DESIGNING FOR GOOD INDOOR AIR QUALITY IN HOT, HUMID CLIMATES: DEVELOPMENT OF A STUDENT DESIGN COMPETITION

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Abstract

Residential indoor air quality (IAQ) is an emerging issue that deserves attention by educators of interior design. This paper focuses on the development of a national student design competition and supporting materials to address residential design for good indoor air quality in hot, humid climates. Utilizing expertise from consultants in the fields of architecture, engineering, interior design, and medicine, an integrative model for teaching environmental design was developed and applied to a hypothetical residential design project. With expanded knowledge of IAQ design, coupled with instructional units aimed at developing student critical thinking and problem-solving skills for complex environmental design issues, educators can contribute to the "greening" of their interior design curricula.

Introduction

In a report of the Science Advisory Board to the U.S. Environmental Protection Agency (EPA), indoor pollution was ranked one of the top five environmental risks to human health in the United States (The Science Advisory Board, 1990). The indoor air pollutants that have received EPA attention include radon, environmental tobacco smoke, toxic chemical substances, asbestos, lead, formaldehyde, and pesticides (Axelrad, 1993). It is important that students and faculty of residential design be fully versed in the issues of environmental illness and indoor air pollution. Clinical case reports have demonstrated a linkage between physical attributes of residential design and adverse symptom behaviors of the building occupants (Rea, 1996). Such environmental health

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issues as lead poisoning and multiple chemical sensitivity increasingly have become factored into interior design decisions (Danko, Eshelman, & Hedge, 1990).

This paper is a report on a project that was funded through the U.S. Environmental Protection Agency Environmental Education Grants Program (Funding Years, 1996-1998) and East Carolina University. A curriculum model, student design competition, and companion teaching guide were developed as a vehicle for improving the quality of interior design instruction to address indoor air pollution and environmental illness. The focus of this article is on the development of the educational program and its possible impact for design students.

High Priority Issue for Interior Design Professionals

The EPA has demonstrated that indoor levels of many pollutants may exceed outdoor levels by two to five times (U.S. Environmental Protection Agency, 1993). The locations of highest concern are those involving prolonged, continuing exposure—that is, the home, school, and workplace (American Lung Association, 1994). Furthermore, because indoor allergen concentrations are higher in homes than in public places, a greater effort should be made to control allergens at home (Fernández-Caldas, Trudeau, & Ledford, 1994). With continued legislation addressing indoor air quality and energy regulations for building performance, interior designers will need to know how to design in more environmentally-responsible ways. There is a critical need for the interior design community to understand the contribution of interior products and materials to the build-up of toxic substances in residential interiors (Danko et al., 1990). Design practitioners need to be taught current thinking in the methods of assessing the causes of environmental illness (Seltzer, 1995). And, interior designers need to learn to critically analyze the composition, construction, and installation of interior products in terms of their acceptability for a particular setting and population with regards to environmental concerns. Interior design educators need to prepare students to operate in an increasingly complex society (Guerin, 1992). It is important to provide educators with curricular tools to address environmental illness as another life-safety issue relevant to the practice of interior design.

Goals and Objectives

The purposes of this environmental education project were to: a) develop, disseminate, and implement materials and methods for assisting post-secondary instructors and students of interior design to increase their knowledge of IAQ issues; b) promote the application of this knowledge to develop innovative solutions for radon-resistant, non-toxic, allergy-free, and accessible interiors; and c) provide opportunities for interdisciplinary problem solving, drawing from the fields of medicine, architecture, and engineering to address residential design solutions for medically at-risk populations such as the elderly and infirm.

Educators need to provide design students with technical information to combat environmental illnesses caused by exposure to indoor air pollution. Reducing pollutant levels indoors can be achieved by: a) improving the way buildings are designed; b)

helping clients to identify and correct potential air-quality problems in their homes; and c) applying current information on how to prevent IAQ problems from occurring and how to resolve them quickly when the do occur (Axelrad, 1993). Increasing access to indoor air information can be achieved by: a) training teachers and students to use information clearinghouses regarding IAQ, environmental disease, and residential design; and b) making use of electronic information retrieval services such as the Environmental Protection Agency IAQINFO abstract and citation search service and the National Institute of Environmental Health Sciences EH/EMF HTML document for the World Wide Web search service [1] (Axelrad, 1993).

The objectives for this paper are: a) to describe the components of the student competition and supporting teaching materials; and b) to relate components and processes for understanding IAQ issues to the teaching of environmental design

Regional Focus

The coastal southeast region was the focus of the design competition and teaching guide because several factors make IAQ concerns critical components of the building design process. First, the population of the southeast region exceeds the national average for age 65 years and older, and for the percent of elderly both in poverty and in poor health (Inman & Shea, 1993). The elderly and the infirm spend more time indoors, increasing their long-term exposure to indoor air pollution. Those in poor health are more susceptible to indoor air contaminants (Zummos & Karol, 1996). Furthermore, the low-income elderly tend to live in older homes containing lead pipes, lead-based paints, asbestos, faulty furnace ductwork, and faulty sewer pipes.

Second, all eight of the states in the southeast region contain housing stock with radon levels exceeding EPA recommendations (Marcinowski, Lucas, & Yeager, 1994). Fifteen to twenty percent of the housing stock in Tennessee and Kentucky exceeds acceptable exposure levels for radon gas. Five to ten percent of the housing stock in Florida, Georgia, and North Carolina have radon at levels exceeding the EPA recommendations. According to the Centers for Disease Control, radon gas is the second leading cause of lung cancer in the United States (Waxman, 1993).

Third, the southeast region has the least stringent restrictions on smoking tobacco in public spaces, with Kentucky, Mississippi, Alabama, and Georgia having no restrictions (Browner, 1993). Widespread exposure to secondhand smoke could occur within congregate living arrangements (i.e., retirement homes and apartment complexes) where retirees could exercise little control over IAQ. Furthermore, the southeast region has a high prevalence of regular cigarette smoking in the United States; smoking prevalence is the highest (30.8%) in the state of Kentucky (Centers for Disease Control and Prevention, 1998). The EPA estimates 3,000 lung cancer deaths annually in nonsmokers in the United States due to indoor exposure to sidestream tobacco (Browner, 1993). For households with smokers in areas with high radon levels, the risk is even greater for lung cancer (American Lung Association, 1992).

Fourth, hot, humid climate conditions increase the growth of bacteria and the release of volatile chemicals into indoor air. These increases in biological and chemical

activity can trigger allergic and toxic reactions among the hypersensitive (Kloeppel, 1993; Peart, 1993). For the entire southeast region, the average morning relative humidity exceeds the comfort range for at least eight months of the year (Lechner, 1991). Outdoor temperature conditions for coastal states in the southeast region are uncomfortably hot between 42% and 69% of the year (Lechner, 1991). Thus, for households with inadequate ventilation, combined conditions of high relative humidity and high ambient temperatures are a causal force in precipitating environmental illness. There is a critical need for professions engaged in residential design to have access to information about IAQ that is relevant to the context of the climate. Conventional thinking about design solutions for air quality associated with heating seasons in cold, arid climates does not fit IAQ considerations for hot, humid climates (Odom & DuBose, 1996).

Approach

A student competition and companion teaching guide served as a model curriculum tool that was made available to 460 instructors of interior design who are members of Interior Design Educators Council. These instructors were affiliated with two- and four-year university interior design programs in the United States.

The curriculum model, student competition, and teacher's guide provided a vehicle for: a) disseminating epidemiological information underlying principles of radon-resistant, non-toxic, and allergy-free design in a format that was geared to an audience that had limited knowledge of biology, chemistry, and physics; b) revealing sources of information from the fields of medicine, engineering, and architecture that are accessed in data bases outside those that encompass residential design subject matter; c) organizing problem scenarios (that require integrative problem-solving in order to explore interrelationships between climate, architecture, mechanical systems, interior space planning, and the specification of interior materials, furnishings, and finishes) for addressing indoor air quality and resident health; and d) incorporating in the design process a method for providing feedback on the relative merits of student design solutions via the external review of competition submissions by an interdisciplinary jury.

Schedule

This EPA environmental education project was funded in 1996. At the time the project was awarded, EPA recommended extending the grant from 12 to 24 months, spanning October 1, 1996 – September 30, 1998. This extension allowed more time to develop supporting materials for the competition and a longer time during the academic calendar for instructors to incorporate the competition into university course work. The first 12 months involved developing the curriculum model, the competition packet, and the teaching supplement; seeking reviews of drafts by consultants; preparing and printing final drafts; and advertising the competition to design educators. Educators received the competition mid-August, 1997. Student submissions to the competition were due mid-June, 1998. The remainder of the granting period was used by jurors to evaluate competitions and to award prizes for the top four ranking submissions as well as four submissions receiving honorable mention.

Student Design Competition

A student competition packet was developed whose stated purpose was, "to stimulate innovative residential design, promote environmental quality in interior design, and recognize exceptional achievements by students for their efforts to meet these goals" (Warsco, 1997a, p.1). The competition packet included guidelines for participating in the competition over the 1997-1998 academic year. The focus of the competition was the design of a retirement residence in a hot, humid climatic region for a hypothetical couple suffering from environmental disease. These requirements comprised a design program that included client profiles describing medical conditions, micro-climate conditions of north central Florida, and building requirements for coastal cottages. Also included in the competition packet were order forms for resources made available during the duration of the competition.

Competition Submission Guidelines

The following submission guidelines for the competition were uniquely suited to promoting environmental quality in interior design (Warsco, 1997a, p.2):

- The design solution is appropriate for sustainable development considerations of the climate, terrain, and vernacular archetype.
- The design solution reflects an accurate and sensitive application of principles of radon-free, non-toxic, allergy-free, and accessible design.
- The solution represents innovative design for the "sanctuary" [i.e., the master bedroom suite], addressing specific medical conditions of the clients as explained in the patient [i.e., the client medical] profiles of the design program.

These guidelines, along with the parameters of the design program, created an opportunity to explore the complexity of IAQ issues for residential design from a multidisciplinary perspective. To solve the problem outlined in the competition, interior design decisions needed to be coordinated with IAQ solutions considered the domains of allied design fields. Furthermore, design decisions had to be made within the context of human medical needs. These decisions included the solution to the competition problem and the choice of presentation media for the solution.

Client Medical Profiles

A client scenario was developed for a husband and wife suffering from multiple chemical sensitivity (MCS).[2] The Human Ecology Action League (1992), defines MCS as an illness triggered by chemicals that are prevalent in air, water, food, and drugs. Direct, indirect, and cumulative exposure to chemicals can cause patients to become chemically sensitized; a small amount can trigger a severe reaction. Susceptibility may depend upon genetic makeup, overall health, gender, age, and any pre-existing conditions contributing to stress (Rea, 1996). For clients with environmental disease, medical data is a critical component in preliminary phases of the design process (Canada Mortgage and Housing Corporation, 1993). The medical reports included in the design program were an important source of information for the competition project. Due to the variety of medical responses of MCS patients, knowledge of specific symptom

behaviors and their environmental causes are necessary in order to fine-tune design solutions to the particular medical needs of specific clients.

Two medical case reports were adapted for the competition, with permission, from Volume 3 of Dr. Rea's series, entitled: *Chemical Sensitivity* (1996). The case reports chosen to represent the medical conditions of the clients for this competition illustrated both physical and behavioral symptoms that have been associated with MCS. The case reports outlined symptom behaviors, diagnosis of specific irritants, and medical treatments. The cases were chosen to provide a range of conditions associated with environmental illness. For example, one case report was chosen to reflect chemical sensitivities that can arise from occupational exposure to chemicals. Long-term exposure to a low dosage adversely affected the neurological system. The symptom etiology of the other client was initially diagnosed as Multiple Sclerosis, and later attributed to MCS. The severity of this client's sensitivity to allergens and toxins prevalent in synthetic products resulted in episodes of wheelchair use. For both client cases, the design of the near environment had direct connections to their health and wellness.

Site Profile

A proposed residential subdivision outside Gainesville, Florida, was used as the hypothetical site for this competition. The subdivision borders a wildlife preserve, and its development was intended to serve as a model for environmentally friendly communities. As part of the competition, students were asked to explore principles of sustainable development. According to The Sustainable Development and Construction Initiative, Inc., sustainable development practices strive to: a) minimize the depletion of non-renewable resources; b) expand the use of renewable resources; c) mitigate the harmful effects of toxins to all life forms; and d) protect natural ecosystems (Kibert, 1995). Students were asked to incorporate principles of environmental landscaping in the development of the site as a means of eradicating pesticides and herbicides from the lawns of their chemically sensitive clients.

Building Profile

Based on Haase's (1992) typology of vernacular architecture for the state of Florida, the 19th century four-square Georgian townhouse version of the Florida Cracker houseform was adapted for use as the footprint and building silhouette. Students were asked to fit this vernacular archetype to the needs of their client family and the code requirements for building in a hurricane zone. The classic features of the rural Cracker houseform have been praised for their suitability to a hot, humid climate (Haase, 1992). Using a vernacular houseform as a starting point in the competition, students explored residential solutions that stressed architectural strategies for passive cooling that predate the widespread adoption of mechanical systems of ventilation and air conditioning. Such strategies are consistent with the principles of sustainable construction (Kibert, 1996). Manipulation of the building envelope, orientation of fenestration to prevailing winds, incorporation of shading devices, and construction of permeable wall cavities are architectural decisions that address the thermal comfort of building occupants and

the dilution of airborne allergens and toxins. In the configuration of the Florida Cracker houseform, students explored problems of accessibility for MCS clients suffering from loss of muscle control and decrease in stamina. Special attention was given to removing interior sources of specific toxins and allergens known to incite adverse reactions in the clients.

Competition Resources

Order forms were included in the student competition listing resources made available during the length of the competition. Literature and audio-visual resources were selected that provided an overview of the complexity of IAQ issues. The resources made linkages between micro-climate, architectural shell, interior space plan, building systems, materials specification, and environmental disease. Resources made available through information clearinghouses included: Canada Mortgage & Housing Corporation, U.S. Environmental Protection Agency, Human Ecology Action League, Institute of Food & Agricultural Services, and National Institute of Environmental Health Sciences. Documents made available for exclusive use during the time frame of the competition included: a) case studies of the Florida House Learning Center, (Sarasota) and the Kanapaha Botanical Gardens, (Gainesville) demonstrating sustainable construction and landscaping; b) the sustainability rationale and residential construction codes for the ABACOA development released by the John D. and Catherine T. MacArthur Foundation and made available through the University of Florida; c) Florida Cooperative Extension documents pertaining to environmentally friendly landscaping, radon mitigation, and building construction for hot, humid climates; and d) portions of draft documents from EPA pertaining to designing for good IAQ. Also included in the order forms were private industry construction guidebooks such as those prepared by CH2M Hill, Inc., in cooperation with the Disney Development Company, pertaining to preventing IAQ problems in hot, humid climates. These resources provided educators and students participating in the competition with important information to guide lesson plans and the design process. Information gleaned from a review of this literature could be synthesized with previous knowledge of residential design to expand students' decision support information for making informed tradeoffs between opposing needs and goals.

Companion Teaching Guide to the Competition

A teacher's supplement to the student design competition was made available to assist educators in incorporating multidisciplinary subject matter in interior design curricula. Recommendations for designing for good IAQ were gleaned from literature in the areas of clinical ecology, mechanical engineering, environmental landscaping, sustainable construction, vernacular architecture, universal design, and green interior design. Student activities relating to the competition problem were provided that included: a) learning objectives, b) recommended readings, c) thought-provoking questions intended to guide discussions, and d) sample outcomes illustrating ways to translate student activities into components of the design competition. The student activi-

ties were cross-referenced to suggested readings provided in the competition. Student activities included programming exercises, schematic diagrams, conceptual drawings, and material specifications.

Programming Exercises

Two programming exercises integrated medical concerns of the client with those of residential design. The objective of the first exercise was to "understand linkages between pollutant sources in the built environment and medical symptom behaviors of building occupants" (Warsco, 1997b, p. 10). With the assistance of the medical consultant, a matrix was developed that students could use to profile the effects of chemical and biological contaminants on a client with MCS. In the section of the teacher's guide labeled, "Samples of Student Work," examples of student outcomes demonstrated use of this matrix for the symptom etiology of a specific client. This information was carried further with a second table demonstrating sources, paths of entry, and environmental controls (i.e., design solutions) for chemical and biological irritants gleaned from the literature on environmental illness.

The objective of the second exercise was to "apply Rolf Faste's (Raschko, 1991) Enabler Model to translate medical data into design parameters" (Warsco, 1997b, p. 10). Students were asked to assign symptom behaviors identified in the previous exercise to disability categories provided in the Enabler Model. The Enabler Model was used to clarify the physical needs associated with the disability and to generate possible design recommendations that could address those needs. In the section labeled, "Samples of Student Work," an example of one student outcome demonstrated an analysis of the effects of MCS on physical dexterity, as applied to the Enabler Model. The programming exercises were intended to serve as preliminary analysis of medical concerns for use in design ideation and refinement of design solutions for the competition.

Schematic Diagrams

Studio draft assignments were developed to explore indoor air quality. Sky vaults, footprints, and section diagrams were used to explore: a) micro-climate design—plotting paths of the sun and diurnal and seasonal effects to velocity and direction of prevailing winds, and orienting windows and architectural shell to daylighting, prevailing winds, and barriers to solar heat; b) radon-resistant construction—designing barriers to radon entry; c) accessible design—space planning from the twin perspectives of moving both people with physical infirmities and air laden with pollutants through interior space; and d) non-toxic and allergy-free design—blocking infiltration of ambient pollutants and exhausting indoor contaminants from the breathing zone. The studio draft assignments were intended to relate interior design considerations to the near environment and to emphasize the necessity of employing a multi-disciplinary framework when designing for good indoor air quality.

Conceptual Drawings and Materials Specifications

Studio draft assignments were developed to explore design solutions for the interior, in general, and the master bedroom suite, in particular, as an allergy-free, non-toxic zone within the residential design. Floor plans, lighting plans, section-elevations, and perspective drawings were used to explore interior architecture, space planning, and mechanical lighting. Remaining draft assignments called for identifying generic solutions for the selection of interior materials, furnishings, appliances, and features of mechanical systems to address the needs of the clients in the design competition.

Complexity of IAQ Issues

The student design competition and companion teaching supplement were designed to enhance students' critical thinking skills for complex, multi-disciplinary design issues. The supporting literature encouraged students to consider IAQ issues as intertwined with such issues as energy efficiency, environmental responsibility, health and wellness, micro-climate, and vernacular culture. To enhance problem-solving skills, principles of radon-resistant, non-toxic, allergy-free, and accessible design were linked to student exercises requiring their application in the development of design solutions for a hypothetical client family and setting. The supporting literature provided opportunities for students to research issues in the process of developing design solutions. Consultants for the environmental education project were available by telephone or e-mail through the duration of the competition to assist educators in their use of the competition and teacher's guide and to assist students in accessing both popular and scientific literature supporting an integrative approach to IAQ design.

Critique of Competition and Supporting Materials

This environmental education project was one of nine out of 350 proposals that were funded in 1996 by the EPA at the national level. Success in receiving funding was, in part, due to EPA's interest in addressing the under-representation of IAQ as a focus in funded proposals. EPA funding of this proposal was unusual in that the environmental education program was established to assist students and educators of primary and secondary schools rather than as projects for university instruction. Additionally, this federal program has not funded design competitions before. However, in all other respects this project was a fit with parameters of the funding program, thereby demonstrating viable linkages between the arts and sciences in exploring environmental education issues.

Over the course of the first funding year, drafts of the student competition and teacher's guide were reviewed by the following project consultants: a) the director of the Environmental Health Center, Dallas, a practicing clinical ecologist who has written more than 100 scientific articles on the subject of chemical sensitivity; b) the sustainable design director of Conservation Consults, Inc., Pittsburgh, a practicing architect/engineer who specializes in non-toxic, allergy-free design; c) a member of the Interior Design Educators Council (IDEC) Environmental Quality in Interiors Net-

work who specializes in interior lighting design education; and d) a mechanical engineer who serves the southeast region for the EPA. Additionally, drafts were reviewed by two members of IDEC who teach in an interior design program accredited by the Foundation of Interior Design Education and Research. Changes based on reviewer comments were incorporated in the final drafts. Substantive changes to drafts resulted from attention to facilitating student completion of components of the competition not readily accessible outside the Southeast. For example, prescriptive information was given regarding site and building requirements so students need not access the Southern Building Code. The format for student submissions was set at a conceptual level to lessen the need for advanced knowledge of construction, HVAC systems, and landscaping that are outside the arena of interior design.

The final draft of the design competition was evaluated by the IDEC Competition Review Committee. In assessing the competition content and format for the purpose of improving or modifying the competition for future years, the committee made several comments, observations, and recommendations. Positive comments included: a) confirmation of the importance of IAQ as an emerging field of specialization within the interior design profession; b) commendation for the organization, clarity, completeness, and professional layout of the design competition; c) commendation for the thoroughness of reference information, teaching supplement, and sources for preparing an instructor to administer the competition; and d) confirmation of the need for a consultant to assist students and educators in their participation in a design competition of this scope (A. Black, personal communication, March 31, 1998).

Concerns of the committee included: a) the content and requirements of the competition went beyond the boundaries of interior design, and there was no provision for teams of students from allied fields of landscape architecture and architecture; b) the time involved in researching and designing a thoughtful solution would make integration into existing course work for design studios difficult and would overwhelm or tax the interest of students; c) the cost of ordering all suggested resources without having a ranking of their relative importance for participation in the competition would be excessive; and d) the cover of the competition was suggestive of design solutions that could influence participants in their development of unique solutions.

The committee made the following recommendations for the development of a sequel to this design competition: a) consider requiring multi-disciplinary design teams to encourage a holistic approach to the solution and a better understanding and depth to solutions involving an eco-environment; b) consider providing a suggested time schedule for participating in the competition; c) consider providing a short list of suggested resources that get at essential considerations for the design problem within an economical budget; and d) consider either tightening design parameters or using a sliding scale for evaluating projects to take into consideration class level, numbers of team members, length of time allowed for the project, and focus of the studio integrating the competition into existing curricula.

Conclusions

This environmental education project represents a first attempt to partner with the EPA to employ student design competitions as a vehicle for disseminating scientific environmental information to post-secondary schools of interior design in the United States. Fulfilling sponsor expectations for developing a design competition inclusive of the major threats to human health by indoor air was a tall order. The complexity of design issues was exacerbated by conflicting assumptions within the scientific community as to what constitutes environmental disease. Although this curricular tool was successful in providing a thorough overview of IAQ design considerations, deliberately retaining the complexity of issues within a multi-disciplinary framework challenged the definition of acceptable boundaries for a problem addressed by interior designers. Future efforts to integrate environmental health issues in interior design curricula must balance the need to avoid unidimensional problem solving with: limitations to the scope of training for interior design students, the attention spans of students, the time allotment for projects that suit semester-length course schedules, and the startup time required of faculty interested in mastering IAQ subject matter in their efforts to "green" their interior design curricula.

Endnotes

[1]Both search services are provided via toll-free telephone hot-lines and e-mail: U.S. Environmental Protection Agency Indoor Air Quality Information Clearinghouse - 1-800-438-4318, iaqinfo@aol.com; National Institute of Environmental Health Sciences Clearinghouse on Environmental Health Effects – 1 – 800 – NIEHS – 94, ehealth@niehs.nih.gov .

[2]Editor's Note: The diagnosis of multiple chemical sensitivity is controversial. However, the competition discussed in this paper focuses on physical and behavioral symptoms of interest to the designer, irregardless of the specific medical diagnosis.

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