THE COMPUTER IN ENGINEERING EDUCATION:
AN EXPERIENCE

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ABSTRACT

Not a long time ago the College of Engineering of the State University of Rio de Janeiro (UERJ), had limited computational resources. The computers available were concentrated in the Computer Sciences Department. Although they were intended for the use of all the engineering students, only a few from other departments used the machines. They used only general purpose software such as word processors and spreadsheet. In short the computer was not used as a design tool.

Things started to change when the College of Engineering obtained funds from a program for modernization of engineering education (REENGE) sponsored by the federal government. Several personal computers were received and instead of concentrating them in a big laboratory, smaller laboratories linked to different engineering programs were created. It's been almost two years since that that decision was taken and the promising results have boosted a new motivation for the students and professors. A fine example of this change is noted in the graduation final projects that since then have been developed using software such as AutoCad, Matlab, MathCad, ANSYS and many others.

The paper describes the above mentioned experience and also shows the plan to continue the modernization of engineering education. The next step is to give the student the opportunity to practice or construct the real model based on what he/she has learned in theory and has simulated on the computer on a so-called hands-on project. That requires the existence of good laboratories and partnerships with industries and other engineering education institutions.

INTRODUCTION

This paper briefly describes the historical evolution of the computer facilities used in the College of Engineering of the State University of Rio de Janeiro, UERJ. This evolution is not only connected to development of computational systems itself but also strongly related to the university creation and development.

This will be followed by the presentation of this paper's main objective: the description of new methodologies used in the Computational Laboratories. These methodologies seek the modernization and the re-structuring of teaching/learning techniques based on the tripod: theory, simulation and experimentation. As an example, the description of a project developed at the Civil Engineering Computational Laboratory is also presented.

HISTORY

The State University of Rio de Janeiro (UERJ) holds a very peculiar computational area history. In 1974, when the Former State of Guanabara and the State of Rio de Janeiro were united, UERJ had some of its colleges located in the neighborhood of São Cristóvão and others in Maracanã. In particular, the College of Engineering, with its Laboratories and Library, was located in São Cristóvão. However, the basic courses of the Engineering program, including Basic Computer Science, were held in Maracanã.

In 1977 João Lira Filho Pavilion located at the new Negrão de Lima Campus, was inaugurated. The different Colleges of the Center of Education and Humanities and of the Center of Social Sciences were then transferred to this building. At this period the UERJ Computer Center was absorbed by the new Data Processing Company of Rio de Janeiro (PRODERJ). In spite of being located in the same building PRODERJ rendered services to other state companies and secretariats with a same priority level given to UERJ. This fact practically distanced UERJ of the computational tools available at that time.

In the beginning of the eighties, with the consolidation of its courses in the Campus of Maracanã, the demands for administrative and academic computational use intensified and PRODERJ created a center for computational support for students and lecturers. In practice this initiative could be summarized as an access to running programs in FORTRAN through data cards and some few terminals.

In 1983 the Faculty of Engineering was also transferred to the Campus of Maracanã with the exception of the Mechanical and Civil Engineering Laboratories. At the same time, concerned with its technological gap and dependence to PRODERJ, the University installed a centralized computational environment IBM 4341 with 3270 terminals by means of a partnership with IBM and PRODERJ. This measure immediately improved the Introduction to Data Processing course, part of the engineering's fundamental cycle.

However the computational centralization still did not allow new improvements in teaching methodologies to be implemented in other engineering courses.

The evolution and consequent migration of centralized computational systems to the use of personal computers (PC's) have affected significantly the computational environment of the College of Engineering. At the end of the eighties the College of Engineering already possessed a few PC's, which led to a decrease of the dependence to PRODERJ. As the computational resources were scarce, the College of Engineering created a centralized computational laboratory, in spite of the great demand from all its departments.

In 1991 UERJ central administration began to invest in personal computers and in the expansion of the use of IBM terminals. Later on, within that centralized structure, some engineering professors were already making use of BITNET. In 1993 a first access, although limited, to the INTERNET was consolidated. At that period, the Electronics and Computer Sciences Departments already made use of the microcomputers to run engineering computational programs, but all the other departments only used them for word processing and spreadsheets' works.

In 1996 all the engineering departments possessed a few personal computers. This fact motivated the use of these resources by students and professors from all the engineering departments. Almost at the same period, as part of the REENGE/PRODENGE inter-governmental program sponsored by FINEP, CAPES/SESU, CNPq, the College of Engineering was mobilized to develop a computer decentralization project to boost the motivation of students and professors for the use of new computational and teaching methodologies. Three new laboratories were then created: the Computational Laboratories of the Civil and Mechanical Engineering, and a Simulation Laboratory as part of Electrical Engineering Laboratory already existent.

As part of the program REENGE, a computer network, linking all the departments and computational laboratories, was created to improve internal communication and to provide Internet access. At the moment the Computational Laboratory of the Basic Engineering Sciences is being concluded. This laboratory will make possible a better performance and a larger participation of the students enrolled in the fundamental courses of the Engineering program.

COMPUTATIONAL LABORATORIES

This section will present the description of general use and new methodologies adopted in the Computational Laboratories of the College of Engineering

Regular activities

The Computational Laboratories were created as part of the effort made by the College of Engineering of UERJ to decentralize its computational facilities. This action was supported by the overgrowing need to access programs specifically designed for engineering use. These programs have changed the way designers deal with laborious tasks such as structural and fluid dynamics analysis by simplifying these jobs and allowing the engineers to be focused on more significant issues. Before computer decentralization the use of computers in the different courses was an exception.

The computational laboratories are frequently used by students. Statistically about 50 students are logged every day in each Laboratory. The users not only access word processors and spreadsheets, but also different programs as engineering design tools. Programs such as AutoCAD, Mathcad, Maple, MATLAB, TQS, ANSYS, CYPECAD and others are now regular tools for the course assignments. Another regular activity in the laboratories is the use of Internet connecting the university with the whole world.

Educational experiences

The use of any program for engineering analysis and design should be followed by a close and adequate supervision. The great majority of those programs are conceived as a hermetic system (so called "black box") producing results, consistent or not, in accordance to the input. Some of the more frequent errors are associated with incoherent use of units, misconception of boundary conditions, among others. It's very clear that every engineer should develop a sensibility for the assessment of these programs results in order to decide if they are consistent or not.

With that in mind, the laboratories began the implementation of short courses on the use of the above mentioned software. The first one to be implemented was AutoCAD and it is worthwhile to describe that experience. The offering of that course was basically motivated by two reasons: the students were constantly asking for a specific course on this software and, in addition to that, the market was discarding hand made technical drawings, only accepting the ones produced in the electronic format, in which the AutoCAD has become a standard.

Up to the present more than 200 students have attended this course that have been constantly upgraded in accordance to the time that a new version of the AutoCAD was made available. A new version of the AutoCAD 14 is recently being implemented. As part of the REENGE effort two new short courses using AutoCAD are currently being implemented: an Intermediate and an Advanced level.

One interesting point about this course was that no fee was charged despite the fact that other similar courses from other institutions did not proceed in the same manner. In order to obtain the certificate of conclusion the students have to attend a minimum of 80% of the lecturers and to produce a final project using AutoCAD. With this format in mind, one question arises: how can these courses be supported? The answer to this question is divided in two parts: the College of Engineering and its laboratories provide the computational facilities. The instructors and tutors are selected from the students that have achieved the best

performance in the AutoCAD courses re-feeding the System (A third generation of instructors is currently lecturing in the AutoCAD Course).

Another course was recently organized and produced very interesting results. This short course (30 hours) was focused in teaching the C programming language and the fundamentals of how to produce a simple graphical tool. The aim of this graphical tool is to serve as a friendly interface to engineering programs and processes. In order to evaluate its performance, a pilot class was tested in students involved with a graduation final project, a scientific initiation program or in a laboratory trainee program. The objective of selecting these specific types of students was to quickly access the impact of the course in their projects. The results were quite remarkable producing a boost in the student's projects and awakening in other students the desire to be part of this initiative.

This last initiative is part of the objective of producing, training and giving tutoring support to a new generation of engineers capable of producing software with quality. Very few of these professionals are available today pointing out for a new work field for the engineer. As stated before the laboratory is currently focused in training students involved with a graduation final project or a scientific initiation program but in a medium term all the students interested in the program will be contemplated.

To highlight some of the results already achieved, a brief description of one of these final projects developed at the Civil Engineering Computational Laboratory will be presented [1] . The main motivation for this specific project was the knowledge that a large majority of civil engineering students possessed a great difficulty in visualizing and properly understanding the structural analysis and behavior, in particular, of the column buckling in a 3-D space.

A computer program Column was then conceived to teach the students all the necessary procedures for welded steel columns design. This system was developed in Pascal as part of a Delphi environment. The Delphi environment was selected for producing a Windows 95 compatible program using an object oriented technique. The program was divided in independent modules to produce the necessary portability and to improve the system maintenance.

Figure 1 below exhibits the first main dialogue box of the program where the menu bar, design variables and results and four image objects are pre

An interesting feature for producing designs with different buckling lengths in the x and y-axis is also implemented, figure 2. This feature came as an aid to help the students to overcome the difficulty of understanding the real structural behavior of columns in 3-D.

Finally in figure 3, a list of all the steel sections in which the load/resistance ratio (N_d/N_r) is limited in an interval defined by: $0,8 \quad \dfrac{N_d}{N_r} \quad 1,2$ is exhibited.

CONCLUSIONS

The presence of the computer in the education process at the different Departments has improved substantially the quality of the offered programs. In a short period of time the students began to be familiar with modern tools that make them better prepared for the engineering career. In addition the laboratories created an environment where the students meet, discuss and solve engineering problems. There is an increasing demand for more and more powerful machines forcing the university to keep up with the latest versions of software and hardware. The tutor training program for students has achieved very interesting results. There is a new motivation for students to pursue graduate studies and to be involved in teaching and research activities.

The next step for the future is to provide the student the opportunity to practice or construct a real model based on what he/she has learned in theory and has simulated on the computer, on a so called "hands-on" project. On the other hand, this proposal requires the existence of well-equipped laboratories, which is expensive. The partnership with industries and other engineering education institutions will be one of the ways to make it possible.

REFERENCE

[1] Almeida, M., B.Sc. Final Project, Structural Engineering Department, College of Engineering, State University of Rio de Janeiro, UERJ, 1998.
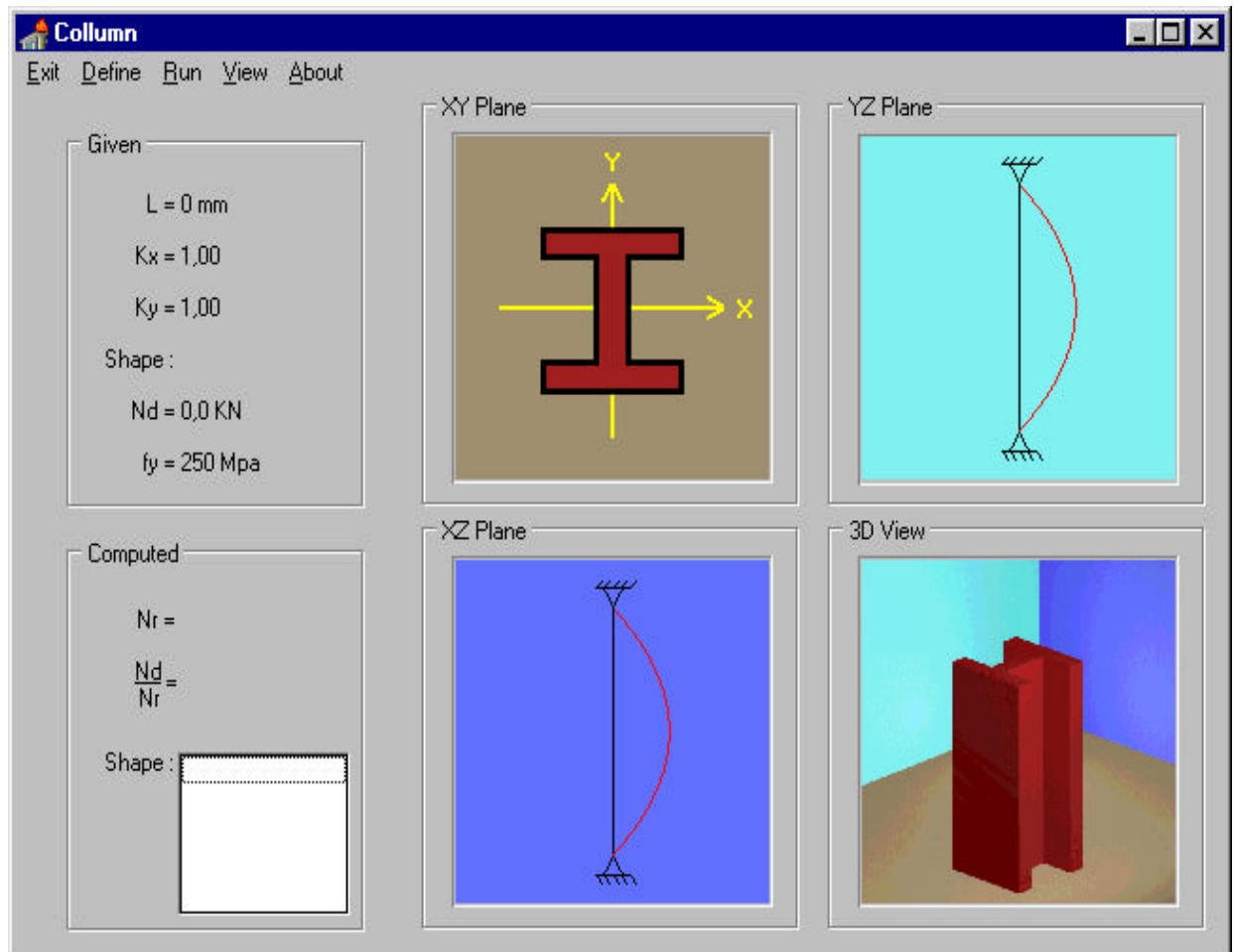
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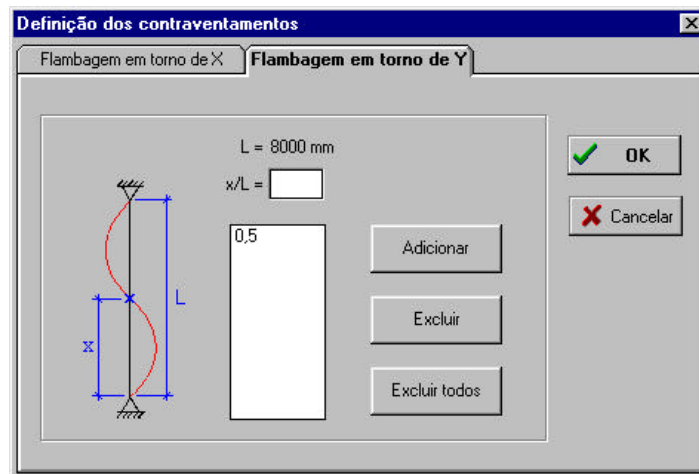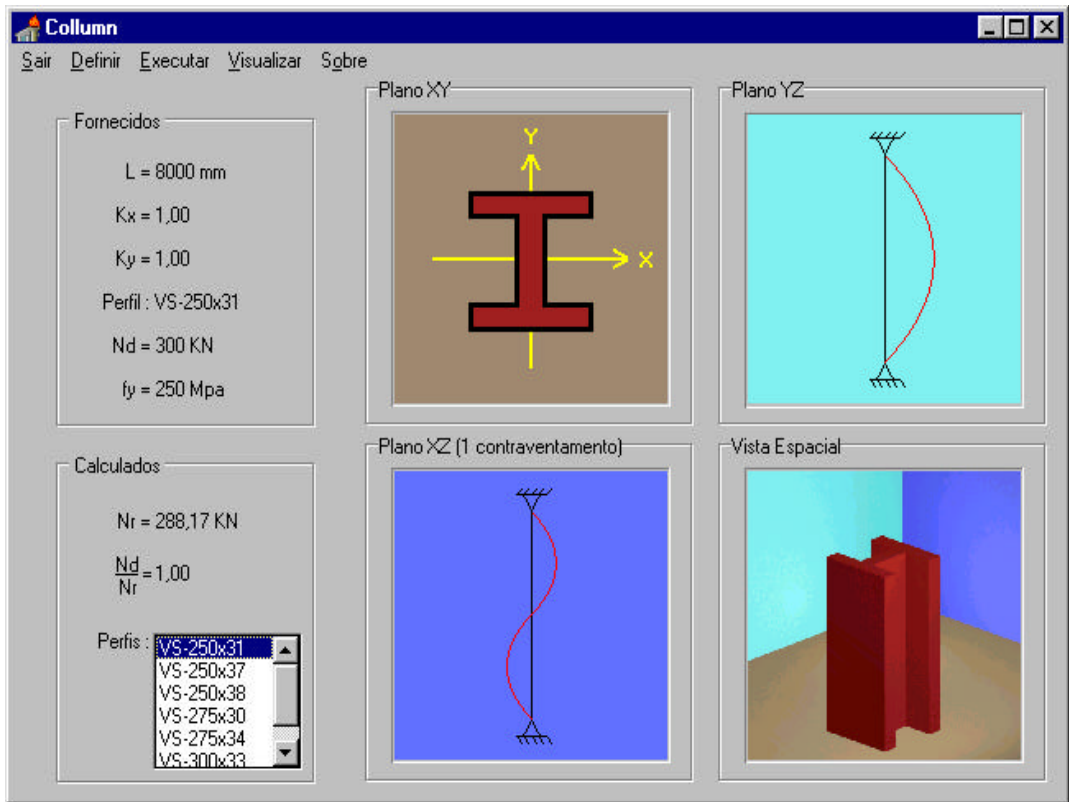Figure 1: *Column's* Main Dialogue.

Figure 2: The Definition of Lateral Bracing Points

Figure 3: Final Design Dialogue