Session No # 2151

THE "NATURAL HOUSE" PROJECT: AN EXPERIMENT IN LEARNING BY DOING

Ali Uddin Ansari, Ishrat Meera Mirzana

Mechanical Engineering Department
Muffakham Jah College of Engineering & Technology
Hyderabad, India

Abstract

The "Natural House", a design and construction project of Centre for Environmental Studies & Socioresponsive Engineering (CESSE) at Muffakham Jah College of Engineering & Technology (MJCET), is directed at involving engineering students in a "real life" project with direct social benefits. The Centre's primary objective is to help orient engineering theory, practice, teaching and learning toward socially and environmentally responsive goals. The Centre (CESSE) has organized a group of twenty mechanical and civil engineering juniors, 11 male and 9 female students, to undertake a few projects, one of which is the concept, design and construction of "The Natural House". As conceived, the "Natural House", would have a wide spectrum of novel features, many of which are designed for compatibility with the surrounding natural environment. It is intended that the house itself would "behave" like an "organism", i.e. it will regulate itself to maintain homeostasis (temperature and humidity) and will intelligently adapt and respond to the environment. Some of these features are achieved through static geothermal cooling and evaporative cooling panels, and constructing walls from panels of different materials which can be assembled in multiple ways to optimize their properties and behavior. The entire (slightly curved) roof is designed as a solar collector comprising a network of pipes with full-length parabolic concentrators. It is also proposed to investigate the possibility of power generation from the solar collector roof, with either steam or compressed air as the working medium. It is expected that following the completion of the design the group will build a small Natural House.

The paper describes the two teachers' experience of creating, developing and implementing a project designed for learning by doing and the satisfaction, exhilaration and lessons involved in it.

It also discusses a new approach to inculcating sensitivity towards nature, based on physical, rather than cognitive, learning.

Keywords: experiential learning, energy-efficient design, eco-friendly housing

Address for correspondence: Ali Ansari, Professor, Mechanical Engineering Dept., Muffakham Jah College of ngineering, Rd.3, Banjara Hills, Hyderabad 500034, India.
Email: aliansari@vsnl.com

The "Natural House" project: an experiment in learning by doing

I. Introduction

Roger Schank, former Director of Institute for the Learning Sciences, at Northwestern University, and a well-known researcher and commentator on the "state of higher education" relates an experience he had with the "old guard" school of thinkers – the board of editors of *Encyclopaedia Britannica* [(1)]. For them higher ("liberal") education meant grounding in the classics of literature and natural philosophy. Schank believes he has a finger on the pulse of *future* university education, signs of which he sees evolving in the egalitarian Internet society and the expansion of inquiry and knowledge it has unleashed [(1,2)].

For Schank education of the future will have little to do with remembering anything and being tested on the ability to do so. Rather, it will be about "doing", and the "experiences" one has had in school. "Certifying agencies will worry more about what you can do – what virtual merit badges you have achieved – than what courses you have taken"[(1)]. Schank quotes Einstein: "The only source of knowledge is experience", and presents a cryptic quote from Aristotle: "For the things we have to learn before we can do them, we learn by doing them".

Schank is a futurist and a visionary. He seems to think that the changes he foresees are going to happen more or less on course in the emerging pattern of social and technological development. One instance of this pattern is, perhaps, the increasing recognition within the business world of the need for sustainable development, in the form of what one corporate leader has called "a *virtuous circle* between the success of our business and sustainable business practice" (emphasis added) [(3)].

Needless to say, these are hopeful visions - especially the long overdue recognition of the need for sustainability in business and technological planning. But how will this impact engineering education? Will the changes in education foreseen by Schank happen automatically in response to changes in the business world? Or would they involve a process of catalysis in the form of initiatives by educational innovators?

The role and responsibility of the teacher, especially the innovative teacher, in this somewhat confused scenario remain undefined. The dilemma of the innovator has been highlighted by Splitt, echoing the analysis of Christensen; "the dilemma is that educational products in this vital area do not represent the coin of today's academic realm – simply put, they do not fit the present-day rewards and recognition systems operative at most of our engineering programs" [(4,5)].

If what is involved is a "formula" for "breaking the ice", then we believe we have found a rather simple and basic recipe.

II. The context of the natural house project

We teach at a small college in India – an ancient civilization founded on sacred traditions. To take a cynical view, one of the functions of a social institution in a culture such as this is to curb the free energy of the human spirit. The Indian university education system is no exception. Our college is part of a vast umbrella of institutions centrally overseen by a regional university. This system still carries the imprint of colonial times, with its bureaucratic control over what a teacher may and may not teach in the classroom and how he or she may and may not do it. A "syllabus" is set down by a university board for each course of a particular program and examination papers are centrally made up by anonymous individuals selected by the university, *excluding* the teacher who has taught the class. It is no surprise then that students find much of their university educational experience something to go through and be done with in order to move on to "where the action is".

This scenario is an indication of both the challenge and the opportunity that await an innovative educator. We – a team of a senior professor and a junior female colleague, resolved to take up the challenge and bring "the action" to the teaching-learning process. The first step was the setting up of the Centre for Environment Studies And Socioresponsive Engineering. A project was begun in a low-income residential area close to the college that is beset with numerous environmental problems and very poor living conditions. By a forming a team comprising students and faculty from both mechanical and civil engineering departments, the project recognized the need for a holistic and multidisciplinary approach to the solution of "real" problems. Professors in the Civil Engineering Department drew up an action plan for successful "slum management" and enlisted the help of fifteen students to initiate its implementation. It was a novel way of learning by doing, while serving the needs of poor people through simple engineering solutions.

The Natural House project has been conceived in a somewhat similar spirit. It had its genesis in the observation that the present approaches and practices of building construction in this densely populated city of five million have resulted in a concrete jungle of overheated homes and suffocating interiors. Trees have been cut down to make space for building construction and residents of the town squeezed into closely spaced rectangular boxes of brick and concrete, cut-off from nature and isolated from their human surroundings. Physically and psychologically, the quality of life has suffered. Since our region lies in a temperate zone with day temperatures in the high 30's to around 40C a good part of the year, people who have air-conditioners use them quite heavily, causing considerable electrical load. Other people experience much thermal discomfort and tend to live with it.

These observation led us to think on new lines concerning "climate responsive architecture" and energy-efficient buildings [(6)]. Although this was the original impetus, what evolved in the form of The Natural House Project soon became a fascinating adventure in teaching and learning. The realization emerged that, in their mind, everyone has a "dream house". We are all natural architects. We build elaborate models of things in our minds, combining art and science, function and form, possibility and reality.

It occurred to us that the idea of a “dream house” that would provide year-round comfort and a constant experience of beauty, with the least overall consumption of outside power, would be an ideal design topic for a group of budding mechanical and civil engineers.

III. The unfolding of the project

The concept of The Natural House may be summarized as follows. Could a house be designed that would behave like an organism, adapting to, and blending in with, the natural environment and responding to it appropriately and intelligently?

In placing this idea before our student group of twenty juniors, with a female-male ratio of almost one, we drew attention to the fact that every organism and plant and tree does exactly this and yet survives and thrives under a wide range of environmental changes of temperature, humidity, wind currents, light intensities etc. And it does so without undue use of energy and materials, automatically conserving energy and recycling materials. It is evident that nature is an ingenious engineer. Every organism, even one as small as a single cell, knows how to maintain itself in a desired state of internal equilibrium, using complex feedback mechanisms and means of sensing.

Plants, for example, use transpiration as a means of cooling themselves. By drawing up underground water and controlling the rate of evaporation from leaf surfaces, plants maintain thermal homeostasis. The rate of energy received from the sun and converted into waste heat and the processes of respiration and transpiration are delicately balanced. Could this be used as a model for designing a house that would keep itself cool in summer and warm in winter?

Under our guidance, the student group has been using the above as an inspiration and as a challenge create a house that is not merely eco-friendly in the usual sense but rather modeled on the principles of nature.

The preliminary design makes use of the following “natural” means of achieving thermal comfort.

(i) Closed loop geothermal cooling panels attached to inside walls.
(ii) Open loop evaporative cooling panels attached to ceiling and surrounded by an air channel.
(iii) Sun screens at various sections (on east, south and west sides), which hang down from the verandah roof to keep out direct solar radiation and open (automatically) when no direct radiation is present, i.e. when the sun has moved up in the sky and at evening and night.
(iv) Ceiling isolated from the roof. The roof serves as a solar collector-cum-radiation shield, preventing all direct radiation from reaching the ceiling and being conducted inside.
(v) An air channel with a very low speed blower blows oxygen-rich air from a greenhouse, located on the verandah, across cooling panels and into the house.

(vi) Cross ventilation using venturi effects induce diagonal air currents.

It is to be noted that attaching evaporative cooling panels to the ceiling with air channels provide symmetric cooling and induce natural vertical circulation, while preventing thermal stratification.

The use of cooling panels on the inside wall surfaces supplied by water from an underground tank should work perfectly for our region. It is known from elementary transient heat conduction analysis that the effect of diurnal and seasonal variations of temperature is limited to a depth of one or two meters from the ground surface. Below that depth the soil temperature stays reasonably constant at a value close to the mean temperature between the winter low and summer high. We estimate this to be around 26C for our location. This estimate was confirmed by data received from National Geophysical Research Institute of India. It was found that the earth temperature below 2 meters in and around Hyderabad varies from 25^{o}C in winter to 28^{o}C in summer.

Our preliminary design allows for the panels to be used as heating surfaces in winter by feeding solar heated water from the roof. The roof is so designed that the entire surface serves either as a collector or as a radiation shield.

An external view of the conceptualized model Natural House is shown in Fig.1.

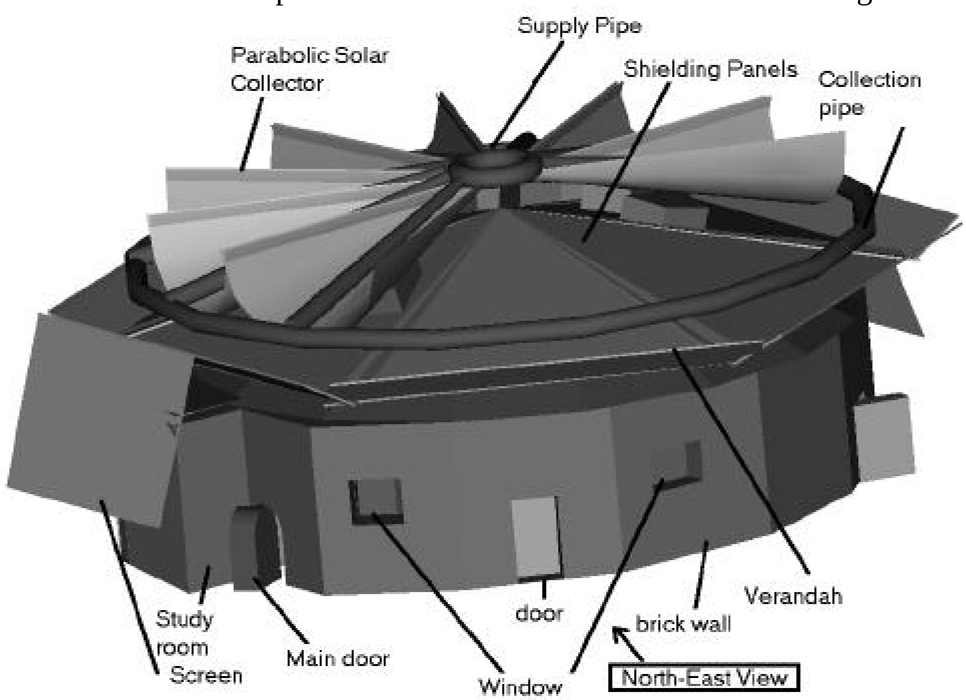

Fig.1. An External View of the House

Fig.2 shows a representative floor plan. The polygonal shape allows a great deal of flexibility in situating walls and glass surfaces according to the features of the surrounding landscape.

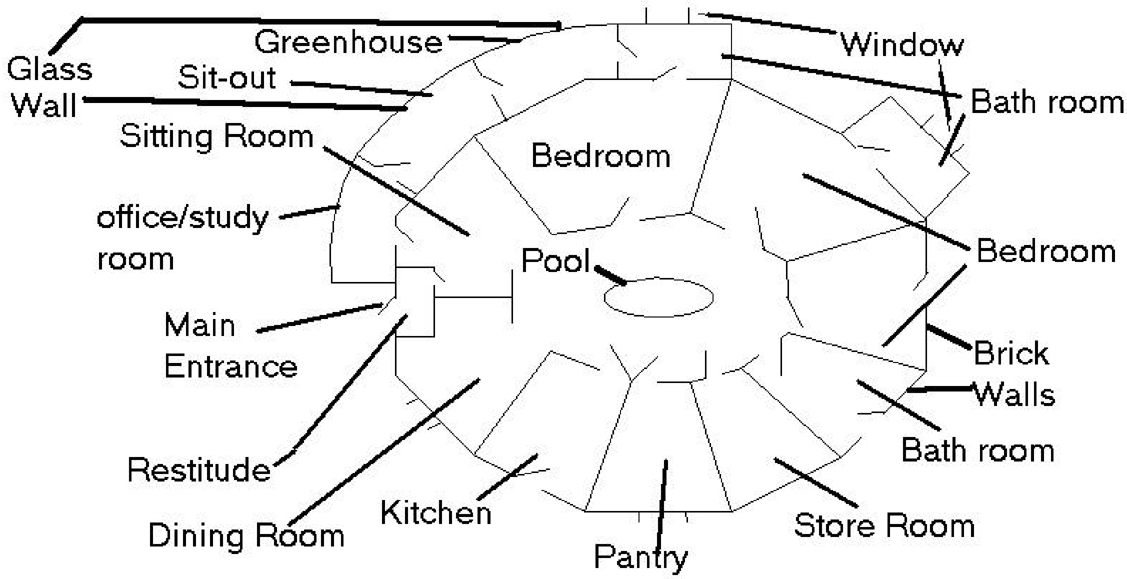

Fig.2. A Representative Floor Plan

While we have been working so far with mostly mechanical engineering juniors and a few civil engineering students, we have been approached by students from other departments, such as Electronics and Computer Science, who have expressed interest in participating in the project, especially the "intelligence" aspect. Until now the work has focused on conceptualizing the principles of energy conservation, thermal comfort, wall and roof design, and cooling system design. The group recognizes, however, that for the design to be viable all its components would have to be harmoniously integrated. Inevitably, this exercise would cut across traditional and disciplines and divisions within engineering.

IV. Summing up

In conceiving and developing The Natural House Project we believe we have found a way to promote environmental literacy and sensitivity among engineering students without inviting the resistance so often encountered by innovators and environmental educators. In the context of the Indian university system this is especially significant. Not only is change difficult to achieve within this extremely bureaucratic system through individual initiative, but in line with official government thinking and planning, the emphasis is on producing engineers in large numbers to support quick industrial growth. This, among other things, explains the almost to neglect of environment related themes in mainstream engineering curriculum. Earlier attempts by the first author to introduce such themes in courses were met by general apathy and institutional resistance on the one hand, and on the other, by lukewarm student response [7].

Through this project, however, we have got our students not only interested in appreciation and preservation of nature but also excited about observing it and learning from it. By proposing the notion of a house designed to behave like an organism in relation to the natural surroundings, we have been able to stimulate the natural intelligence and creativity of young minds. The process of design involves making assumptions and physical judgments and, in this project, students will be able to test their judgments through computer simulations of the house, and later on by making a working model. We have noted that some undergraduate programs in the U.S. have begun to recognize the need for getting engineering students engaged in "physical homework" [(8)]. In our project we hope to take this approach to a logical and rather rewarding conclusion.

Everyone has a "dream house" tucked away somewhere in their mind. To be able to give it shape and form through Autocad drawings, followed by design and modeling, enables at least a virtual realization of the dream. But what is even more exciting to our students and us is the prospect of actually constructing a small Natural House.

The Natural House project represents a new approach to not only engineering education but also engineering practice by bringing art, science, engineering and technology together in an application that impacts our life profoundly – the nature of the homes we live in. It is an approach that sweeps across constricting barriers. It sees as nature as a teacher, friend and guide and attempts to invite it literally into one's home. On the lines proposed by John Ehrenfeld, this approach attempts to reconstruct the disciplines in a way that mimics the "seamless web of the very world we (as scientists and engineers) are trying to understand" [(9)].

References

1.SCHANK, R.C., 2002. "Are We Going To Get Smarter", in *The Next Fifty Years*, J.Brockman, Ed., (Vintage, N.Y.)

2. SCHANK, R.C., 1995. "What to Know, How to Learn It", in *How Things Are,* J.Brockman, Ed., (Orion Books, N.Y.)

3. EARNSHAW, C., March 1, 2001, *Digital Futures Report*, Digital Futures Conference, London

4. SPLITT, F.G., "Environmentally Smart Engineering Education: A Brief on a Paradigm in Progress", *J. of Engineering Education, Vol.91, No.4 (October 2002)*

5. CHRISTENSEN, C.M. 1997. *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*. Harvard Business School Press, Boston, MA.

6. KRISHAN, A. Ed., 2001. *Climate Responsive Architecture*, Tata McGraw-Hill (New Delhi)

7. ANSARI, A. 2001. "The Greening of Engineers: A Cross-Cultural Experience", *Science and Engineering Ethics*, Vol.7, No.1., Jan.2001, pp.105-115.

8. PARSONS, J.R. *et.al.* 2002. "The Engage Program: Implementing and Assessing a New First Year Experience at the University of Tennessee", *J. of Engineering Education*, Vol.91, No.4, Oct.2002, pp.441-446.

9. EHRENFELD, J.R. 1994. "Industrial Ecology and Design for the Environment: The Role of Universities, *The Greening of Industrial Ecosystems*. National Academy Press, Washington, D.C. 228-240.