Teaching for integration of building energy simulation in the design process

S. Delbin, V. Gomes da Silva, D. Kowaltowski
State University of Campinas (UNICAMP), Brazil

ABSTRACT

For many reasons building simulation programs are still not recognized as useful design support tools to the same extent as Computer-Aided Design (CAD) or cost-estimating software. There is a strong perception that simulations are time consuming, costly, slow and require expensive or specialized equipment and knowledge that increase design costs. Additionally, simplifications applied to model description, algorithm inaccuracy, or deviations inherent to weather data treatment methods result in poor matches between measurements and predictions, which decrease confidence in obtained results. Finally, complex tools and interfaces raise doubts among potential users. In general terms, energy efficiency is a recent concern in Brazil, but has clearly come to the discussion forefront among all construction sector stakeholders. In architectural design teaching at the undergraduate level in Brazil, environmental comfort and energy efficiency have been traditionally kept as separate knowledge domains. To overcome these problems a simulation course was designed to best suit the architecture undergraduate course at the University of Campinas (UNICAMP). The bioclimatic design studio given in 2005 provided students a contact with simulation tools and was used to select the most suitable tool for teaching at undergraduate level and still be usable within local constraints. Students were followed up in the subsequent semester (day lighting design studio), while the simulation course was formatted. To consolidate the knowledge acquired in bioclimatic design studios and check concepts on student’s designs, the simulation course was experimentally offered the first semester of 2006. This paper discusses the contextual framework that motivated and founded the approach for the introduction of simulation as both a decision support tool and a design teaching resource, and presents some results and major lessons learned, as well as suggestions for extrapolation and replication at different teaching conditions.

1. INTRODUCTION

Architecture design instructors believe that professional architects have difficulty understanding comfort feelings in buildings (KOWALTOWSKI, 1998; KOWALTOWSSKI et al 2005; DELBIN, 2006). Such difficulty is a consequence of, among others, the lack of knowledge on bioclimatic design and on how to apply related solutions into their daily design problems. Comfort courses are usually taught in a combination of exposition of theoretical content followed by a problem-solving sessions rarely connected to real design problems. Such method fails to fully stimulate development of students’ critic judgment regarding comfort-related issues (BITTENCOURT, TOLEDO, 1997; VIANA, 2001). The statement made by the above-mentioned authors are four years spaced out, indicating that little progress has been made in bioclimatic teaching methods in that period. Teaching methods limitations seem to be combined to a certain lack of effort by design instructors to incentive application of bioclimatic solutions across the non-specific design studios, which could be linked to deficiency in their own background on the subject.

Some architecture design instructors consider the use of simulation tasks during the design process as a solution to overcome the described barriers and help bridging the resultant gap.

2. BUILDING SIMULATION IN BRAZILIAN ARCHITECTURAL SCHOOLS

Building simulation in Brazil is still mainly concentrated in the academic circle with modest application in architecture and engineering practice. The prediction of energy consumption of energy in buildings begun in the 80’s in Mechanical Engineering Departments, and little has changed since then (MENDEZ et al, 2001). The use at undergraduate level, specifically in architectural design teaching, poses additional requirements regarding the most appropriate teaching approach and results interpretation. In Brazil, specialized simulation softwares like DOE2 and ESP-r are used by researchers and post-degree students. In some cases, they are taught for undergraduate mechanical engineering students. At undergraduate level the use of simulation tools integrated into comfort disciplines is modest. Some Brazilian tools such as CTCA and Luz do Sol are employed in comfort disciplines to solve thermo physics issues totally disconnected from a design problem.

Some schools have introduced building simulation into design classes. At the University of Pelotas, students sketch their projects in a specific design tool and simulate them using ECOTECT. The use of simulation tools makes possible to assess comfort performance integrated into the design process (FRESTEIRO, MENDEZ, 2004). The teaching methodologies proposed by Bittencourt
and Toledo also encompass the use of simulation tools as a powerful source by making possible to evaluate different design alternatives, to be combined to comfort laboratories for the development of tasks that can motivate the sensorial perception in different situations (BITTENCOURT, TOLEDO, 1997).

As a response, UNICAMP proposed a pro-active approach, in which environmental comfort is specifically taught in three design subjects where theory and design practice are combined. An applied physics discipline and introductory design classes prepare the students for the discussion of comfort problems. Bioclimatic design is introduced in the fifth semester of the six-year course. The remaining design studios expect the students to apply their environmental comfort knowledge as a synthesis in resolving more complex design issues.

3. CONDUCTED RESEARCH: AIDS AND METHODOLOGY

The use of simulation in design studio activities presents practical limitations, especially concerning the limited time available in a semester system for important complementary studies. A second problem is related to the fact that simulation tools are not fully available or adapted to the design studio practice or to local conditions. Also, students must learn how to use the tools, develop their designs to a degree of detail to obtain input data for simulations all within the time constraint of a 15 weeks semester.

To overcome such barriers our faculty team proposed the introduction of a new discipline course following the bioclimatic design studio, to consolidate the acquired knowledge and test concepts on students’ designs. As a preparation, an experimental research was carried out in the specific design discipline dedicated to thermal comfort and bioclimatic architecture. Lessons learned from this studio experience launched the bases for the specific Applied Computation discipline.

The bioclimatic design studio had an elementary school as design object. The students visited several public schools in the region, covering both good and bad design examples. They fully analyzed the buildings, placing emphasis in comfort aspects. Interviews with users demonstrated that most schools presented acoustic and thermal comfort problems. After this field characterization, design activities began. The architectural brief was presented together with thermal comfort conditions expected for interior spaces. In previous editions of the bioclimatic design studio, final thermal analysis of produced designs has been based on design crits and on a simplified method included in the discipline scope, but these have shown limitations in fully checking achievement of comfort conditions. Simulation was expected to help to bridge this gap.

The full research examined different simulation tools, but for this specific pilot study, Ecotect was chosen (DELBIN, SILVA, 2005), for being an environmental design tool conceived and written by architects.

Students interested in simulating their designs scheduled assistance sessions. In this first contact, students were not exposed to the major barriers that tend to discourage potential users: weather data file was in place, as well as a minimum database on building materials. The same professional conducted all simulations, to accelerate data input and ensure result reliability. Again, the original models were gradually modified, with students’ participation, and re-simulated as many times as judged necessary, answering “what if?” questions to quantitatively experience and analyze implications of possible design decisions or interventions in the built space. This research included design methodology follow-up of this group of students in the sequential design studios. Students evolved in this experiment were followed up during the next design studio which was dedicated to natural light. Once more students had an appointment to have their projects simulated by one of the researches. The main questions expected to be answered were if the students felt that simulation had actually helped them to enhance their final design and, if the perceived improvement in design process provided the necessary stimulus to integrate simulation into their quotidian practice and if and in which way it has modified their design thinking.

Based in these experiences, an elective course dedicated to building simulation was offered to undergraduate students on the first semester of 2006. It was elaborated based on comparative investigation of simulation tools teaching methods. Some adaptations to schedule and teaching methods applied at School of Civil Engineering, Architecture and Urban Design (UNICAMP) were tested. Students that took part in the pilot study demonstrated a need for more efficient tools to analyze comfort aspects of buildings, faster and simpler than typical manual calculations. Theory subjects regarding comfort topics were concentrate at the first six classes, were tutorials were applied to help students handle with the simulation tool. In the following classes students were asked to simulate a real building, designed by an acknowledged architect, and a project of their own. In these two simulation exercises students should analyze building performance and suggest improvements, as a way to build confidence on the use of the simulation tool.

4. RESULT ANALYSIS

During the bioclimatic design studio students clearly demonstrated preference to, rather than thermal effects, simulate lighting aspects of their projects like glare and brise soleil design for quality daylighting delivery. Thermal performance of buildings was left to a second simulation session. During simulations students were frequently surprised by the obtained results. Also, by watching enhancement in colleagues’ designs, students that at first were not motivated to simulate their projects began to feel there were opportunities for improvement.
in their own design as well.
UNICAMP architecture students are prepared with a solid basis on computing skills, so that they quickly became familiar with the software features and their manipulation. As a discipline to support comfort teaching, it was a successful experience, as students were capable to carry out deeper judgment of their projects spending less time than they probably would do with manual calculus and to consolidate comfort concepts learnt before. Students declared that the simulation tool itself is easy to be handled, but presented as major limitations for internalization of simulation procedures the difficulty to model organic forms and to divide a building into thermal zones; and the fact the tool interface is in a foreign language, brings further difficulties in tasks like choose the appropriate building material. All the difficulties pointed out were transposed with specific lectures and exercises exploring modeling limitations of the tool, zoning, and creation of a material library based on Brazilian code for thermal performance of buildings. All students that attended the elective discipline see the simulation tool as a facilitator to assess comfort performance of buildings and feel fully capable of using it in their future projects. Regarding the modeling difficulty, they believe that is worth spending some time doing the task, due the quality of results and the straightforwardness on changing parameters to test new simulation alternatives. Solar charts construction was the most acknowledged feature, as it only requires information on the building location and a 3D model that can be imported from tools they are familiar with.

The elective building simulation course intended to stimulate students to the potential of building simulation tools. The 30 hours made available proved to be enough to teach how to use Ecotect and its insertion in a design context. Lighting analysis was very welcome by students, which also showed their interest on learning other more sophisticated tools, such as Radiance. Also more complex tools like EnergyPlus could be introduced through simple exercises to present other robust building performance analysis procedures.

5. CONCLUSIONS
This paper describes the contextual framework that motivated the research and fundament the approach for introduction of simulation as both a support decision tool and design teaching resource. The bioclimatic design studio for 2005 gave students the opportunity to have a first contact with simulation, without being exposed to the major barriers that tend to discourage potential users. Suitability of a certain tool to the proposed experience was tested.
Students were receptive and excited with the opportunity to experiment their designs and with the possibilities simulation presents in this sense. The first question asked is if and when they should bring their 3D digital model, which confirms the expectations for linking geometric information and non-geometric information about the represented objects.
During the elective the thermal simulation task indicated that students have a good comprehension of modeling commands and know how to run shadowing and insulation analysis. Difficulties are clearly related to thermal comfort analysis. Building zoning, materials application and results interpretation played the major role in impairing their ability to intervene on their designs. In some cases the students could perceive that the building did perform satisfactorily, but did not know how to find a solution to the problem or which design alternatives to test, revealing a lack of consolidation on bioclimatic concepts taught previously.
The elective discipline contents would probably be better absorbed if formatted as a regular course in the same semester or right after the first comfort discipline. During the following design studios the students should be asked by design teachers to apply the studied – or other - tool during the design process.
Also is well recommended that all faculty members be involved and incentive students to use the simulation tool during design process.
Better results can be achieved through hybrid (digital + drawing board) studio implementation. Students that evolved in the experiment felt more confident designing bioclimatic buildings as observed in the 2006/2007 studios. Simulation complemented in loco observations and building physics exercises.
The research carried out with architecture students in design studios provided the basis for the proposition of a simulation discipline at UNICAMP.

REFERENCES: