

Empirical Studies and Laboratory Investigations Promote Environmental Design Knowledge in Architectural Schools

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ABSTRACT: Environmental Design (ED) in buildings, theory, knowledge, technology, and performances' measurement tools are still perceived by many as being architects-unfriendly, complicated, and expensive. ED applications considered expensive to develop as well as challenging to operate. This paper shows number of current developments, trials, and efforts in order to promote ED knowledge at an early stage for architectural students. The research work displayed in this paper represents number of simple-experimental and onsite investigations carried out in the "Physical Environment in Buildings" (which the author is the main lecturer and course developer) module (PEB) for architectural students at the AAST. This is a RIBA part 1 core-module at the Architectural Engineering and Environmental Design Department at the AAST, in Alexandria, Egypt. The Environmental Design Department at the AAST is RIBA part 1 and 2 accredited. Generally, the module focuses on how architectural students should be committed to environmental and climatic contexts. Students are encouraged to explore sustainability, renewable energy technologies, and passive design techniques. The paper describes simple approach that effectively can introduce such knowledge and experience to the architectural students. The paper also concerns about the integration of ED and built environment into the academic curriculum of architecture schools. The process and end results of implementing the integration of ED applied, experimental and onsite investigations are discussed. The paper illustrates the challenges of introducing ED appropriate knowledge to the students as well as establishing an unsophisticated Environmental Design Lab (EDL). The paper explains that onsite investigations can also create acceptance of such teaching/learning techniques by academic staff and students. The paper highlights the consequence of construction industry interests in terms of financial -support for such educational techniques and projects. The study shows that simpleminded ED experiments, if integrated appropriately within architectural academic program, demonstrate clear promise to provide a foundation for more widespread ED knowledge in architecture.

Keywords: experimental and applied research in architectural education; environmental design laboratory; onsite environmental monitoring; research-oriented design studio;

1. INTRODUCTION

The built environment is an important key factor towards sustainable economic development [1]. In order to provide internal environments with comfort, health and well being, buildings are one of the highest consumers of energy from fossil fuels. This energy is used for cooling, heating, ventilation, and lighting. Therefore, external local and global environments that we are sheltering from are effected in a negative way. Neither have we designed in a way that depend less on artificial energy resources nor passive environmental design techniques.

Nowadays, production of new buildings is more concerned about sustainable, environmental and economical aspects. Sustainable and environmental aspects are a vast umbrella under which comprise all related social, cultural, political, and technical aspects and do not only include climatic aspects as many architects presume. Accordingly, architectural education and profession have experienced a rise of new applications in the field of sustainable energy technologies and passive design techniques [2]. Therefore, integrating experimental, technical, and quantitative analysis for buildings' sustainable and environmental performance has developed various common design ideas and solutions in education and practice. Moreover, architects will be more capable to generate passive ED techniques and low energy buildings.

Students entering higher education are neither applied nor experimental research literate. Growing up in an age of sustainability, green and eco architecture, students should be introduced to appropriate ED knowledge which will improve their design required by their profession and environment, and society. Architectural students and consequently architects need to design buildings to be more responsive to the external climate [3], and generally speaking such buildings are usually able to

provide better environments for people to live and work. Using an appropriate mix of architectural and engineering solutions, we can reduce the complexity of mechanical services in our buildings making them more efficient and effective in providing good comfortable and healthy environments [4]. Many of the passive/active techniques needed for sustainable design are readily available in number of taught courses. What is lacking is knowledge of how these techniques managed to provide indoor comfort and how their ED performance can be improved [5]. Proper understanding, analysis, and interpretation of these techniques from one hand and the knowledge and theories behind their mechanism from the other facilitate constructive integration with architectural curricula and practice [6]. This provokes great challenges for academics and architects to consider and respect global curial requirements and balance it with the demands of buildings towards carefully designed built environments and sustainability of resources.

2. PEB MODULE'S APPROACH, TEACHING METHODOLOGIES AND TECHNIQUES, AND LEARNING OUTCOMES

The PEB module at the AAST focuses on how architectural students should be committed with the sustainability, environmental design and passive cooling/heating techniques, indoor thermal and visual comfort, ecological/green approaches and proposals in architecture. It defines, tests, and justifies how a design proposal is appropriate and relevant in a particular physical, social, cultural, economic and environmental context.

The aim is to become increasingly familiar and confident in seeking out and finding an appropriate way of acting as an architect within a given environmental context or climatic condition. This means

that the emphasis will be placed on achieving a detailed and precise understanding of passive techniques' principles, theories, and technologies. Therefore, students will be aware of those techniques' economical, cultural, social, ethical, political, environmental, structural and technological features.

The proper understanding of such techniques and principles in architecture will lead for better development of the environmental performance of the same techniques by modifying their features [7]; design, form, shape, construction materials or other aspects which may effectively improve their environmental performance within specific climatic conditions.

This module gives details and clarifies the different theories of environmental design, development of various methods, tools, and techniques available for environmental designs. Natural Elements (air, sun and water) are examined as they interact with human needs within buildings or building complexes. The course illustrates number of related topics such, thermal control, lighting, acoustic, elimination of wastes, circulation of air, methods of utilizing solar energy to provide heating, cooling, hot water and electricity for buildings and related techniques for reducing energy consumption. Conservation of natural resources and the need for relying upon renewable energy resources are pointed out. The module includes lectures, research and laboratory experimental tests.

This undergraduate module rehearses the student's ability to deliver a well developed, ambitious and resolved environmental design proposal which has taken into account the complex and predictable climatic conditions of a particular environmental context and geographical location.

The aim of the module is to prepare the student for an appropriate environmental design project by promoting a self-conscious and clearly articulated understanding of how ED knowledge,

theories, and agendas can be developed. The module has been designed to include design, experimental, applied, onsite exercises. Students study the module through number of events and activities:

- Formal lectures that transfer the knowledge, theories, and principles behind several ED techniques for different climatic regions.
- Discussions and seminars in studio on a range of environmental design processes and approaches, traditional and vernacular examples.
- Introductory talks, discussions and analytical workshops on a range of different environmental design case studies.
- Individual and group research work for number for ED-related topics.
- Individual development of an illustrative model that fully documents the rationale of design process and its intentions.

ED teaching, studio applications, acquired knowledge, and successful architects' passive design concepts and ideas, are also learning-essentials to this module in order to develop the students' way of thinking and designing. In general, the paper represents a part of a continuous research work which is concerned with various environmental design aspects in architectural education, and design studio pedagogy for both under and postgraduate architectural curriculums. Therefore, PEB module gives details and clarifies the different theories of environmental design, development of various methods, tools, and techniques available for environmental designs. Natural Elements (air, sun and water) are examined as they interact with human needs within buildings or building complexes. The course illustrates number of related topics such, thermal control, lighting, acoustic, elimination of wastes, circulation of air, methods of utilizing solar energy to provide heating, cooling, hot water and electricity for buildings and related techniques for reducing energy consumption. Conservation of natural

resources and the need for relying upon renewable energy resources are pointed out. The module includes lectures, research and laboratory experimental tests. The EDL overall aim is to promote an understanding of the various forces that shape the human environment with a particular focus on ecological determinants.

➤ The outcome should consist of a three-dimensional and spatial design proposal, which is equivalent in scope, and complexity to a small/medium sized building. Through the proposal students will make explicit how the environmental, social, ethical, political and cultural context of design proposal has been considered.

➤ Modes of documentation should include: group/individual research work; drawings; photographic material; multi-media material; quantitative data; qualitative data; 3D models or prototypes; web-based material. All 3D and multi-media work should be recorded in graphic form and explained to a standard suitable for assessment purposes.

3. ENVIRONMENTAL DESIGN LAB (EDL) for ARCHITECTURAL STUDENTS

Since it has been founded in 1997, the AAST architectural school has been named "Architectural Engineering and Environmental Design". Therefore, draw attention to the importance of ED and sustainable renewable energy resources in architecture education and practice. However, it is obvious that there is a need to increase the ED and sustainability-related knowledge and application within the school's curriculum [8] as well as increasing the activity of experimental and applied ED research in both various architectural modules and design studio. Generally, yet schools of architecture in developing countries have no encouragement to do so. Consequently, the AAST's EDL has been founded in order to assist the school's main objective and to support teaching/learning

process for under/postgraduate students. The overarching goal of the EDL at the AAST is to advance sustainable design through research, education, and community outreach, with the aim of improving the dynamic interaction among the built, natural, and human environments. The Lab's primary purpose is to support the department's curriculum and the educational experience of our under/postgraduate students.

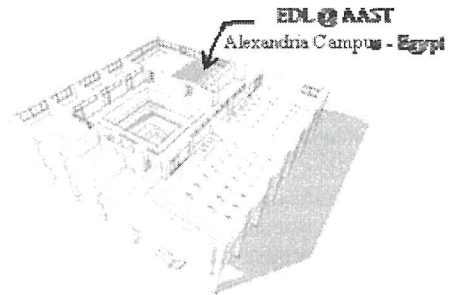


Figure 1: Architectural Engineering and Environmental Design Dept. Building

3.1 EDL primary mission

Mainly, EDL provides assistance to PEB's enrolled-students and their passive design techniques in different climates (6th-semester group). In addition, EDL provides support to other design levels students in order to allow them evaluate the ED performance of their design products through testing their scaled physical models. The EDL is committed to providing hands-on measurements and experimentation as a viable component of the environmental design educational programs.

In addition to provide specific environmental performance rigs and tests, EDL provides number of computational simulation facilities which support students' various design projects and assignments. EDL may work jointly with the facilities of mechanical engineering, the wood-shop and the metal shop, as well as the model-making cutter workshop. The EDL is equipped with simple and advanced devices in order to monitor both indoor and outdoor environments.

The EDL at the ASST's architectural school underpins many of the students' research-activities and ED applications and examples of famous architects' work.

3.2 EDL Solar and Lighting Applications

EDL solar and lighting applications include variety of facilities for use by students and faculty members in conjunction with solar architecture, shading, and lighting classes. Different design-studio modules, and research work may also use this facility.

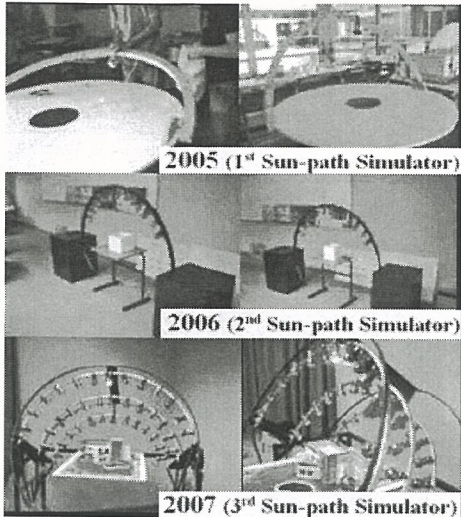


Figure 2: EDL Sun-path simulator has been developed over the last years

EDL provides number of lighting and solar simulation tools, which include lamps and lighting fixtures, a mirror-box, a direct-beam sunlight simulator, assorted light meters, simple data loggers, and cameras. Some of the artificial skies and simulators available are designed and built by the students undertaking out the module.

3.3 EDL Airflow Applications

Simple airflow box; this facility is a wind-tunnel-like tool which allows students to simulate airflow around buildings using physical-scaled-models and smoke generator and digital cameras, Fig.4.

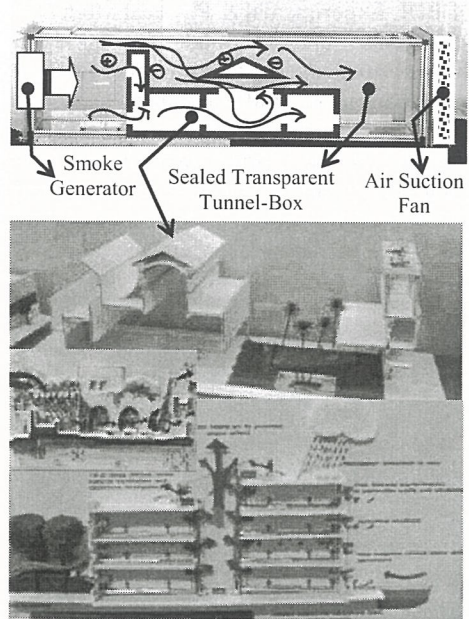


Figure 3: EDL Wind-tunnel Simple Box and students work on 3D airflow visualization

4. EDL and Design Proposals

Before the end of module activities, students are required to carry out a full design proposal as stated earlier taking into account all passive cooling/heating techniques in order to provide thermal comfort in buildings. At this late stage of PEB module, design forms' arrangement and layout for a particular building function with extra considerations to environmental aspects are properly investigated and this stage is divided as follows.



Figure 4: Design Proposals are Developed with the Aid of EDL Sun-path Simulator

4.1 EDL Experimental & Physical Models

Students are required to build a physical/full scale model(s) in order to carry out experimental and laboratory tests and monitoring for functional boxes arrangements and orientation, as well as employing various passive cooling and environmental design techniques and strategies in order to enhance indoor environments.

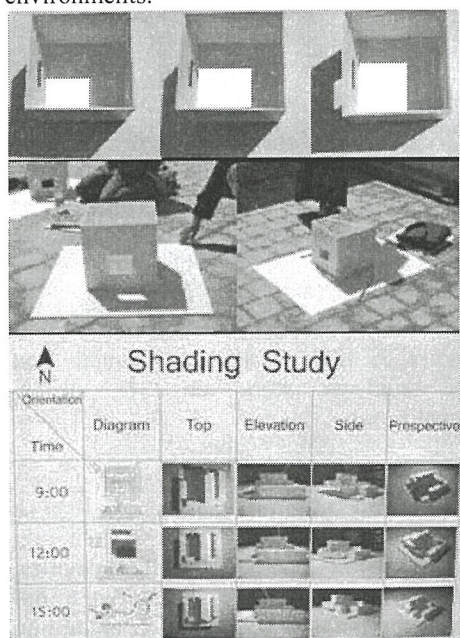


Figure 5: Real-sun/shading Studies for Physical Models

Extra-curricular research activities involve students, support graduate assistantships, bring needed resources and equipment to the school and enhance the studio and the classroom experience and ultimately provide value to the larger community beyond the school's boundaries.

4.2 EDL Computational Simulation

Students are required to use one of the computer software packages in order to simulate the ED performance of their design proposals and show proper understanding of the employed passive techniques.

4.3 Final Design Proposal & Research

At the end of the module, each student has to be assessed on a well-developed and appropriately presented architectural design proposal showing his/her understanding of passive design techniques and principles in different climatic conditions, submitted at the end of the Semester. This will be supported and illustrated with reference to their portfolio work. Presentation and recordings in support of lectures and seminars will also form part of the final design product.

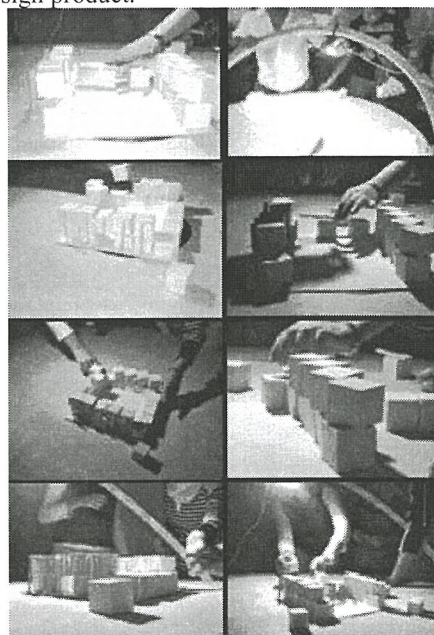


Figure 6: EDL solar/shading studies for different Forms' arrangements and layout

The final EDL design proposal must demonstrate the student's knowledge and understanding ED applications and PEB module. Finally, students are required to present their intellectual skills regarding various aspects of passive ED and sustainable techniques in buildings. Final studied-proposal should also enclose an interpreting-report of the employed elements of environmental design, passive sustainable architecture, energy efficient vocabularies

and passive techniques. The final proposal and report show comparison between different ED evaluation-tools in order to validate outcome.

5. CONCLUSION

Environmental Design appropriate knowledge and techniques are becoming vital for architectural students and professionals to have a handle on. For example, ED vocabularies for passive cooling or lighting have to be properly understood in order to improve their performance and consequently constructively employed in architecture. The paper concludes that the evaluation of ED performance of buildings can be fairly unsophisticated processes which should now be available in architectural schools. The PEB module contents, applications, laboratory-assisted exercises, onsite investigations, and various related research topics allow the student to build up an advanced mature knowledge and intellectual skills with different view about passive design process in different climates using various techniques and vocabularies as a consolidation and conclusion to undergraduate study. The module's final-project requires that the students should show their own personal and environmental context agendas in order to form their design proposals. It is important to direct students to keep depending on EDL in their future design studio works. Therefore create a link between design studio and EDL is crucial for architecture curriculum and sustainable future.

ACKNOWLEDGMENT

The author acknowledges the British Council (Egypt Office) for their sponsorship to disseminate this work. The author wants to acknowledge the efforts of Prof. S. Riffat and the Institute of Sustainable Energy

Technology - The University of Nottingham – UK in order to host and give technical support for different parts of this research. Thanks are also due to Prof. Abbas Yehia Head of Architectural Engineering and Environmental Design Dept. at AAST for his continuous support. The author values the efforts of architect Hossam Yonis to guide the students' EDL work. The author also acknowledges the Faculty of Engineering and Technology at AAST, Alexandria Campus for giving support to the EDL and ERDG. Finally, thanks are due to the architectural students at AAST for their impressive and remarkable outcomes.

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