The Dilemma Created by the Instruction of Environmental Systems Design in Architectural Pedagogy

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Abstract

This paper illustrates the dilemma faced by educators in the fields of architectural engineering and environmental technology and discusses procedures that may be employed by faculty of schools of architecture in Africa in exposing students to new methods of rapid graphical evaluation of their architectural designs. The paper begins with a review of various techniques that have been reported in previous literature, presents suggestions that may be employed in design studio and continues to illustrate the problems that are faced by faculty staff in introducing the concepts of environmental technology to architectural design students. The paper uses two examples of methods of modeling to illustrate the issues that are presently faced in the education of student in environmental technology, specifically in the field of building energy simulation. One high end building simulation package and a web-based interactive program are used compared in the illustration.

Keywords: Building energy simulation, on-line application, simulated graphical representation

Introduction

The process of education of students of architecture, the study of environmental control systems and the interaction with architecture design provide a dilemma to many educators. In many schools of architecture, students are required to combine the relevant combination of architectural theory, architectural design, historical precedent, structural design, environmental technology and climatic consideration in their design projects. This is the expectation of every architectural education program; aiming at enabling students to provide the evidence of their understanding of the design process and product of the design program. However, techniques for rapidly evaluating the various design solutions during their design process have not evolve rapidly enough to keep pace with the current the development of computer technology, and the rapid rate at which designs are expressed and presented by students. The required evaluation of designs by students may include aspects of structural or thermal performance, acoustical characteristics, lighting and sustainability analysis. Invariably, the entire design process must consistently be completed prior to the performance of an evaluating procedure or building performance simulation. There is invariable a considerable lack of efficient time use. This may be addressed with the use of technology that enables the use of deign options during the design process.

Computer technology and the associated programs have been used extensively in education in the last three decades in many areas of design. In the field of environmental controls the main methods of thermal and energy use whole building system analysis programs developed over many years namely, DOE-2 from the University of California/U.S. Department of Energy; BLAST developed by the University of Illinois; and TRYNSYS developed by the University of Wisconsin. BESTEST a new generation building energy simulation program has also recently been develop and combines the principle properties of DOE-2 and BLAST (Judkoff, 2006). These are high-end simulation programs which while providing considerable detail on the annual performance of a design, require in depth knowledge of the expertise in the computer coding and execution. There are simpler programs that have been developed for use which have been developed for building energy simulation, Energy-10, EnerWIN, FSEC 3.0 and which require less knowledge in computing programming. The disadvantage of these programs is that they are stand alone packages which are presently not developed sufficiency to provide the flexibility to operate over an on-line platform.

Development and Use of a complex model

The process of creating a calibrated simulation model of a building to measured energy data will in the paper be used to illustrate the procedure of evaluation of the design decisions that will be taken in the architectural process in a typical architectural student studio.

One method of evaluation is the use of a stand alone program, another method which illustrates possibly the other extreme of the spectrum is a web-based methodology for design evaluation.

The process of creating a simulation model requires specific hourly weather data including dry bulb temperature, relative humidity, global solar radiation from an on site location and peak wind speeds gathered from a nearby National Weather Station (preferably from a nearby National Airport). The global solar radiation needs to be converted to global horizontal beam and diffuse radiation using routines developed by Erbs et al. (1982). This is then converted into a packed weather file that may be used with the simulation program. New methods have been developed to simplify the weather packing procedure by various authors (Crawley, et al, 1999).

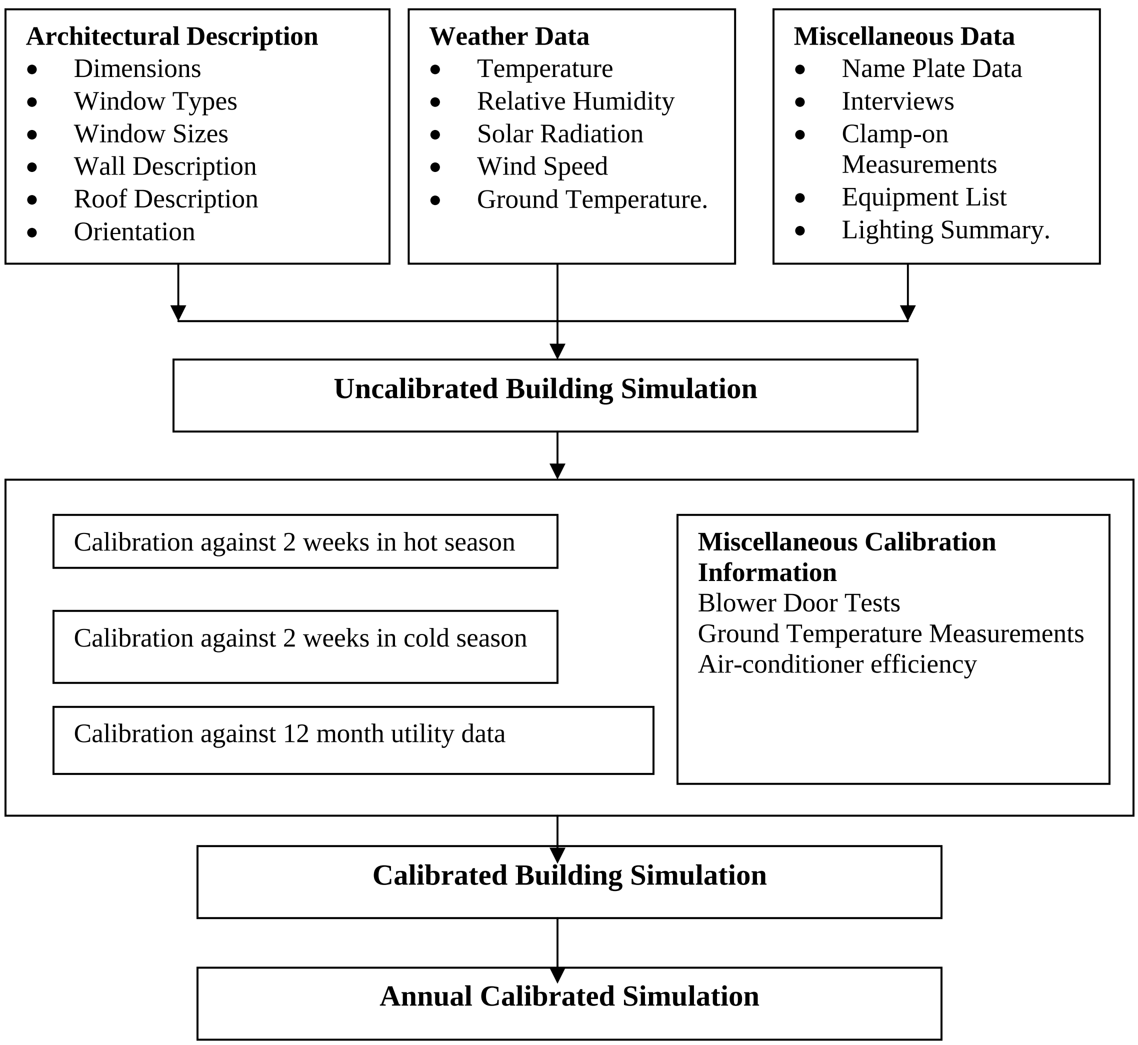

Figure 1: Overall Methodology for the Calibation of the DOE-2 Building Energy Simulation.

In studies by researchers it was found the calibration process enabling an accurate enough evaluation could only be performed after the following requirements had been provided (Haberl and Bou-Saada, 1998; Kootin-Sanwu et al., 2001). These processes were listed as

1. A complete set of as built drawings (architectural, mechanical and electrical). Information gathered from the as-built includes envelope description, HVAC zoning, lighting loads and control specifications.
2. An HVAC air balance report including supply and return air temperature and air flows.
3. Information concerning actual thermostat settings including day/night setbacks
4. Measured indoor temperatures in each zones during normal operating hours and night time periods.
5. Hourly HVAC schedules, hourly interior /exterior lighting schedules and hourly equipment schedules.

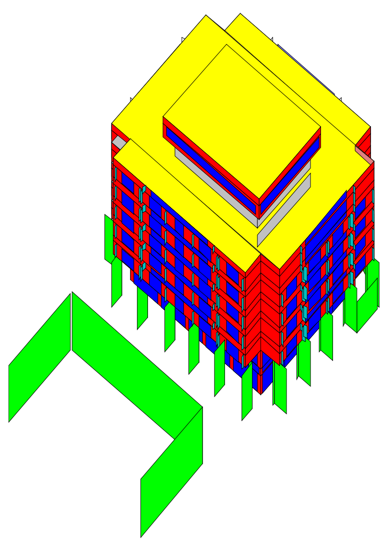

Figure 2: The DrawBDL output of a the Calibation of the DOE-21e Building Energy Simulation of a Seven Storery Building

The quality of a calibrated simulation of the building energy use will only provide the accurate description of the energy performance of the building, and numerous authors have determined that the accuracy of a calibrated model is determined by using statistical methods of evaluation. These are low mean bias error (MBE) and the coefficient of the root mean square error (CV (RMSE)) (Haberl and Bou-Saada, 1995, 1994, Bronson, 1992). Therefore to present an accurate graphical description that is required in a studio program relatively low statistical values need to be obtained.

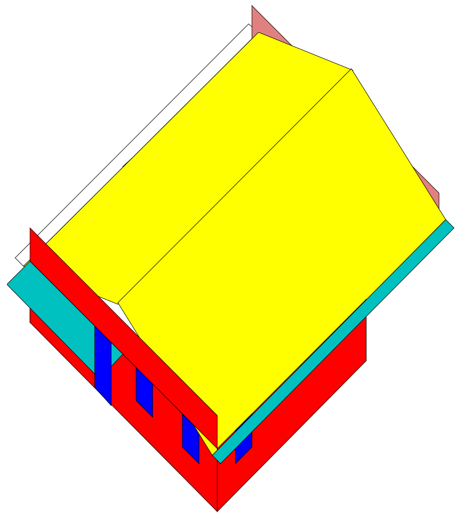

Figure 3: DrawBDL Output of a the Calibation of the DOE-2.1e Building Energy Simulation of a Single Storery Building

It is clearly evident that the requirements of creating a simulated energy model to evaluate the energy use of a building design in an architectural studio class involves considerable amount of technical knowledge, expertise in computing and considerable amounts of time and patience. The creation of a true simulated energy model (using this methodology as defined) can only be created when the "building that is being designed" has been completed and actually is in operation.

The process of creating this evaluation tool for environmental technology is not a simple procedure, requires considerable a time to be understood by designers. The process is not web-based and hence not able to provide rapid graphical feed back, and requires in depth knowledge of programming by the facilitator and the recipient

Using a simple model

One example of a building energy simulation program that is designed for on-line interaction between faculty and students has been developed by the Lawrence Livermore Laboratory, at the University of California, Berkeley. The program named the home energy saver was developed by was created by a group of researchers to assist the public with improving the energy efficiency of their homes and can be used effectively as a tool educational interactive web-based program which allows faculty and students to study over the an internet browser the graphic output of the basic energy use of a residential building. (???????, 2005) check?

An example of program that permits on-line interaction between faculty and student has been developed at the University of California, Berkeley. This has an interactive web-based program that allows faculty and students to interact over a web-based graphic user interface (GUI) to provide basic understanding of energy use in a residential building (Huang, 2000). This gives the student the ability to appreciate in real-time the possibilities what their design decisions will have on a potential project. In a study carried out in the United States it was found that the individual characteristics of the students affected their preferences on the learning path (Cagiltay et al., 2006). The aims of the application include an attempt to provide a cost-effective energy policy, increase objectivity and inclusiveness in an up- to data method of analysis and ease of use. (Pinckard et al., 2005)

The advantage of this program is that it is simple and can be understood by students at each level of the education. It requires very technical background knowledge to operate and it also allows initial concepts of environmental control systems to be introduced and experimented without difficulty. For large numbers of simultaneous users with web access, there is great advantage for both instructors and student in the evaluation of a design.

However, it does have a number of drawbacks. Since it is a fixed model of a particular building, the elementary components (shape, number of stories, etc) of the design are pre-determined; there are very few variables (20) that can be evaluated in the design process and these are aimed at evaluation the energy efficiency of the design. The design process is therefore bound with these variables. As it is web-based program it also has the added disadvantage of being susceptible to computer server failure. It is quick response program and may be even used in a classroom/lecture environment.

Conclusion

Unfortunately, neither of these alternatives method of building energy simulation addresses the pertinent issues faced by designers during their process of design development. The initial type programs require completion of the design process and in-depth knowledge of all the parameters that are to be simulated; the web-based program has not been developed to be able to take advantage of the potential for change in the design as it develops.

Architectural education attempts to concentrate on the process of bring visual processes of design to the fore, and the issues that are evaluated in a design schemes are generally represented graphically. The problem therefore remains, should architectural pedagogy in environmental control systems concentrate on the quick, uncomplicated models or the high end computer simulations in searching for and evaluating the issues of design. The solutions may be summarized in the need for an increased number of simple web-based programs similar to home energy saver which provides increased on-line interactivity for the design process

a) Increased number of simple computer simulation programs.

Many organizations have developed computer programs that enable students to simulate architectural designs aimed to achieve reasonably accurate prediction of building performance in energy use (heating, cooling loads, electricity use, and air flow). These programs used in parametric run mode enable an effective method of determining the potential advantages of numerous design alternatives and evaluation of various energy efficiency measures in architectural designs. These processes have been documented various authors (Kootin-Sanwu, 2004 ;) One of the disadvantages of these simulation programs is the steep learning curve associated with acquiring knowledge of their use. They are complicated, requiring considerable amounts of time for tuition and practice to develop the necessary skill to learn and write the computer code, and correctly interpret the program results. Examples of the more complex computer programs are

DOE-2 (LBL, 1999), BLAST (UI, 2001) and TRNSYS (UW, 1998). Less complicated programs include Solar-10 and ENER-WIN.

b) More advanced building simulation computer programs for more advanced students

The use of complicated computer programming may be addressed in a number of ways. Traditionally, architectural schools did not introduce students to computer programming as part of their educational curriculum and they have typically been the users of products of software engineering companies; requiring students to use prescribed draughting and modelling programs for their designs and example is the ubiquitous AutoCAD range of products. However in the new education paradigm this area of expertise may become necessary and to address the need for greater interaction computer programming may have to be introduced in the curriculum of schools. Changes in the curricula of many schools may have to be introduced which assist the development of the applications relevant to the design process. Development of programming expertise must be combined with training of faculty and a revised appraisal of the students.

c) Improved computer skill for students

In the already crammed timetable of schools of architecture, providing increased time for the acquisition and development of computer skills becomes both imperative for the students and difficult to achieve by the faculty. The problem has been solved in certain institutions by using either night classes, and/or out-of-department elective options with schools depending increasingly on expertise of faculty in the computer programming field. It may be necessary for schools to provide pre-requisites for students in the area.

1. increased on-line information that may be accessed for the design procedure e.g. material characteristics, climatic data, lighting information, structural systems, air flow (using computational fluid dynamics principles (CFD)), heat flow allowing designers to take advantage of more advanced simulation packages for greater study
2. improved computer skills for students and improved technical knowledge of the faculty
3. an issue that may be particularly relevant to Africa is the development of a knowledge base for the design typology, material information and climatic data.

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