the defining and understanding of these mediating chains that is key.

Moos's (1979) model of the factors affecting 'classroom climate' (see Figure 2) is an attempt at a general model, which he points out is simplified by the use of uni-directional arrows despite the fact that causal influence can in each case work in both directions. However, it is reasonable to suggest that positive changes, selected by the teachers and learners, might tend to beget further positive changes in a 'virtuous cycle', whereas negative elements might cause a vicious cycle of decline. Externally imposed changes, regardless of their merit, might be expected to have less of an effect than changes brought about through genuine consultation and the design process.

Figure 14: Moos's (1979) model of the determinants of classroom climate



In trying to envisage the detail of how these causal influences might work, it is helpful to remember examples such as the proposal that certain seating arrangements or positions might lead to more positive student attitudes, through the mediating factor of a reduction in negative interactions with the teacher (eg, Wheldall et al, 1981) or an increase in positive interactions (Moore & Glynn, 1984). Another mechanism commonly suggested is that of time saved through, for instance, classroom organisation (Gump, 1987; Loughlin & Suina, 1982) or reduction in external noise (Weinstein, 1979), which can be used for learning. Conversely, a distinctly poor environment might lead to absence through ill-health (Earthman, 2004) or alienation and truanting (Hallam, 1996), and so a reduction in learning time.

Additionally, many authors propose a direct link between the environment and student attitudes through the values and assumptions implied by a particular setting. Many writers note the negative effect of poor surroundings with, for example, Hallam arguing that neglect of the school building 'will inevitably pervade the attitudes of staff and pupils.' (1996, p.120). Given

this, some projects aim to improve attitudes, and perhaps ultimately achievement, by using the building to convey ideas about valuing the students. For example, the Head Teacher at a recently opened flagship school asserts: 'This is more than just another school in Hackney: it is a symbolic school, an emblem, saying these places should be where children from all backgrounds in inner city areas should come and be successful.' (*The Guardian*, 14 Sept 2004).

In her review of the effects of the physical environment in education, Weinstein was quite cautious about effects on student achievement. She concluded that although the 'weight of the evidence suggests that design features can have a significant influence on students' general behaviour...and on their attitudes' (1979, p.584), it is difficult to find reliable evidence of a definite effect on achievement. She points out, however, that the 'more positive attitudes and behaviours may eventually result in improved achievement.' (op cit, p.599). More recent reviews have tended to be more optimistic about positive evidence for direct as well as indirect effects of the environment (see, eg, Moore & Lackney, 1993). Yet many of these effects seem to be observed as deficits in performance in schools with poor environments (eg, Schneider, 2002; Young et al, 2003).

A recurring question is the extent to which the physical school environment needs to be any more than adequate. Earthman (2004) concludes that while inadequate school buildings cause health problems, lower student morale and contribute to poor student performance, he is not convinced that schools need necessarily be any more than adequate. Rutter, who found no relationship between physical environmental factors and a range of learning and behavioural outcomes, comments that, 'It was entirely possible for schools to obtain good outcomes in spite of initially rather unpromising and unprepossessing school premises'. (1979, p.178). Stricherz points out that, 'Research does show that student achievement lags in shabby school buildings... but it does not show that student performance rises when facilities go from the equivalent of a Ford to a Ferrari—from decent buildings to those equipped with fancy classrooms, swimming pools, television-production studios and the like.' (2000).

Yet, as a number of writers argue (eg, Young et al, 2003; Moore & Lackney, 1993), the built school environment can be altered and is open to improvement so that, even if such changes only make a small and uncertain difference to performance, they can be morally defended, particularly in schools where the students are disadvantaged in other less immediately alterable ways. Interestingly, Gump urges that 'change, for its own sake, can be a stimulating experience.' (1987, p.703). This comment returns us to the potential catalytic effects of the design process, since without planning and design there is a tendency to be unreflectively conservative. As Rivlin and Wolfe comment, 'It is rare for a person to move a chair once it has been placed – even in one's own living room'. (1985, p7).

Indeed, what becomes clear from this review, is that the design process has the potential to animate the various elements of the design grid (Figure 1), encouraging all of the stakeholders to inform the change as an iterative process. When environmental change fails to change teachers' and learners' behaviour, this may well be because issues of communication have not been addressed and systems and processes have, therefore, failed to adapt to meet the change in the environment.

Clear evidence of effect

Physical elements in the school environment can be shown to have discernible effects on teachers and learners. In particular, inadequate temperature control, lighting, air quality and acoustics have detrimental effects on concentration, mood, well-being, attendance and, ultimately, attainment. According to the Ofsted 1999-2000 Annual Report, a quarter of secondary schools fail to conform to standards and regulations in these areas. Beyond the level of meeting basic standards, there is not enough evidence to give clear guidance on how to set priorities for funding, or to evaluate the relative value for money of different design initiatives. Moreover, once provision

reaches a reasonable standard, the complexity of environmental interaction comes into play. An attempt at improving acoustics in a classroom, for example, by deadening echo noise through the use of hangings, may actually decrease the air quality, through increased dust and allergen particles being held in the fabrics.

What is clear from this review is that while much of the evidence is inconclusive, this is because design problems tend to be rooted in their own particular contexts. In interpreting this evidence we must be aware of both the inadequacy of a research paradigm which seeks to generalise to multiple sites and of the limitations of a design agenda which promises a single solution for multiple futures. The evidence is unequivocal with regard to the importance of user engagement in defining and solving design problems in schools, and a necessary consequence of this is the realisation that design solutions will be individualised, organic and local. Indeed, the most successful are likely to be those which are seen as interim solutions and which have within them elements of flexibility and adaptability for new cohorts of learners and teachers, new curriculum demands and new challenges.

More research is needed about the effects of the design process on teachers' and learners' locus of control with regard to other aspects of school life: there is an implication in many studies that the empowering process of re-designing and taking ownership would spill over into motivation and empowerment in other areas, encouraging creativity and experimentation in the curriculum, raising motivation towards academic and social goals. However, there has been limited longitudinal work looking at the positive effects of change, although there is an emerging literature on the negative impacts of externally generated curriculum and pedagogical change (eg, Angus, 2004, Fisher, 2004, Rossides, 2004). A further area for development is an investigation of the different ways in which the design process is managed and a greater engagement with understandings of involvement, consultation and partnership.

The recommendations of the reviewers are that:

- Policy makers summarise the lessons of the past for various audiences: architects, designers, construction firms, LEAs and teachers as well as the wider public audience
- Environmental considerations should be embedded in teacher education and in school management training, so that these important elements are not relegated to the 'background noise' of educational discourse
- Further empirical investigation should be carried out into key elements which are insufficiently covered in the research literature
- The design process must be the focus of environmental change in schools, so that teachers and learners might experience motivational and perspective-changing benefits beyond the specific problem-solving
- Environmental improvement in schools should be locally driven, user-led and embedded in pedagogy
- Investment in change should be seen as an iterative process, rather than a five-year programme to cover the needs of a subsequent generation. Building Schools for the Future pre-supposes a commonly held view of what the future will look like: unless this is generated collaboratively and implemented flexibly, there is a significant risk of expensive failure.

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