EDUCATION AND NEW TECHNOLOGIES TO PROMOTE SUSTAINABLE BUILT ENVIRONMENTS

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Summary

Existing buildings are a physical representation of the way people live. The need for knowledge of indoor environment is based on the fact that indoor air affects people and that agents in indoor air can cause illnesses and discomfort. The provision of healthy environments is a fundamental component of design, construction, operation and maintenance or re-use of existing buildings.

A number of actions are taken to improve the environmental qualities of living spaces and promote sustainable built environments. However, we still have unsatisfactory results. Education has proven to be an important component in the prevention and control of adverse health effects caused by indoor environmental exposures.

The promotion of healthy indoor air and the minimization of environmental impacts are essential to sustainable development. While all these factors are linked to economic and cultural aspects specific to each community it is also true that a lot has to do with awareness of the population and level of education of each actor that plays a role in the indoor environment (e.g., occupant, designer, facility manager and administrators and hygienists).

This contribution deals with education and training of professionals and the use of informational technology in promoting sustainable built environments. First, the need for a better understanding of the existing buildings is reviewed. Than indoor air sciences education as a tool to achieve sustainable environments is discussed. The third part reviews the new context for graduate education. This contribution concludes by presenting selected educational models.

1. Culture, Existing Building and Sustainability

"Culture" means different things to different people and at different times. The World Commission on Culture and Development, in its report titled *Our Creative Diversity*, and UNESCO defined culture as follows:

"*the whole complex of distinctive spiritual, material, intellectual and emotional features that characterize a society or social group. It includes creative expression (e.g., oral history, language, literature, fine arts, performing arts and crafts), community practices (e.g., " traditional healing methods, traditional natural resources management, celebrations and patterns of formal interaction that contribute to group and individual welfare and identity), and material or built forms such as sites, buildings, historic city centers, landscapes, art, and objects*".

People have been adapting existing buildings for uses other than originally designed throughout the history of buildings. Existing buildings are often acquired for their ideal site or architectural qualities to be used to serve new needs. In the United States (US), the interest in rehabilitation grew in the late 1970s and 1980s as many practical and emotional factors called for retaining the existing building stock. The economy was suffering from high inflation rates and scarcity of resources. A strong environmental consciousness supported the benefits of reuse as a mean to conserve resources. The preservation of significant historic properties became governmental objectives on the international front as well as in the US. Lastly, undesirable development patterns, occurring at the time, focused on new construction while sacrificing the old, created a consensus to save the existing built environment that had not yet been lost.

Inevitably, development means change. However, there are many parts of the old that must be preserved and/or can be adaptively reused to suit the present quality of life and current standard of healthy and comfortable living. Within this framework each society must find its own solutions. Culture is basic to improve development effectiveness in education, health, the production of goods and services. A development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It is in this context that preserving the past--or at least parts of it--is a form of cultural continuity.

In the US, the environmental resurgence gave credibility to the resourcefulness of reusing the existing building stock to serve the present needs of present society. This approach, based on the fact that both preservation and environmental movements share similar goals of conservation, introduces a totally new vision of "cultural resource" moving away from a protective legislative approach to a new anthropological perspective. Here a few aspects to illustrate the importance of the reuse of buildings that have motivated sustainability objectives:

- Eliminate the concept of waste in the building's life cycle;
- The built environment counts for 90% of the extracted materials in the US;
- Construction and demolition waste is the highest contributor of industrial waste;
- Service lives of buildings are unpredictable, and are often shorter than the design life of a building;
- New technology-dependent systems shorten the service life of a building.

The preservation of historic and historic-to-be buildings is an integrated aspect of social-cultural development policies and strategies. Economic valuing is an important first aspect to convince ministries and other stakeholders to invest in cultural heritage, but this has its limits and some risks. Valuing heritage should be done on a broader definition of benefits than economic cost-benefit analysis only and, apart from quantitative monetary measurements, qualitative and multi-criteria methods for assessing existing in other field should be applied.

Further, historic buildings, carefully preserved and protected, can contribute to economic growth. Can historic buildings and historic-to-be-buildings (e.g., modern architecture) be a development "asset", a form of cultural capital that can provide employment, generate income, and mobilize communities to revitalize areas. Economic and social development can put cultural capital at risk, but it can also create opportunities for increasing that capital.

While many buildings will continue to be constructed each year, approximately 90 percent of the buildings that will exit in the developed countries during the first quarter of the next century have already been built. Nevertheless, data from the literature also show that the quality of a large percentage of buildings is less than desirable and that a continuum exists in the degradation of buildings (Woods 1994). Such degradation may be attributed to the natural aging of the buildings, design deficiencies, improper construction, changes in occupancy profiles, or inadequate operation and maintenance procedures, and may occur at any phase of a building's life. This continuous degradation process of buildings emphasizes the necessity of focusing on the principles of assessing building performance and of building diagnostics in educational curricula to stop and prevent further deterioration of buildings.

The concepts of "*Sick Building Syndrome*" and "*Healthy Buildings*" have helped the research community to refocus on the integration of health and building sciences. However, they have also caused controversy, especially among those who are responsible for the financing, design, construction, and operations of buildings and their systems; those responsible for public health; and those who are responsible for medical treatment of occupants.

We face a critical need to protect existing and new investments while also protecting the health and safety of the people who occupy these buildings. Thus, educational curricula for building and health professionals should include points of interface where health professionals know more about building systems, and building professionals understand more about human response.

Since the 1970s, with no doubt, a remarkable progress has been made in improving the understanding of the design and construction practices to achieve healthier living environments. The health effects associated with indoor environment have become more known in the construction industry and the market has seen an increasing client's demand for knowledge regarding the impact that buildings have on health, well-being, productivity of the occupants and environment. Still, a lot of work remains to be done. Among the building science issues that call for urgent attention is the one of moisture control.

2. A Call for Better Understanding: The case of Moisture Control

A number of multi-disciplinary state-of-the-art literature reviews on the relationship between indoor air exposure and health effects show that allergies and allergies related illnesses are among the most prevalent illnesses. This increased prevalence is associated with exposure to indoor allergens such as house dust mites, fungi and other microorganisms, pets, cockroaches, environmental tobacco smoke and certain chemicals. Further, building dampness is one of the environmental factors most commonly associated with respiratory diseases. Here are a few facts reported from the literature.

Allergies and allergy-related illnesses are among the most prevalent illnesses related to indoor environmental exposures (Sundell 2000). Approximately half of the population in developed regions of the world is affected by allergies, younger people more than the elderly. Such illnesses and subsequent development of the disease have increased rapidly in the past few decades. According to the US Environmental Protection Agency (US EPA 2000), about 17 million people are affected by asthma, of which 4.8 million are children -- 1 in 15 -- under the age of 18. The asthma rates have increased 160% in the past 15 years in children under the age of 5. Asthma, currently, is the leading chronic illness in children and the leading cause of school absenteeism due to chronic illness (i.e., 10 million missed school days per year).

Allergic diseases in Europe are more common in association with good social and economic conditions. However, the opposite has been shown in the US, for example, according to the US EPA asthma related hospitalizations have risen disproportionately for inner-city children, and in particular for minority populations. It is not known whether this increase is due to the disappearance or depletion of protective factors, or the emergence of damaging or promotional factors. It is not known whether the cause of this observed increase is to be found among the factors that are known to trigger asthma such as allergens (e.g., cockroaches, house-dust mites, molds, and pollens) or among factors that are considered an exposure to infectious diseases, especially early in life, such as vaccination, and hygienic and eating habits. There may also be some yet-to-be-identified factors in the indoor environment, which contribute to the increase in allergic asthma.

Indoor factors can play a role at three different levels:

- Activating the immune system to react unfavorably to some factor in the environment (*sensitization*);

- Triggering symptoms (*exacerbation of asthma*) in those already sensitized;

- *Maintaining* a sustained inflammatory state in the mucous of the respiratory passages which is the result of a heightened sensitivity to other irritants or provocative conditions, such as oxidant or corrosive air pollutants, cold air or physical exertion;

- *Exacerbation* of asthma and allergic illnesses is strongly linked to the exposure to allergens, such as house-dust mite, cat, dog, cockroach, and "dampness", fungi or mold, NO_2, NO_x and ETS exposure, and suspected to be linked to exposures such as domestic birds, horse, cow, rodents, certain houseplants, endotoxins, insects other than cockroaches, pesticides, volatile organic compounds (e.g., formaldehyde and fragrances), viruses, and low ventilation rates in the building.

- From a building science point of view, the most important consensus findings from the reviews for reducing exposure to provocative agents and subsequent allergies and asthma are:

- *Keep the building or dwelling well-ventilated* in order to reduce exposure to airborne allergens, microbials, particulate and chemical agents, and reduce indoor air humidity (to antagonize the growth of house-dust mites, to prevent "dampness" and subsequent mold growth)

- *Keep the building "dry*", i.e., without "dampness" problems during the whole life of the building. This means for example that building materials should be protected against rain and snow during the time of construction, that building constructions, such as concrete floors, should be dried out properly, that the building and its installations should be safeguarded against factors such as water leakages, flooding and drainage.

- *Design the building to be easy to clean* (for the reduction of allergens from cockroaches, and sites for growth of molds and house-dust mites and insects).

Although the knowledge and literature available on the physics and engineering of moisture control in building is extensive; in spite the worked carried out by professional society such as the American Society for Testing and Materials (ASTM), the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) and the International Society of Indoor Air Quality and Climate (ISIAQ) in publishing technical material, reference standards and guidelines for the control of moisture-related problems, moisture problems are very common in residential as well as commercial buildings.

According to the data of the US Census Bureau, published in 1995 in the American Housing Survey, occurrences of water leakage during the last 12 months in 97,697,00 households are as follows: 11,411,000 had leakage from inside structure; 15,999,000 leakage from outside structure; 7,266,000 from roof; 4,944,000 from basement; 3,075,000 walls, closed windows or doors; 5,456,000 pipes leaked; 3,728,000 fixtures backed up or overflowed. The overlaps between these categories are not indicated and the total percentages of homes with water leakages are not reported, however, the extent of the problem is quite substantial.

Further, from preliminary data from the US National Allergen Survey it is found that 45.6% of housing have dust allergens (bedding and carpeting) and 1 in 5 home has 5 micrograms/per gr. of dust mites in their homes (Malindzak 2000). Dust mites have been shown to respond to increasing humidity and their concentration have been associated with humidity and sign of dampness as well as with conditions that lead to dampness such as increasing number of occupants and reduced ventilation (Sundell et al. 1995).

This is an indication that many designers and builders still have inadequate preparation on the means of preventing moisture build-up and/or appropriate information and knowledge doesn't reach all stages of the building process. Further, inadequacy of financial resources; solutions on operation and maintenance being made by speculative builders and decision -makers not affected by future moisture problems; lack of full understanding among tradesmen and the general public of the association between moisture and health effects; and lack of effective communication mechanism among players of the building process are among the exacerbating factors.

Risk factors indicating moisture problems maybe summarized into the following categories:

- *Outdoor sources*, water leaks from the interior and exterior of the building, moisture entry into the building often due to bad drainage around the foundation of the building, melting of ice or frost (e.g., in attics);

- *Indoor sources*, processes that generate water vapor (e.g., cooking, bathing and humidifiers), insufficient water vapor removal by dehumidifier and air-conditioning systems, low ventilation rate especially during the winter, water vapor condensation;

- *Building materials and construction processes*, water present in building materials at the time of construction is significant especially during the first year (e.g., wood and concrete), improper location of the vapor barriers, capillary transport from moist soil (e.g., through concrete foundations), condensation in the building envelope; and

- *Accidents climatic zone*, flooding, very cold and very humid climates.

In sum, the number of moisture-problem buildings is quite high. People have always been exposed to fungi and bacteria in their environments. However, if there is an increase of illnesses due houses infested with molds, something must have occurred in the indoor environment. A change that can be related to quality and quantity of microbes, and/or subject are more vulnerable to mold and/or the indoor air chemistry has changed. It has been observed that microbes observed in damp houses are not found in "healthy buildings" (Reijula 1998). Moisture problems are widely depending from regional climatic conditions. Results form studies are dependent from type of construction and type of questions investigated or asked.

Having presented a detailed view of the US situation in regard to the issue of moisture control in buildings, it must be said that in other countries the situation is unfortunately similar. A summary of representative studies that reports on home dampness occurrences is provided in Table 1.

Study	Country	Number	Tool	Prevalence
Dales et al. (1991)	Canada	403	Questionnaire	38%
Brunekreef (1992)	Netherlands	3,300	Questionnaire	25.4%
Pirhonen et al. (1996)	Finland	1,460	Questionnaire	23%
Norback et al. (1999)	Sweden	98+357	Questionnaire	27%
Schafer et al. (1999)	Germany	1,235	Questionnaire	8.8% (10.3% E, 1.9%W)
Tsongas (1985) (as reviewed in Tsongas 1994)	US (Spokane, WA)	96	Inspection	59% condensation 36% mold/mildew on window sills 38% mold and mildew 79% no gutters or downspouts
Rose (1986) (as reviewed in Tsongas 1994)	US (Illinois)	670	Inspection	5.4% major moisture problems 35% visible mildew or surface stains or surface damage
Trechsel et al. (1987) (as reviewed in Tsongas 1994)	US (Florida)	86	Inspection	30% current, past, or potential problems 48% mildew problems 66% mildew or moisture problems
Nevalainen (1998)	Finland	450	Inspection	80% signs of current or previous moisture problem 55% need of repair 83% of damage were technically and economically feasible 15% of occupants were not aware of moisture problems

Table 1. Results of selected studies on home dampness occurrences.

All these reasons point to a change of philosophy and priorities that would need to prevail throughout the entire construction and building supply industries to create the needed change. An effective step to be taken to enable this change is through education of the next and current generation of professionals.

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Biographical Sketch

Nadia Boschi, Ph.D., Architect, is Professor of Building Construction and coordinator of the MS in Architecture/Construction Management option at the Virginia Polytechnic Institute and State University. Her research interests focus on building performance evaluation for the provision of healthy and safe environments in new and historic buildings. She has conducted extensive research to enhance education in the field of Indoor Air Sciences in terms of paradigms, international harmonization of curricula and delivery systems using interactive multimedia tools in support of distance based teaching. Her research has been supported by a number of private and public entities among those NATO, European Union, US EPA and the Italian Government. She is author of 3 books chapters, 14 peer reviewed papers and editor of 2 books. She is a member of ISIAQ Board of Directors, a member of ASHRAE and a registered architect in Italy since 1988.