Learning from the past to identify and respond to the new challenges facing architectural science

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ABSTRACT: The strengths and weaknesses of architectural science research from the 1960s to the present are evaluated to identify necessary changes in goals and techniques as a response to new challenges and design directions. The traditional approach of simple, carefully-controlled studies with a concentration on physical and physiological issues treated different sensory modalities as being independent and largely ignored people’s psychological interaction with their environment. Resultant problems, such as the sick building syndrome, are discussed and on this basis it is argued that architectural science is ill-prepared to adequately research people’s interaction with the more natural environments that are an inevitable outcome of design philosophies embracing sustainability and minimal impact on the external environment. Architectural science needs to recognise and research the complexity of people’s interaction with the sensory world and this should be tackled as an essential element of research relating to the adoption of low-impact strategies. Very recent neurophysiological research findings concerning interaction between sensory modalities are discussed and their implications explored as part of an examination of this new research challenge.

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INTRODUCTION
The statement was made in the published information about this 40th Architectural Science Association Conference that, referring to architectural science research, “the focus has shifted from protecting the people to protecting the environment”. The statement may have been intended to be deliberately provocative and this paper may be seen as rising to the bait (although it might be more sympathetically seen as opening debate rather than rising to it). It is not intended to argue that the statement is wrong; it may be a very accurate summary of what is starting to happen in many architectural scientists’ research philosophies and strategies. Rather, the intention is to express concern at the issues which are, by implication, ignored or overlooked by such philosophies and strategies (and this may include not only their newly-developing philosophies and strategies but also the ones which are being superseded).

Much of the architectural science research undertaken in the second half of the twentieth century had a more positive goal than simply the “protection” of the inhabitants of buildings from the more adverse elements of the natural environment. A significant part of the research also sought to enhance people’s experience of the interior environment of their buildings. Particular emphasis was placed on thermal and visual comfort, together with some concerns about air quality and (to a much lesser extent) other sensory aspects of people’s interaction with their environment. However, there were significant weaknesses in this positively-themed research, mainly due to a concentration on physical and physiological issues and little concern for (or, perhaps, little ability to include a concern for) the psychological aspects of people’s interaction with their environment. But some researchers did at least try. The researchers also developed an interest in energy efficiency, although the application of the outcomes to the design of buildings, while good for energy conservation, was often to the detriment of people’s psychological interaction with their environment. Energy efficiency as a research theme comfortably embraced and was then subsumed by the broader issue of sustainability, and this latter research interest has seemed to offer a better opportunity to re-introduce a psychological element into the study of people’s interaction with the interior environment alongside the more explicit concerns for conserving material and energy resources.

Sustainability has had a key role to play in any transition from concern about protecting the people to concern about protecting the environment. However, the transition is a major one – ironically including a change of interest from the interior environment of buildings to the natural environment from which people were originally to be “protected” – and it is not clear whether or not it will enable a complementary, positively-themed research interest to be carried with it. The remainder of this paper will explore this topic, principally by reviewing the recent history of architectural science research, to avoid letting any adverse aspects of that history be repeated while promoting those aspects which have been successful. It will also explore very recent developments in architectural science, particularly those with an interdisciplinary flavour, to ensure that these are not lost in any transition to a focus on protecting the environment.

1. PROTECTION VS ENHANCEMENT

1.1. Protecting the interior environment
Building construction has a long history of simultaneously protecting both the inhabitants of interior environments and also the exterior (sometimes, but not always, natural) environment. This can be seen in the shelters built by many,
so-called, “primitive” societies. A contemporary architectural counterpart would be the work of sensitive architects such as Glenn Murcutt. It can also be seen, in another sense, where the design of the fabric of a building enables it to act as a filter, not only to prevent or reduce the impact of adverse features of the natural environment but also to prevent or reduce any impact on the area surrounding the building from the activities undertaken within it. This can be assisted by regulation; for example, where a neighbourhood is protected from the noise of a suburban indoor sports facility, or from spill light from an outdoor sports venue or other community amenity. An extreme example would be the design of a nuclear power station to protect the surrounding areas from radiation and (at least reduce) the impact of any accident. With the probable exception of such extreme cases, the protection afforded to the exterior environment does not necessarily compromise enabling the protection of interior environment to be complemented by measures intended to also enhance the inhabitants’ experience of that interior environment. (Why this has not been entirely successful will be discussed in the next chapter.)

1.2. Protecting the exterior environment

For the purposes of this discussion, it will be assumed that the term “exterior environment” excludes any deliberately designed spaces which are outside a building but associated with it and which act as a form of “outdoor room” which is also given some measure of filter-type protection from adverse aspects of the microclimate such as wind, rain and strong sun. An exterior environment could be a truly natural environment or an urban neighbourhood. At either end of this range of possible exterior environments (or anywhere within it), it is difficult to conceive of a way in which that environment’s protection could be accompanied by some form of designed enhancement; the concept of protection of an environment seems to be strongly tied up with that of having a minimum impact, and that in turn seems to preclude the possibility that any “enhancement” could be acceptable.

If this argument is valid, we can note a significant distinction between “protecting the people” and “protecting the environment”. The first of these can be accompanied by a design intention to enhance the interior environment as experienced by its inhabitants while for the second it would not only be meaningless but also a contradiction in terms. What we might hope for is that the focus on protecting the exterior environment does not preclude enhancing people’s interaction with the interior environment. Ideally the two should be conjoint goals of research. The history of architectural science suggests that this is unlikely to be the case, but at least we have that history to forewarn us. If we can heed the warning, the outcome might be more richly rewarding.

2. INFLUENCES AND OUTCOMES OF ENVIRONMENTAL RESEARCH

2.1. Influences

In a critique of a recommended strategy for energy conservation in the United Kingdom following the energy crisis in the 1970s, Cooper (1982: 244) contended that

…developments in building science and design practice … have led to the creation of a narrow concept of what comfort means to people in buildings – a concept which fails to encompass the plethora of features which may render internal environments acceptable or unacceptable to those who use them…[W]hen applied in practice, this limited concept of comfort has resulted in the construction of a demeaning and dehumanised specification of the relationship which should exist between people and the buildings they occupy.

Cooper argued that this outcome was based on a combination of economic reasoning and an engineering model of thermal design that was derived from building science. The counterpart to this “engineering” approach was one which would enhance the environmental experience of building occupants by focussing on the generation of satisfaction, pleasantness and delight, of which the best known proponent was probably Lisa Heschong (1979).

The most significant components of the thermal comfort research criticised by Cooper had been completed before the energy crisis (e.g. Fanger, 1972) so we need to look back further for influences on this work. Part of the responsibility for this situation might be the dictum expressed by Sir William Thomson (later to become Lord Kelvin) which was frequently quoted by architectural scientists in the 1960s and 70s. Thomson (1889) wrote

When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind: it may be the beginning of knowledge, but you have scarcely in your thoughts, advanced to the stage of science, whatever the matter may be.

For architectural scientists wishing to establish the credentials of their relatively new discipline (particularly in the UK and possibly in Europe), this or similar statements by scientists held in high esteem must have seemed like very good guidance to follow. But there had been other voices. In the related area of visual comfort, also studied under laboratory conditions, Petherbridge and Hopkinson (1950) had written that their studies

…were directed more towards an extended knowledge of the relationships between the various physical factors which govern discomforts of these factors associated with any specific degree of discomfort. The results are therefore not a substitute for experience in lighting practice, but serve more to assist the quantitative interpretation of this experience.

And yet their results, with successive modifications as to how they are combined into a ‘glare index’, have come to be used by some lighting designers as just such a substitute. Petherbridge and Hopkinson had proposed, to their credit, that any further studies should have an interdisciplinary base, with at least a psychologist joining the research team, but it seems that this never eventuated.

2.2. Potential influences

There were other, potential influences which were noticed only by a handful of researchers and which therefore had little impact at the time. Nevertheless, these are still pertinent (and in some cases have an increased significance in the light of recent research findings). It is useful in the present discussion to record representative examples of these potential influences. One of these may also help explain why so few researchers noted these comments at the time. This particular example is, in fact, a number of contributory comments, books and papers by the mathematician Alfred North Whitehead who also developed strong interests in other areas such as philosophy and education. In the Lowell
Lectures of 1925, published as *Science and the Modern World* (Whitehead, 1926), he comments on the professionalising of knowledge and the training of professionals (p.244)

“...who specialise in particular regions of thought and thereby progressively add to the sum of knowledge within their respective limitations of subject.

By “professional” he is referring to both researchers and practitioners in all fields of knowledge, rather than the more limited definition of the professions we currently use. While Whitehead acknowledges that effective knowledge is “professionalised knowledge, supported by a restricted acquaintance with useful subjects subservient to it”, he sees a danger here in the weakness of the professionals outside their own subject area. He writes that it “produces minds in a groove” with each profession making progress only in its own groove, with that groove preventing “straying across country”. He sums up the effect on society as being that (p.245)

“...the specialised functions of the community are performed better and more progressively, but the generalised direction lacks vision. The progressiveness in detail only adds to the danger produced by the feebleness of co-ordination.

While this might explain why researchers and practitioners in other professions have either been unaware of or not heeded this warning, the message has a particular significance within architectural science and the architectural profession as a whole, given the wide range of contributing disciplines and subject areas. The range of environmental subject areas and their corresponding professional consultancies (in thermal design, lighting, acoustics, mechanical services, materials science, etc; together with the further subdivision of most of these) has weakened the overall co-ordination in both research and practice to the extent that it is no wonder that we fail to take due account of the way in which the people who inhabit buildings might integrate all of the corresponding sensory inputs in forming their overall psychological response to an interior space. Specific failures of note include the Sick Building Syndrome (SBS), where the role of people’s overall psychological response to a space or a building as a whole is still not recognised by most professionals (of the contemporary kind) and the proposed problems and solutions continue to be seen to lie within single subject areas (most notably, indoor air quality). A growing awareness of the importance of people’s integrated sensory response to their environment and the need to research the extent and nature of this integration will not be helped by a research model and associated research techniques which largely fail to recognise the existence of such integration.

Further potential influences can be found which relate to issues of subjective appreciation and of cultural differences which need to be taken account of in environmental research and design. As one example, Hall (1969) discussed the important role that the history of art can play as a chronic of the development of people’s perception of their world and of the cultural differences that can arise. Art reveals that some people still exist in a sense-rich environment, while for others this is no longer true. Whether this perception is shared by all people, including architects, in a given culture at any particular time has been called into question. The British architect Sir John Soane (1753-1837), in the eighth of a series of lectures to the Royal Academy (Watkins, 1996), lamented the failure of fellow architects to employ the hidden light sources often used by French artists to light their studios. The reason he found for this was (p.598)

“...that we do not sufficiently feel the importance of character in our buildings, to which the mode of admitting light contributes no small part.

Earlier in the lecture, he described the use of solar radiation to warm rooms in ancient Greece and Italy but declared (p.596)

“...that this mode of warming rooms might suit hot climates and ancient customs, but in England it is not sufficient that our houses are well warmed; we must see the fire, or no degree of heating will satisfy us.

Soane’s approach to the use of fireplaces for building heating probably contributed in “no small part” to the growing pollution problems in London, and would hardly be acceptable in contemporary design if there was a focus on protecting the environment, but his statement provides excellent examples of psychological aspects of heating and of potential cultural differences derived from climatic experience and associated traditions. Such differences (explicitly denied in the published outcomes of Fanger’s (1972) research on thermal comfort) need to be given careful consideration, not only because of the international experience of contemporary research findings but also because of the more culturally-mixed communities which are emerging in many countries.

2.3. Outcomes

Much of the research undertaken in the name of architectural science over the last 30–40 years has been reductionist in nature. In much of such research project it has sought to examine a narrowly-defined aspect of architecture under carefully-controlled conditions in terms of a research paradigm derived from the physical sciences. The strongest case to justify this approach would probably be a perceived need to obtain consistent, quantifiable results, following Lord Kelvin’s dictum, discussed earlier. Another decisive factor would have been that research projects which have clear and uncomplicated goals and which are likely to produce determinate, reproducible and on-time results have a much better chance of receiving funding. This approach necessarily ignores (or assumes to be insignificant) any interactions between the chosen narrow aspect of architecture and any otherwise-related aspect(s); and the effect of this has been greatest in respect of research into people’s perception of and interaction with their environment. As a result, design guidelines based on this research have been largely restricted to physiological and physical factors related to simplified notions of, say, comfort and performance. Psychological factors have been excluded and any attempt to provide guidelines in this area has sometimes been of questionable validity. In particular, the omission of psychological factors has prevented any offering of research-based advice on how to enhance people’s experience of the environments that are shaped by buildings.

Possibly the best example of this has been the extensive simplification that was undertaken in much of the research carried out in response to the sick building syndrome. (It may even, eventually, be demonstrated that the sick building syndrome was an inevitable consequence of the application of research findings derived from the type of studies described in the previous paragraph.) Initial studies of sick buildings indicated a strong psychological factor contributing to the syndrome, leading to a potentially very complex research situation. However, an overwhelming majority of research undertaken in the name of the sick building syndrome was focussed on indoor air quality (which
is much more amenable to traditional architectural science techniques), to the extent that, in many publications, the sick building syndrome and indoor air quality became virtually synonymous. Nevertheless, the main problem with “sick buildings” has remained a combination of a tightly-controlled, non-stimulating environment with behavioural constraints on the occupants as they might try to overcome this, all in the interests of energy-efficiency.

Furthermore, the problem did not stop there, but was potentially aggravated by the approaches developed over the last 20 years to produce buildings in which a supportive intelligent environment could enable an organisation to best achieve its business objectives (Duffy, 1988; Harrison et al, 1998). In a paper to the ANZAScA 2000 conference (Willey, 2000), it was suggested that, by comparison with a typical building displaying the sick building syndrome, …not only does the typical intelligent building share the goal of energy efficiency in the design of its fabric and its electromechanical systems, it also includes a goal of optimising spatial organisation in the interests of enhancing the business performance of its occupants. While the first of these might constrain occupant participation in the control of the interior environment, the second may impose additional constraints on furniture layouts and other ways in which people might wish to personalise their working environment. While lessons learnt from investigation of the sick building syndrome may prevent a recurrence of the physiological symptoms … the psychological effects of behavioural constraints may be exacerbated.

It was suggested that the occupants might succumb to what could then end up being called the “Intelligent Building Syndrome” (IBS).

3. A SOLUTION SPACE

3.1. Stereotype forms of environmental design

Staying, for the time being, with a discussion focussed on offices, it is possible to construct a matrix on which could be plotted the coordinates of stereotype forms of the environmental design of office buildings in terms of two axes: one representing the extent to which the environment was controlled by either the filtering effect of the building fabric or by the input from mechanical plant; and the other representing the extent to which the building’s occupants could exercise or were denied personal control actions such as adjusting blinds and openable windows, adjusting thermostats and switching lighting on or off. Such a diagram was included in the author’s PhD dissertation (Willey, 1978) and a version of this, relabelled for clarity away from its original context, is reproduced as Figure 1. The diagram shows the archetypal cave and campfire, plus various forms of traditional or more recent building types. An example of the “deep-plan, heavyweight air-conditioned” building would be the Integrated Environmental Design (IED) building developed in the late 1960s in the UK with heavyweight fabric, deep plan, small “vision slot” windows, high levels of artificial lighting and full air conditioning required to cool the building for 11 months of the year (Page, 1970). This “solution space” revealed a region in which, at the time, no strong stereotype had yet emerged, although it was suggested by the author that explorations of possible forms were occurring in practice, involving less reliance on both energy-consuming plant and automatic control of that plant.

![Figure 1: Solution space for stereotype forms of environmental control](image)

Of particular interest, in the context of this paper, is the likely location on the matrix of any stereotype office building which either satisfactorily protected the people or protected the environment. Protection of the environment had not become a significant design issue by 1978. Satisfactory “protection of the people” would require some enhancement of their experience as occupants of the building, and we might anticipate that the criteria for this would include the
occupants having a significant level of involvement in the control of their personal work environment and that the building would be stimulating to work in. The latter expectation might be met more readily by “free-running” buildings that were more responsive to the variations in outdoor environmental variables, rather than by buildings with more static environments achieved by mechanical plant. The closest stereotype to this goal would be the traditional heavyweight building, with sufficient glazing area and a relatively high ceiling to provide a useful contribution of daylight to the interior lighting; openable windows for fresh air; and either a hot water system for space heating or perhaps a mechanical ventilation system delivering warmed air in winter. The shaded region in Figure 1 offered the tantalising opportunity for an improved version of this to emerge as a new stereotype, perhaps from the impetus of energy efficiency but also as a response to the underlying problems associated with the sick building syndrome.

Figure 2: Augmented solution space showing post-1980 stereotype

Figure 3: Augmented solution space showing possible zone for “environment-protection” stereotype
In an overview of developments in the second half of the 20th century in what he termed “the architecture of environment”, Hawkes (1996) redrew the solution space to show a post-1980 development of a stereotype building which did fit into the shaded area. As shown in Figure 2, this stereotype was labelled “selective, passive, seasonally adapted”. “Selective” means that a significant amount of the shaping of the interior environment is achieved by the carefully-designed filtering action of the building fabric; “passive” means that the building is responsive to the external environment, but in a way that is controlled by the design of the fabric, giving the potential for a stimulating rather than blandly uniform environment; and “seasonally-adapted” means that the mix of fabric and plant enables the building’s response to be changed between summer and winter, with the winter strategy involving a greater input from plant.

Hawkes discusses representative examples of these as case studies in Part II of his book. He states that this development stems from (p.105)

...a recognition that there now exists a level of understanding about human environmental needs, a rich and diverse set of technologies and related tools of analysis, which offers the prospect of a new synthesis of architectural science and design practice.

And he goes on to say (p.105):

I see these developments presenting two significant challenges for the field of environmental research. First is the need to direct studies of user environmental requirements towards the understanding of environmental diversity, both spatial and temporal, and of the complex perceptual and operational relationships which occur in the total environment. Second is the task of re-examining the relationship of plant and fabric. Both of these demand a major effort in the next decade if research is to keep pace with the rapidly evolving demands of practice.

3.2. A new stereotype for protection of the environment

Hawkes’ “next decade” is now nearly over. It has seen the rapid burgeoning of sustainable design in both research and design practice. Examples of the variety of approaches adopted would be liberally scattered over the shaded area of Figure 1. The question which must now be asked is where in the solution space would or should we place a stereotype building whose design focussed on the protection of the environment? We could anticipate that the design minimised the use of energy-consuming plant and relied on careful selection and detailing of the building fabric (but that the balance between plant and fabric would depend on environmental factors such as the extent of external air pollution and ambient noise). The degree to which individual control of the interior environment was either encouraged or proscribed would depend on the occupancy of the building and a trade-off between the satisfaction of individual control against the potential for individual control to be energy-inefficient. The possible zone within which strong solution-types might fall is indicated in Figure 3. The two challenges outlined by Hawkes in the above quotation might need to be re-stated in this new context, and a further decade allowed for the necessary research and for design practice to have the opportunity to produce a sufficient range of possible solutions for testing against the theory.

4. NEW DIRECTIONS IN RESEARCH

4.1. Sense-rich environments

Characteristic features of the artificial environments found in most large modern buildings are their blandness and the lack of stimulation provided for the occupants. The interior environments have been designed to be functionally supportive while eliminating or minimising any sources of sensory discomfort or distraction, and to achieve these two design goals largely independently for each environmental parameter. Research has almost exclusively supported this essentially “negative” (i.e. non-positively-enhancing) approach to environmental design, and buildings designed on this basis could be described as “sense-deprived” – they fail to provide a stimulating environment in which it is a pleasure to work. The type of research which would support the design of “sense-rich” environments would be more complex and would need to explore interactions between the different sensory modalities.

Sensory richness is a characteristic of natural environments. It is so difficult to imagine any outdoor, “free-running” environment (a streetside café, a surfing beach, a fishing port, a motorcycle speedway arena) with any one of its characteristic visual, thermal, sound, smell, taste or tactile experiences missing, that we can readily accept that our overall experience has been an integrative one, with each component of that experience complementing and reinforcing the others. However, research into the existence, nature and strength of such sensory interactions has been limited and spasmodic, and much of the evidence remains anecdotal.

One of the significant opportunities offered by the concept and practice of sustainable design (and in the context of this paper, the most significant of these) would be the return to natural lighting and to heating and cooling systems based on ambient energy (solar energy and its derivative wind energy), and these would complement each other in the design of public, institutional and commercial buildings as well as at domestic scale. In turn, and as a design consequence, the building interior would be exposed to or presented with the scents, the sounds and the sights of the world external to the building, in a way which has become largely denied in the artificial environments of most contemporary city buildings.

Sustainable design can therefore be seen as a key to achieving a design goal which not only protects the occupants and enhances their experience of the interior environment of their building but also does this in a way which protects the environment external to the building at the scale of both the immediate surroundings and the wider environmental context. This suggests that the region in the solution space in Figure 3 in which we might expect to see the best new stereotypes emerge would be towards the right hand end of the zone, unless the activities or occupancy of a specific building indicated that a reduced freedom for individual control was appropriate. If the
stereotype were unnecessarily located away from the right hand end of the zone, we may end up with what could be called the “Sustainable Building Syndrome”. (However, the acronym for that - SBS - has already been claimed and we might need to think of a different set of words instead. Since we are now concerned about the outside environment, we could call it the “Sustainable Outside Syndrome” and the acronym might be considered rather appropriate!).

4.2. Researching Sensory Richness

Researching situations which focus on the interaction between different sensory modalities, rather than researching these modalities independently, represents a radical departure from typical architectural science. Some attempts have been made to study the interaction between people’s responses to the thermal environment and lighting but these used traditional experimental techniques such as climate chambers. They were unsuccessful and were criticised, essentially for their naivety (Willey, 2004).

The best indication of where these studies went wrong can be gained from some of the implications of recent research in cognitive science and neuroscience and their impact on lighting research. Although there may be further possible subdivisions, it is widely accepted that there are two clear pathways along which visual information is processed in and beyond the visual cortex (e.g. Bruce et al, 2003). Named the ventral and dorsal pathways, they both build a spatial perception but in the case of the ventral pathway it is concerned with the relationship of objects in the surrounding world to each other whereas for the dorsal pathway the concern is for the relationship of objects to the person. It is this latter form of spatial perception which is at the heart of architectural design, and of the way that the lighting of interiors and other sensory inputs can shape the experience that each person has of their environment. However, the dorsal pathway is also found (not surprisingly) to be specifically focussed on providing information for controlling movement.

Other research shows that sensory interaction can occur under conditions of stress, and only under such conditions, and becomes the basis of survival-related actions (where we experience having all our senses pricked and contributing to the decision on how best to react to danger). This strongly suggests that sensory interaction is associated with the dorsal pathway in visual perception. To bring the focus back to architectural situations, the concept of stress could be generalised to ‘heightened sensory awareness’, and the psychologists’ focus on survival-related actions could be broadened to include actions taken to maximise the reward gained, including the attainment of pleasure and delight. This extension of the applicability of published results from cognitive science and neuroscience appears to be supported by neuroscientist V.S. Ramachandran when he comments that “we seem to, paradoxically, ‘enjoy’ horror movies or white-knuckle rides” (Ramachandran, 2004: 128) and also notes that “arousal can be a response to beauty or a response to a disturbing situation. As an example of this extension, we can compare listening to a musical performance on CD in the dark, to the rewards obtained from attending a live performance. These rewards derive from seeing the performers as they play and appreciating the physicality and emotion associated with their musicianship, of being exposed to the atmosphere in the concert hall and sharing this with a large number of other people; truly an integrated, sense-rich experience.

Further published research can be brought to bear to explain why traditional experimental techniques in architectural science have been unsuccessful in exploring the nature and extent of interactions between sensory modalities, and to provide some insight into possible new research strategies. In the context of sensory richness, the dorsal pathway, which establishes information on the spatial relationship between a person and their surroundings, can be argued strongly to be the pathway which establishes a sense of ‘place’. A telling distinction has been made by Fodor and Pylyshyn (1981) which reinforces the significance of place. They have distinguished between the processes of “seeing” and “seeing as”, where the latter requires some knowledge of the world to achieve perception. As they put it (p.189):

> What you see when you see a thing depends on what the thing you see is. But what you see the thing as depends on what you know about what you are seeing.

Typical traditional experimental situations (sometimes nothing more than boxes to look into) require people only to “see” rather than to “see as”; they avoid the intrusion of the real world. The experimental situations effectively focus on the functioning of the ventral pathway in the visual cortex and therefore cannot reveal any integration between visual perception and other sensory modalities handled elsewhere in the cortex. A new research strategy will be necessary to provide the knowledge and understanding to share with design practice in dealing with sense-rich environments. Until we have that research under way and results becoming available, any attempt at establishing a new type of building that responds to the imperative of protecting the environment will risk undermining one of the most distinctive characteristics of sustainable design.

**CONCLUSION**

The principles of sustainable design, and the range of building types developed on the basis of these principles, provide a useful transition path between earlier design strategies based on “protecting the people” and contemporary awareness of the need to “protect the environment”. However, protection of the environment must involve more than the careful selection of materials and construction systems involved in providing the building with minimal depletion of resources and any pollution associated with the extraction of those resources; it must also lead to a building whose functioning does not degrade the environment during its lifetime. If the latter objective leads to a restriction on individual control of personal space within the building and a greater reliance on automated controls programmed for energy efficiency, then the sensory richness of the environment within the building will be seriously at risk.

As a first step, it seems essential that the necessary research should have an inter-disciplinary character, not only to conduct the research in a more effective and informed way but to also provide informed access to the wealth of relevant research outputs from other disciplines which could be translated into a new context and brought to bear on
architectural science studies. A second, complementary step would be to ensure that design practice had a corresponding interdisciplinary character, rather than having design supported by an ad hoc collection of independent professional consultancies. Examples of both, if somewhat tentative, do exist and should provide a useful base from which to expand this strategy. If we can achieve this, the lessons from the past will have been learnt and the outcome will be protection of both the people and their environment.

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The Challenges Facing Beginning Teachers 7. To help new teachers begin to apply this knowledge to the classroom, most preparation programs include a range of guided field experiences under the tutelage of more experienced classroom teacher and/or a university supervisor. Teacher’s preservice programs differ in the approach they take to this learning and in the depth of knowledge and practice provided, but in general, teachers can be expected to bring this knowledge and experience to their first position. I’m really committed to this now. I love working with the kids; they seem to respond well. Second-year teacher. Bartell 01.qxd 7/21/04 5:45 PM Page 8. Other geographical contexts present special challenges for new teacher recruitment and support.