LABORATORY PRACTICE FOR STRENGTH OF MATERIALS AND STRUCTURES BEHAVIOR

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SUMMARY

This article discusses and analyzes an experience that took place at the Rio de Janeiro Federal University (UFRJ): the implantation of laboratory classes for Strength of Materials and Structures Behavior. The main found difficulties are analyzed, as well as the results and the contribution of this work for the quality improvement of the of graduation courses. The implantation of a new pedagogical model is discussed, where the students have a more active and creative participation in the teaching - learning process. Experiences for Strength of Materials and structures behavior disciplines are described. Similar experiences in Brazil, France and Germany are pointed out and analyzed.

It is also described and analyzed some procedures that are being developed at the UFRJ Engineering School, to conciliate the teaching of reinforced concrete theory, design methods and laboratory classes. This subject has great importance for the Civil Engineering education, once many students do not understand how the theoretical concepts can be applied in practice and do not visualize the real behavior of the structures. On the other hand, some students already possess practical knowledge, but can't establish any relation with the theory studied at the university.

In this article the different phases of the structures design and the integration of the student in the learning process are discussed, giving bigger emphasis to the structure's definition, that represents one of the most important stages of the project. The main line of this work is to involve the students in the educate process by leading them to develop their own project at the classroom, having always a critical position and not assuming the position of a simple passive spectator.

Different laboratory experiences used as didactic support for reinforced concrete classes are described. The positive results of the students interaction with the laboratory classes are also analyzed.

INTRODUCTION

The implantation of a didactic laboratory for Strength of Materials and structures behavior has the aim of promoting the improvement of the education quality, by introducing experimental classes in several Engineering courses, especially those of the first semesters like Rational Mechanics and Strength of Materials.

The laboratory gives support to practical classes, design, construction and test of reduced models and study of instrumentation techniques.

The assembly of the Laboratory was coordinated by the Applied Mechanics and Structures Department (DME), in Rio de Janeiro Federal University (UFRJ) which has been traditionally responsible for the disciplines Mechanics (3rd period) and Strength of Materials (5Th and 6Th periods), for almost all the graduate courses in engineering.

This project was developed with the guide lines of the UFRJ's REENGE project, which aims to promote the modernization and the reorganization of the engineering education system at UFRJ.

PEDAGOGICAL OBJECTIVES

The introduction of practical classes with didactic models, in traditionally theoretical disciplines, helps to bring new pedagogical methodologies to engineering education.

The students' contact with the practical classes is planned to be carried through in different levels:

At the first level, the student has an initial contact with the didactic model, during the practical classes. This can simultaneously happen with the hole

class, supervised by the professor, or with small groups of students, monitored by students form later semesters.

At the intermediate level, the student's contact with theory and practice is deepened by means of the activities involved in the conception, design, construction and the analysis of physical models, that will be used in practical classes, from the first level type.

At the advanced level, the student has contact with experimental analysis of physical models, by means of scientific initiation projects. In this case there are an interface between graduate courses and research projects.

There are several other objectives involved in this project, such as:

- provide to the graduate student a basic scientific formation inside of an multidisciplinary integration view;
- extend significantly the contact of the graduate students with laboratory practice in the engineering courses;
- extend significantly the student's amount involved with monitoring activities and scientific initiation;
- create an environment that extends and intensifies the contact of the undergraduate students with research methodology;
- form a team for the continued production of didactic aids for engineering education;
- establish a more clear and direct relation between theory and practice in engineering education;
- enlarge the student's understanding level and the capacity of understanding theoretical concepts;
- provide a room where the students, mainly those of the initial graduate semesters, can actively participate in the process of conception, design, construction and testing of physical models capable to reproduce the behavior of different structures;

These activities can involve a large universe of disciplines, inside of the engineering courses, under the point of view of the integration between theory and practice.

STUDENT'S INTEGRATION IN PROJECT PRACTICE

The elaboration of a structural project demands from the engineer professional an excellent technical qualification and a great experience. With the development of sophisticated computational programs, the work of the structural engineer has modified a lot in the last years. The computation gave a new impulse to the project, but brought new difficulties [1] therefore any error can compromise all the calculations. The engineer must have a global vision of the project and a conscientious position of his responsibility. In this context, the engineering education must stimulate the students' integration in the learning process. The professor does not have simply to transfer his knowledge to the students, but search for the students' participation and lead them to construct their own knowledge. The design classes are an excellent chance for this pedagogical transformation.

A great effort is being made, at the Reinforced Concrete Structures disciplines of the Civil Course of UFRJ's Engineering School, to conciliate the theory with practice in structures Design. The students work with a project in classroom and make another one, more complete, outside the classroom (at home or even at the university). The idea is lead them argue and analyze the best solution together with the professor and, at the same time, to apply the necessary knowledge for the elaboration of their own project. It is important to notice that, in this case, the learning process is not restricted to the classroom environment. The structure's definition, which represents one of the most important stages of the project, is one of the best examples to explain this teaching methodology. The students analyze the architectural plants and define the slabs, beams and pillars positions. During this process, the students begin to understand that a better structure's definition will facilitate calculations, simplify execution and reduce building costs. On the other hand, an inadequate definition will compromise the construction, bring great difficulties to the structural calculation and, even though, financial damages. Thus, the plants of the project are elaborated by the students and not imposed by the professor. The load estimation for a previous definition of the dimensions of the structural elements is also made. This preliminary study serves as an initial reference so that the students can make comparisons with the final results. Without this initial estimation of the magnitudes involved in the project, it would be very difficult to evaluate values obtained from the computer programs.

The students have also the chance to analyze and choose a more adequate structural model in accordance with the characteristics of the project. This choice depends on many factors, such as the calculations degree of precision, the structure's complexity, the loads, the available programs and also the computer's capacity. Not always it is possible to use a more complex three-dimensional model and, many times, some simplifications become necessary. It is better that each student adopts a different model so that different possible solutions can be compared and analyzed. In the final project, the last semester students' have the chance to improve their knowledge. For example, Fernandes [2] made an interesting comparative study of structural models for a building floor. He used a composed model for finite elements. This solution was compared with the traditional structural conception of slabs and isolated beams. Chaves [3] analyzed a flat slab with finite elements and compared with the design method proposed in the Brazilian norm NBR-6118.

Thus, the student's integration with project practice will not only promote the development of all

project phases, but mainly helps to develop his critical and creative capacity.

The teaching of Reinforced Concrete Structures at UFRJ, is planned according to different integrated levels. From the basic program of the disciplines Reinforced Concrete I, II and III (6^{Th}, 7^{Th} and 8^{Th} semesters), the students learn the theoretical basis of the dimensioning procedures. With the laboratory lessons the students can stablish a relation between theory and the real structures' behavior. From the project, developed in the disciplines Reinforced Concrete Structures I and II (9^{Th} and 10^{Th} semesters), the students have the chance to improve their knowledge and to have more contact with calculation and sophisticated methods for structures' dimensioning.

LABORATORY PRACTICE FOR REINFORCED CONCRETE AND STRUCTURES BEHAVIOR

The implantation of the new laboratory and the introduction of experimental classes for the study of reinforced concrete structures behavior, gives to the graduate students the possibility to design structural elements, build and test them, and finally compare the results with theoretical models. This procedures will let the students make the synthesis of all contents of the disciplines involved in this process.

The positive effects of the proposed methodology can already be clearly noticed. A great increase of motivation and involvement is being observed, not only on the students'part but also on the teachers' part. It is also noticed, the increasing of the students' capacity of comprehension and analysis.

A similar pedagogical methodology is already successfully adopted in different Engineering courses all over the world, like in France, USA and Germany.

Some professors from CEFET - PR, that took part on training programs at Engineering and Thecnical Schools in France and Germany [4], had initiated a project with the aim of introducing experimental lessons for reinforced concrete and structure's behavior disciplines. Later, new disciplines specifically orientated to structures laboratory practice were also introduced. In those disciplines the students worked with structural models made in concrete, steel and wood.

THE ASSEMBLY OF THE LABORATORY

The laboratory is working since the second semester of 1996. At the beginning, practical lessons with the use of didactic models manufactured by the English company TeQUIPMENT had been introduced. Initially, the lessons involved only the disciplines Introduction to Engineering (1^{st} semester), Elements of structural Mechanics (4^{Th} semester) and Strength of Materials (5^{Th} and 6^{Th} semesters). Gradually, new disciplines were also involved: such as Mechanics (3^{rd} semester), Structural Analysis (7^{Th} e 8^{Th} semesters), Wood Structures (6^{TH} semester), Steel Structures (7^{Th} semester) and Computational Methods (10^{Th} semester). Currently, the amount of disciplines involved with the laboratory and the proposed methodology is expanding significantly.

Initially only the Civil and Naval Engineering courses were involved. Now, other courses are gradually being involved with this methodology.

ACKNOWLEDGMENTS

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STUDENTS' PARTICIPATION

The students' participation in this project was extremely important. They have directly participated in the didactic models design and construction, besides acting as monitors at the laboratory. Although these activities are usually seen as complementary, the abilities developed during this process have vital importance in the students' education to be future engineers. For this reason, we consider essential the maintenance of the students' training program at the laboratory.

AVAILABLE DIDACTIC MODELS

The didactic models used in the laboratory classes are listed below:

1- tensions' measurement;
2- displacement in frames;
3- displacements in beams;
4- beams' balance;
5- shear center determination;
6- columns buckling study;
7- trusses study;
8- shear study;
9- torsion study;
10- arcs functioning demonstration;
11- tensions, deformations and displacements in metallic beam study;
12- flexure in a wooden beam;

CONCLUSIONS

For everything that it was previously presented, it can be observed that the implantation of the new laboratory and the organization of the team for the development of didactic aids for engineering education is occurring in a surprisingly speed. It is happening mainly due to recent supporting programs specially orientated to graduate courses. University itself.

The positive effects of the laboratory activities can be clearly noticed, in the disciplines' attendance (by offering laboratory classes in traditionally theoretical disciplines) and in the students' education by means of the training programs and the research projects developed in partnership with companies.

The continuation of the supporting programs aimed to graduate courses, such as REENGE, has vital importance for the consolidation of this project.

It is important to stand out that normally the university has no funds or financial supporting programs for maintenance or improvement of the laboratories for graduate courses.

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