An easy-learning and easy-teaching tool for indoor thermal analysis - ArcTech

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ABSTRACT: ArcTech is a software being developed, applied and improved with the aim of becoming an efficient sensitization tool to support the teaching-learning process of Architecture courses. The application deals initially with the thermal comfort of buildings. The output generated by the software shows if a student is able to produce a pleasant environment, in terms of thermal sensation along a 24-hours period. Although one can find the very same characteristics in fully-developed commercial software, the reason to create ArcTech is related to the flexibility of the system to be adapted by the instructor and also to the need of simple tools for the evaluation of specific topics along the courses. The first part of ArcTech is dedicated to data management and that was developed using the visual programming language Delphi 7 and Firebird as the database management system. The second part contains the parameters that can be changed by the system administrator and those related to project visualization. The interface of the system, in which the student will learn how to implement and to evaluate the project alternatives, was built using Macromedia Flash. The software was applied to undergraduate students revealing its easy-learning and easy-teaching interface.

Keywords: building simulation, thermal comfort, teaching tool

1. INTRODUCTION

Although buildings energy consumption is strongly dependent on the human environmental comfort, still nowadays this fact is neglected in many building designs.

In Brazil, for instance, many contemporary architects were taught as if the thermal comfort was just an optional parameter in Architecture. The obligatory emphasis of thermal comfort in Brazilian Architecture courses has about 20 years now. That means that even many building design professors teaching today barely acquired the knowledge of the importance of the environmental comfort for the energy saving process.

Common results of this fact are bad oriented buildings (like west façades for tropical climates) and the use of high energy consumption materials (as glass façades exposed to direct solar rays).

Unfortunately, the implementation of environmental comfort as an obligatory matter does not yet guaranteed its application in architectural design. There are still many actions to be developed in order to get the right value of that matter and to have architects effectively applying it.

One of the barriers for getting better results is the teaching and learning process itself. There is an urgent need of developing strategies that point to the experimentation field and predicting tools and not only to the theoretical approach.

Considering the important role of software applications in these strategies, there are fully-developed commercial or free software that are good tools examples. For instance, ECOTECT, developed in Australia by [1] in the early nineties, is a complete system of software for thermal, lighting and acoustical performance of buildings. In Brazil, one of the earliest references in the simulation of thermal performance of buildings is the software Arquitrop, having many versions developed by [2] (in the late eighties). Also a Brazilian example is the always up-to-date work of the team of [3] that must be highlighted, where many tools for environmental performance of buildings are freely available. All these tools brought to the teaching and learning process important contributions. However, they work mainly as tools for an engineering-like approach, or for graduated professionals and specialized people, who can easily manipulate the interfaces and interpret their results.

On the other hand, for beginners or undergraduate students of Architecture, this is not true. There are too many information and inputs necessary to simulate buildings thermal performance that does not yet belong to their knowledge domain and some complex outputs not easily usable. Furthermore, the interfaces manipulation complexity usually does not attract the architects.

Therefore, the proposal of this research is the development of a teaching and learning tool, whose main target are the undergraduate students of Architecture.

The very first step here presented is a result of a cooperative action between the Architecture Department and the Industrial Technical School, both of the São Paulo State University. A group of students from the very last year of the technical school were asked to consider the development of that tool as part of their one year practical work. For that purpose they were supervised by a teacher of computer science and others of environmental comfort.

This paper presents the complete process of this first step, showing the development, the interface created and the evaluation of the results applied on a volunteer group. The tool was called ArcTech.

2. THE DEVELOPMENT AND THE GOALS OF ARCTECH

ArcTech should present some important features:
- It should be a simple tool with friendly interface compatible with the architecture language;
- It should be a flexible enough system to be adapted by the instructor for the identification of the actions of the students and evaluation of knowledge.
- It should be the first embryonic step that must be enhanced for further teaching and learning environmental tools.

First of all the technical students had to make a research about the graphical language of architects and how to translate that into a computational algorithm. That was part of their practical evaluation in the school and should be done in order to prove their capacity of developing a real case software package.

ArcTech should have two parts, the first one dedicated to data management, what includes the algorithm for thermal comfort assessment. For this purpose the thermal algorithm applied the finit elements implicit method. It was developed using the visual programming language Delphi 7 and Firebird as a database management system, [4] and [5]. The second one contains the parameters that can be changed by the system administrator and those related to project visualization.

The databases of the Arctech are:
- Cities: latitude data and climatic data;
- Materials: specific heat, specific mass, thermal conductivity, color, area and thickness;
- Objects: doors, windows, floor and walls.

The interface of the system, in which the student will learn how to implement and to evaluate the project alternatives, was built using Macromedia Flash. It was developed for MS Windows environment, to run on a network and it applies Portuguese language, since it was developed aiming the Brazilian students.

For the thermal comfort conditions evaluation the thermal algorithm applies the traditional Mahoney tables comfort zone. That considers the maximum temperature as a parameter for the diurnal comfort conditions and the minimal temperature for the nocturnal comfort conditions.

This embryonic tool should than serve as a basis for another group of student at the technical school to complement its development in the next year, including other parts like daylighting and acoustical modules.

The most important goal in this step is to achieve the simplicity of the interface, allowing the thermal environmental analysis of simple rooms and showing to Architecture students the importance of design decisions in their projects. In this case, the use of ludic components brings the necessary attention of the students.

3. THE INTERFACE AND ITS TOOLS

The interface was created with two kinds of environment, one for the instructor and another one for the students.

3.1 The instructor environment

A fundamental feature of teaching and learning software is the administrator role. The administrator should be able to determine the main aspects of the specific topics to be emphasized in his class.

For the instructor coordination it was created the administration module, where the instructor manages all the work of the student. He is able to introduce the users' name, their login and the name of the users group – Figure 1.
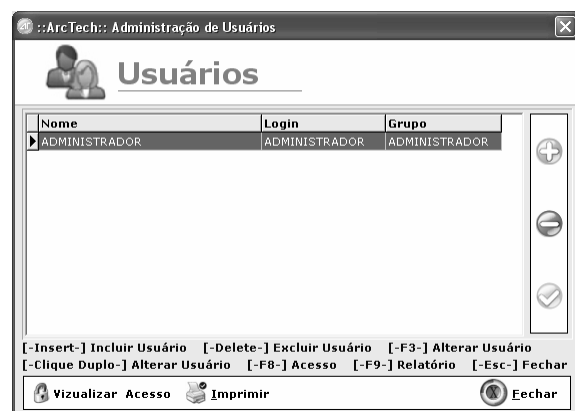

Figure 1: The administrator area to coordinate users.

Another important advantage for the administrator is the possibility of controlling the tools a group is allowed to use in a window named Groups Record - Figure 2. The instructor may check in each field he wants to be available for the students work. The ones he does not check will remain locked during the students work. So it is possible to lock or unlock the field of Projects (new, open or every project), Records (materials, objects and cities), Reports (materials, objects and cities) and Administration (users, groups, history, backup, backup restore).

Figure 2: The Groups Record window.

For each user action, there will be a report available to the administrator in the window called History – Figure 3. That window contains data about the users name, action, date and time.

For teaching purposes, these features are important tools. That makes the instructor's work an easy task. It's a way of identifying many difficulties it may occur in manipulating the software or even in applying the theory. In addition, it is a way of evaluating the students' work in a very simple interface.

3.2 The students` environment

The students` environment launches with the interface presented in Figure 3.
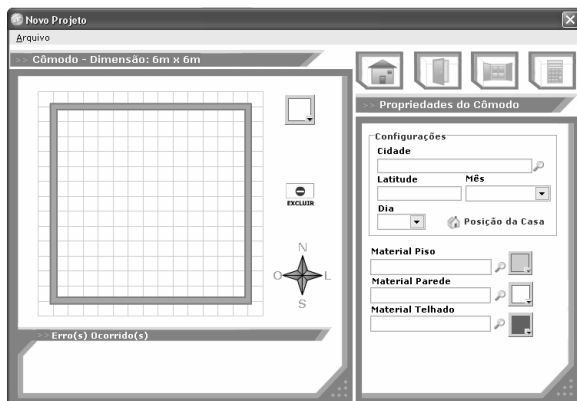
Figure 3: The students ArcTech interface

On the left side of the environment there is the graphical representation of the plan view of the room to be thermally evaluated. The icons of the above right side of the interface are available to insert doors and windows – Figure 4.

Figure 4: The icons of ArcTech

These icons access the material library for each element.

The first icon is used to specify the general properties of the room, which means, the city, the latitude, the data to be analyzed, the materials and colour of floor, walls and roofs. These properties can be extracted from a library. It is possible to fix also the orientation of the room by a field that access a window, as can be seen in Figure 5.
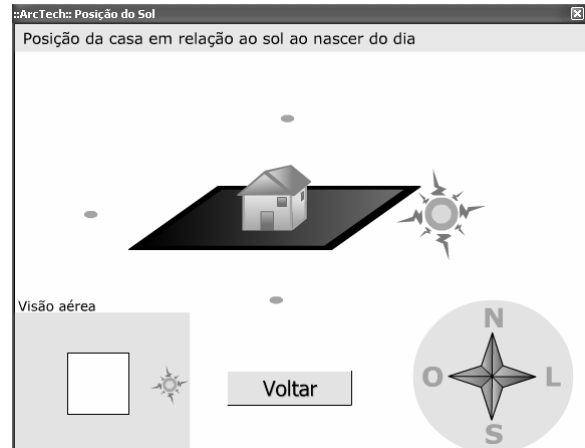

Figure 5: A way to fix the room orientation

Another icon deals with the doors specifications. It opens a box to specify materials of the door and consequently their thermal properties – Figure 6. In that part a "plus" icon is available, so that the door can be included in the graphical representation of the room, on the left side of the interface. The representation of the door appears on the left side of the screen and it can be drag and put into the desired position – Figure 7.

This is the same kind of access generated for the windows specifications, which is the third icon.
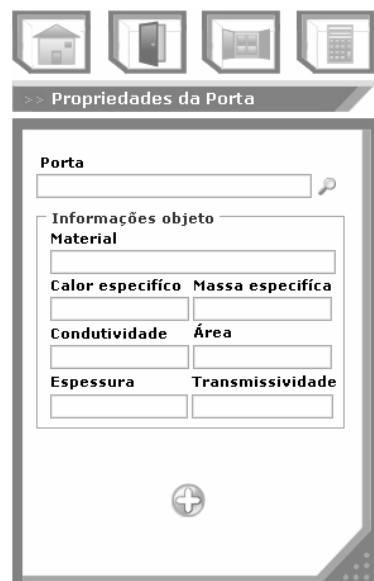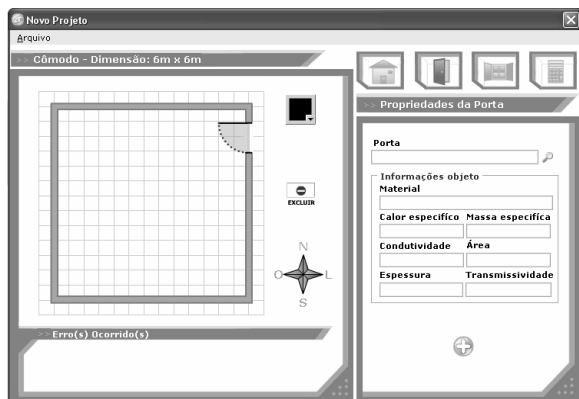

Figure 6: Accessing the doors specifications

Figure 7: The door positioned on the desired place.

The last icon is the calculator module. Then it is possible to visualize indoor temperatures in a tabular or graphical presentation. And there is the option to verify the diurnal and nocturnal comfort conditions buy visualization. There is the ArcTech mascot that flashes, indicating if it is cold, hot or under comfort conditions. Figures 8 to 10 show the representation of the three cases.
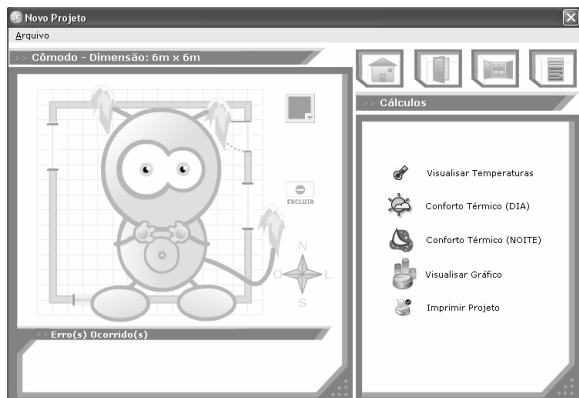

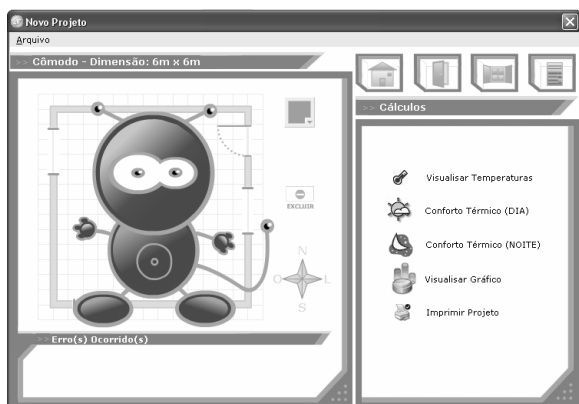**Figure 8**: The ArcTech mascot indicating cold conditions

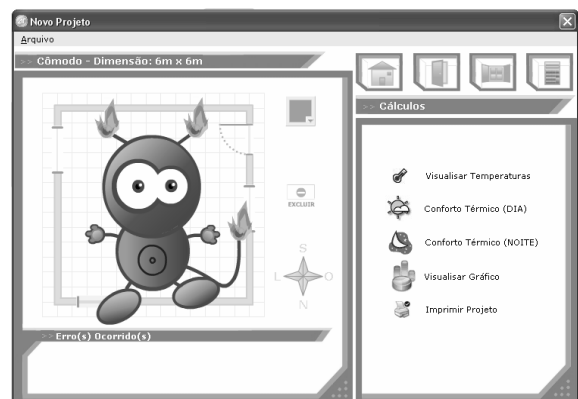**Figure 9**: The ArcTech mascot indicating comfort conditions

Figure 10: The ArcTech mascot indicating hot conditions

In the end the user can also print a report showing the specifications of the room created, as shown in Figure 11.
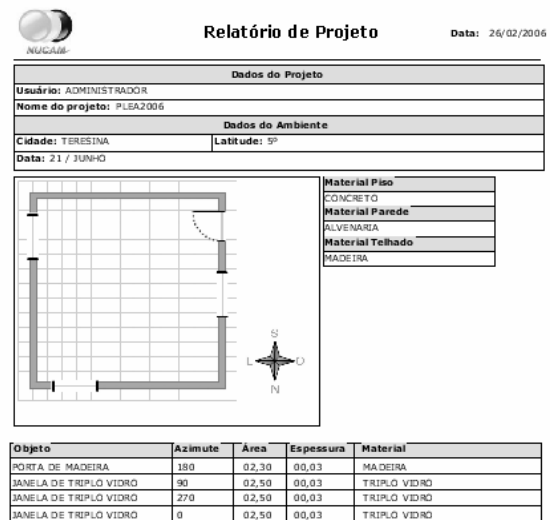

Figure 11: A report of the room created.

4. EVALUATION OF THE RESULTS

Some volunteers were asked to participate in the first application session of the ArcTech tool. That group represented a sample of 5 % of the undergraduate students of the Architecture course, and 17 % of the students actually engaged in the Environmental Comfort discipline. There was also a participation of one computational teacher (this one out of the developer group).

The evaluation was centred in the students' environment. All of them were aware that the software was an environmental tool, but not knowing exactly the purpose. Although in different stages of the Architecture Course, all students were attending or had already attended the discipline of Environmental Comfort. About 56 % of them were enrolled in the first year of Architecture, 38 % in the second year and 6 % in the third year. They were in average 21 years old.

Without having much information about the tool, they were asked to manipulate the interface and fill in a form. They were given 5 to 10 minutes to answer some questions about the software.

The first question about the software was "What do you thing this software can be used for?" All students were able to precisely answer the question, some of them emphasizing that it could simulate indoor thermal comfort, allowing variations in the building orientation and in the materials applied and the assessment of the thermal effect of those changes.

They were asked to classify the interface among these options: very easy, easy, not very easy, not very difficult, difficult, and very difficult. About 23 % considered the interface very easy, 65 % easy and 12 % not very easy. There were no answers pointing to the other options.

Another classification of the interface was taken into account, so that the didactic point of view could be evaluated. Therefore, they were asked to answer the question "How do you classify the interface didactically, when you compare to the other tools you have been introduced during the course of Environmental Comfort?" For that question about 12 % considered it very didactic, 76 % didactic, 6 % not very didactic and 6 % did not answer.

For them the weak points detected were the impossibility of changing the room shape and the small number of materials available in the library by the time of the test.

The positive aspects stressed were the easy manipulation, the possibility of practical analysis, the friendly interface and the simplicity and attractiveness of the interface.

Although still under development and not yet evaluated by most part of the undergraduate students, there is a belief that ArcTech must be an alternative tool for the teaching and learning process of designing buildings considering their thermal performance. The results here pointed out the tendency of classifying the tool as a didactic instrument.

What it is also interesting to highlight is another dimensionless fact. While applying the test, the group of developers could verify the reactions and expressions of volunteers, and consequently the attractiveness of the interface. It could be verified that many of the volunteers were reacting as if they were playing a game.

In other words, it seems that ArcTech achieved the language of the undergraduate students of Architecture, who could also take the advantage of having fun while studying.

5. CONCLUSION

What is important is not the innovation, but the simplicity of the interface.

The ArcTech teaching and learning tool has proved to be a very efficient way for applying the students' knowledge of thermal comfort in buildings. In a generation of games and computers users, applying the software to explain the physical phenomenon demonstrated to be a link to achieve the interest of undergraduate students. It works as a digital laboratory, where the practical analysis is an efficient learning tool.

Specifically for undergraduate students of Architecture, the interface created was very friendly, mainly if the student was familiar to other packages of architectural simulations.

On the other hand, the experience itself of developing a teaching tool in a collaborative way, by linking the knowledge of environmental comfort specialists, computation specialists, and students of the Technical School and Architecture students was very efficient and successful.

The next step of this work is to enhance the possibilities of room configurations and to correct or optimize tools that could be causing any difficulties during the classes of Environmental Comfort.

ACKNOWLEDGEMENT

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