The challenges of teaching bioclimatic architectural design

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ABSTRACT

This study presents an experience of a bioclimatic design studio. The teaching methods used in the Architecture Course of the University of Campinas, UNICAMP Brazil are discussed. Design studio activities are combined with thermal comfort experiments and students are encouraged to evaluate design proposals through calculations and design references. Some conclusions are drawn, particularly regarding student design quality. Results indicate the need for new ways of bringing the feelings of comfort close to the design discussions in the studio and incorporate thermal simulations in the course requirements.

1. INTRODUCTION

The University of Campinas (UNICAMP) opened an Architecture and Urban Design course in 1999 as an evening course. In Brazil Architecture Schools emphasize the multidisciplinary nature of the subject. Courses thus include urban planning, landscape and industrial design in their curriculi. A six-year program admits 30 students each year.

Widely noted problems in architectural education directed the development of goals for this course. The most cited difficulties stem from viewing architecture as pure art and the finding that in practice architects lack knowledge and fail to anticipate users' needs (Salama, 1997). Importance given to the artistic content often causes architects to ignore social aspects in architecture and to emphasize their self-expression. This can be shown further through the content of most architectural publications, used as principal teaching material in design disciplines (Nasar, 1986). These are virtually devoid of human content and are directed towards the formal aspects of design with little attention given towards problems of environmental comfort. To overcome this problem in architectural education an attempt is made in our course to structure design disciplines to discuss and develop specific themes; therefore connecting theoretical content with the creative exploration of solutions to problems. Globalization increases competitiveness and in turn demands high productivity of quality design and force many sequential design acts to become concurrent. The requirement for speed exists not only in technology but in the practice of architecture as well. Being competitive today implies skills, knowledge and attitudes towards creative solutions to problems.

The UNICAMP architecture course emphasizes architectural design. Building design must be based on technical, artistic and scientific-theoretical knowledge. This design process needs creative stimulus as well as the development of communication skills. Urban planning and design is supported by GIS (Geographic Information Systems) instruction within the planning disciplines.

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 combine their environmental comfort knowledge as a synthesis in resolving more complex design issues. During the last two semesters of the course, each student must develop an individual design project which has to be defended before a jury of invited architects.

2. TEACHING THERMAL COMFORT AS A DESIGN ORIENTED SUBJECT

Teaching design is traditionally based on studio 'crits' of students' drawings and models. The discussions of aspects of thermal comfort are mostly limited to siting of buildings, forms or volumes which enhance ventilation conditions, orientation and location of openings and detailing of shading devices. Combining theoretical aspects of thermal comfort phenomenon with design studio activities is the way our architecture course has been the guiding idea to widen the discussions. As shown in Tables 1 and 2 students in our thermal design classes are introduced to a variety of subject, design discussions, laboratory activities, calculations, case studies with measurements and visits to sites and buildings which illustrate solutions and problems. Invited talks are present during the semester.

Each semester a design theme is chosen mostly concerning educational buildings. This theme is selected primarily because school buildings in Brazil are for the most part not air conditioned and thermal comfort depends therefore on bioclimatic design.

Design theory and practice classes pay special attention to discussions on the contemporary school environment, teaching methods and federal and state recommendations for school building design. Stock plans for educational buildings are discussed through local examples, since public administrations favor the repeated building design principle for reasons of economy through large scale contracts and reduction of design costs. The pros and cons of these issues are discussed to make students aware of some fallacies. Technical visits are introduced to enrich the discussions. They also consider the various siting conditions that a stock plan design should be able to respond to as shown in the matrix of necessary design adaptations of Figure 1.

Bioclimatic design is introduced formally in the first class with examples of design strategies. The design studio team has experience in relation to special conditions of the local climate and social and economic considerations (Labaki

Table 1: Subject matters of bioclimatic design course.

Introduction to the design theme and Bioclimatic Strategies
Climate as a basis for design
The school environment, introduction to case studies of school buildings in the region of Campinas (Design crits)
Human response to the thermal environment and thermal indexes
Stock plans and other design principles for public school buildings in Brazil (Design crits)
Solar geometry
Debate on contemporary tendencies in school design and stock plans (Design crits)
Sun shading devices
Thermal properties of building materials
Design development
Solar radiation, external wall and roof color, glazing, green house effect
Visit to design examples (solutions and problems)
Ventilation, cross and stack ventilation
Thermal Mass and evaluation calculations
Site-planning, vegetation and pavements

Table 2: Activities and Tasks of the bioclimatic design course.

Exercise 1: Critical bioclimatic design evaluation of contemporary Architects
Exercise 2: Climate evaluation using the Mahoney Method
Exercise 3: Site evaluation and site model
Exercise 4: Measurements of environmental parameters and use of thermal index software
Exercise 5: Preparation o debate on pros and cons of stock plans for school building design
Exercise 6: sun dial construction, use of solar charts and demonstration of heliodon with models
1st. Design hand-in: site analysis, volumetric modular study
Exercise 7: Design of various sun shading devices for different orientations and locations
Exercise 8: Case study of school environments with measurements and questionnaire application
2nd. Design hand-in: preliminary studies
Exercise 9: laboratory demonstration of thermal performance of materials and building components
Exercise 10: wind tunnel experiments
Final design hand-in: design detailing
Exercise 11: calculation of a space from students own design
Exercise 12: Trees species and solar attenuation

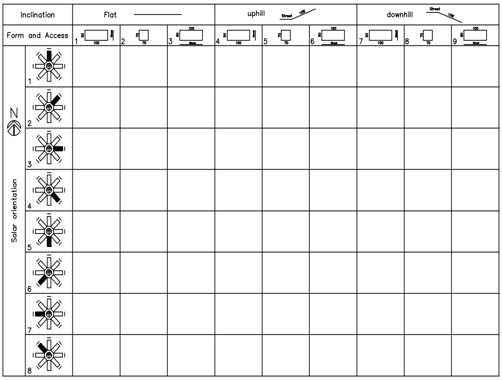


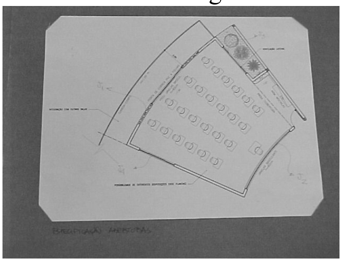
Figure 1: Matrix developed for students to reflect on siting conditions of designs based on stock plans, considering three different topographical and eight solar orientation conditions and nine site shapes and access conditions.

and Kowaltowski, 1998). All classes are available to students through the Universities distance education system.

The following issues are presented and illustrated: site analysis, architectural program and activity definitions with relation to metabolism, clothing, form, volume and site distribution definition; shading and sun penetration analysis (opening dimensions and orientation, shading devices); glazing area definition; roof area exposure and detailing (color, material, openings for stack effect, access and maintenance); ventilation conditions (predominant winds, opening orientation); construction details (materials, thickness, composition of building components, exterior color); site detailing (vegetation, water ponds). In the second class climate is discussed in depth: medium, maximum and minimum temperatures and their yearly distribution in the local climate; predominant winds; relative humidity and macro and micro climates. Thermal comfort is presented as a feeling of well being and discomfort is shown to cause health and productivity problems in humans and animals. Thus extreme temperatures, humidity and ventilation conditions should be avoided. Excess thermal and direct solar radiation are problematic as well. The type of clothing and user activities are also shown to be related to comfort.

Students develop their design projects on an individual basis and have weekly studio *crits* by two different design professors. A specialist (physicist) is also present in the design studio for consultations on thermal concepts. The first definition of the design form or the design concept may force the total design in the direction of a bioclimatic form with problems such as for instance found in round forms with multi-oriented building façades (Figure 2 A and B). A wrong first choice can hamper the successful development of a bioclimatic design. Students are often reluctant to give up a formal approach even when flaws are pointed out.

Even with good students at this stage the bioclimatic principles are not sufficiently clear or strong to direct their design choices and the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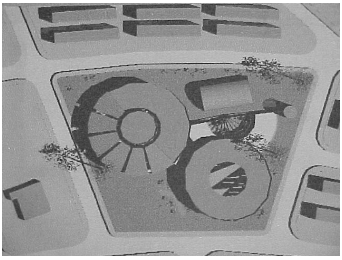
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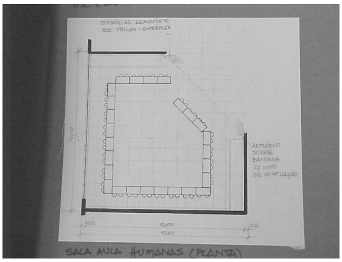
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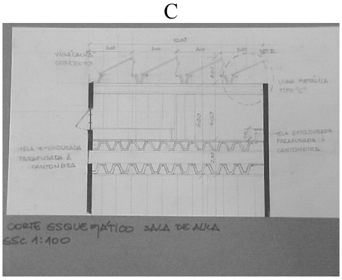

D

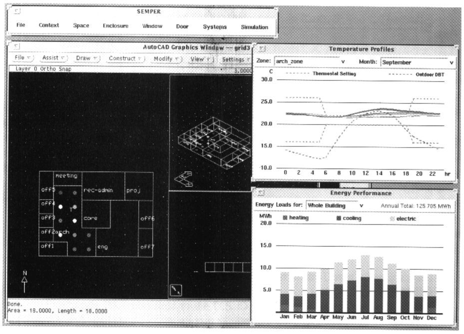
Figure 2: Examples of Student designs.

thermal analysis of designs which must be performed at the end of the semester often are disappointing. On the other hand students can reach a fair amount of good detailing in one semester when they adopt a good design basis early and feel confident throughout the term to develop the concept (Figure 2 C and D) One of the problems encountered in the teaching of bioclimatic design is the visualization of feelings of comfort through the design medium, the drawing (Kowaltowski et al., 1998). The visualization of the feelings of comfort is a challenge in graphic representation of architectural designs. Research in environmental comfort is normally based on technical theory and architectural elements that can bring about conditions of comfort.

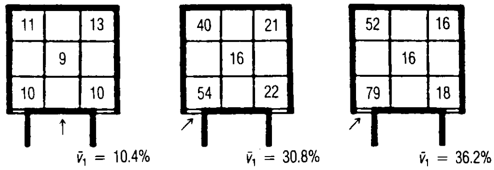
To visualize comfort phenomenon during the design process is considered of importance, so that theoretical knowledge can be transferred correctly and efficiently. Due to peculiarities of graphic communication, difficulties exist in incorporating environmental comfort parameters and simulation results presentation (Figure 3 A, B) into design expression. The design process necessarily includes evaluations, which would be greatly enhanced through graphic images of comfort concepts.

However in the design studio the traditional architectural drawing is still prevalent and attempts to evoke feelings of comfort often elude. For instance, the degree of ventilation can be misinterpreted from the typical representation of air movement in drawings through arrows passing through the section or plan of a building (Figure 3C, Figure 4A). Mistakes are often perceived only through post occupancy evaluations. In the teaching environment however the opportunity for post occupancy evaluation of the students design does not exist.

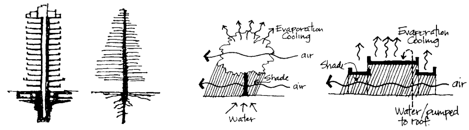
Professors involved in design studios believe simulation exercises during design development are the answer to overcome some of the difficulties identified. This presents practical limitations, especially concerning the limited time available in a semester system for important complementary studies. 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



A: Graphic results from typical computational thermal simulation (Mahdavi, 1996).



B: Graphic results from wind tunnel experiments (Givoni, 1976).



C: Architects often design through analogy (Laseau, 1994).

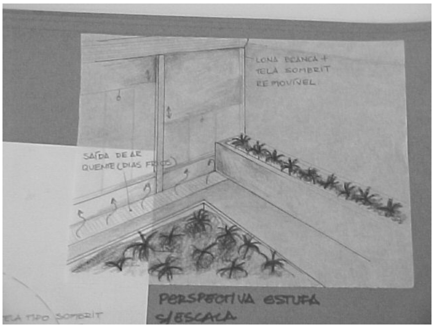
Figure 3: Visualization examples of thermal phenomenon.

for simulations all within the time constraint of a 15 weeks semester.

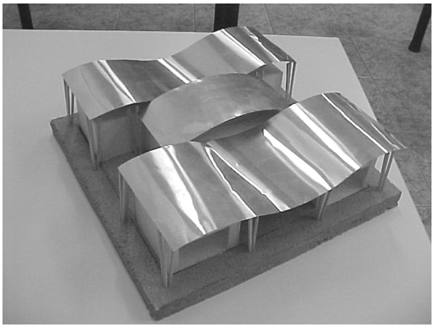
To overcome these problems our faculty team proposes the introduction of a new discipline soon after the bioclimatic design studio, to consolidate the acquired knowledge and test concepts on students´ designs.

3. DISCUSSION

The course has come full circle in 2004, with the first graduating class and our design faculty members have analyzed our bioclimatic design studio teaching approach in final design projects, presented in Figure 5. An evaluation of these projects shows that the bioclimatic quality of designs depends on three specific conditions: studio instructors/advisers with a strong interest in climate conscious design; student's direct participation in research project, linked to environmental comfort; the personality of students'



A: Students use the typical representation of imagined ventilation conditions.



B: Some students explore comfort aspects in roof design with: double skin, ventilated atrium, overhangs and air renovation through stack effect.

Figure 4: Examples of student work showing bioclimatic concerns through design elements.

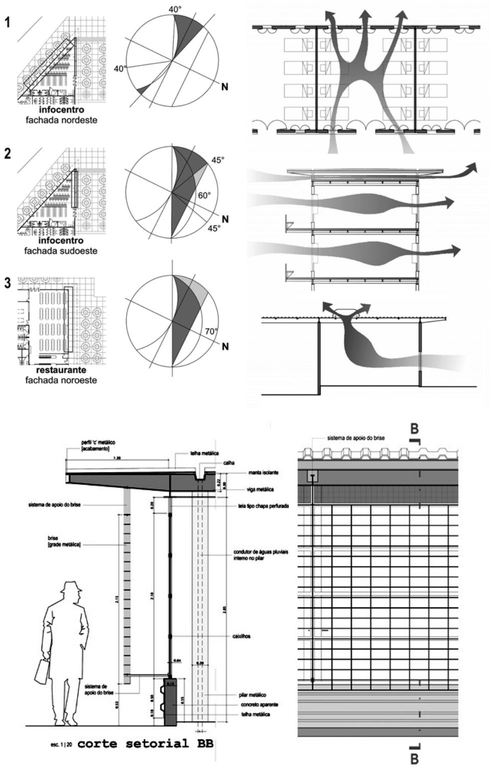


Figure 5: Examples of final design projects of students showing bioclimatic aspects through design elements.

which may divert students’ interest in other issues of design. While some students are more open to advice, others see the final design project as an affirmation of a new found professional character, avoiding important comfort issues in favor of aesthetic and ideological concerns.

During the final year our students often expressed specific doubts in areas such as acoustics, thermal control, structural analysis and building technology. Although these areas are all present in the curriculum and integrated into the design studio, the final project seems to awake a greater sense of responsibility of students and a true interest in the synthesis of varying architectural aspects. To enrich their final design process of their formal professional education, students individually sought advice from faculty, which was not always very effective. Advice was often too general and in some cases too conservative, especially in relation to structural design. Thus our design studio teaching team recommends a formal system of consulting in specific fields as part of the final year program to improve the dynamics of student - faculty interactions and to better simulate a complex professional design situation.

4. FINAL CONSIDERATIONS

The experience of emphasizing environmental comfort and particularly bioclimatic design in an architecture course was presented here and some conclusions can be drawn.

New ways of bringing the feelings of comfort close to the design discussions must be introduced into the design studio. Use of models as a source of information regarding response to visual and thermal comfort should be intensified. Simulation tools adapted to design studio activities should be made available and intensively used. The whole design teaching team should share goals for stimulating environmental comfort thinking in architectural projects. This compromise should be present in all design studios.

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