THE IMPROVEMENT OF THE LEARNING PROCESS OF BASIC DISCIPLINES AT THE ENGINEERING DESIGN

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Abstract *- The goal of this paper is to reflect upon Engineering Education, starting from experiments that have been carried out at the Federal University of Juiz de Fora (UFJF), aiming to improve the learning process of the content of basic drawing disciplines concerned with graphic representation, which are subjects of the initial terms of the courses of Civil Engineering and Architecture. Those experiments are, as well, the basis of researches that have been done by the authors of this, in the master's degree course (Borges) and in the doctorate (Oliveira), in the field of Technological Innovation and Industrial Organization of the Production Engineering Program of the Engineering Programs Coordination (COPPE) of the Federal University of Rio de Janeiro (UFRJ), under the orientation of Professor Naveiro. The experiments were structured beginning with, among other factors, the verification of the students demotivation for the study of such disciplines, linked to great difficulty in the learning process of the same. One of the reasons for such situation was the students' difficulty in concretely understanding the practical application of those disciplines. The obtained results have demonstrated a radical change in the students' view on basic disciplines of graphic representation and have benefically influenced on the motivation for the study of those disciplines. Besides that, the student begins to have a realistic perception of the chosen habilitation right in the initial terms of the course, which would only happen before with the "engineering applied disciplines" or the so-called "professionalyzing cycle", which are ministered in the second half of the course.*

Introduction

The technological and organizational changes, fruit of the current technical-scientific revolution, determine impacts on all sectors of society. Those changes have particularly affected the professional qualification, as well as determined the appearance of new professional profiles and new requisites for work in a general way (Segre, 1994). Within such context, this paper is concerned with the issues related to the professional formation and qualification in engineering, considering that the current patterns of graduation courses strutucturing present signs of exhaustion, as one can verify from several studies and publications regarding Engineering Education.

In terms of Brazil, diverse researchers that publish in the magazine of ABENGE (Brazilian Association of Engineering Teaching) and participate in the COBENGE (Brazilian Congress of Engineering Teaching), as well as the declarations registered by Engineer 2001 magazine, among others, perfectly show the need for a revision and re-structuring of the courses of engineering so that they become adequate to the current necessities of professional formation. FINEP itself (Science and Technology Ministry Studies and Projects Financier), aware of that shortcoming, has fostered and financed the re-structuring of the engineering courses through the PRODENGE (Engineering Development Program) launched in 1995.

One can verify that such studies, initiatives and programs, kept the due proportions, are in tune with what has occured in other countries, as one can check in articles and publications such as: *Journal of Engineering Education* - American Society for Engineering Education; *The International Journal of Engineering Education* - Tempus Publications (Hamburg, Germany); *Journal of Professional Issues in Engineering Education and Practice* - American Society of Civil Engineers. Also, the existence of inter-institutional programs has been registered, which is the case of NSF (National Science Foundation) Engineering Education Coalition (Engineering the 21st Century) of the USA.

In terms of organizational structure, the courses of engineering, up to this day, have as basis the positivistic conception that guided the birth of the Engineering Schools as we know. That philosophical presupposition for the division and hierarchy of science led to the separation in curricular structuring, among the diverse sciences that participate in the engineer formation, dividing them into blocks: the basics, the engineering basics and finally the engineering applied ones, as reported by Bringhenti (1993). Still the same author considers that "such analytical conception can be useful in getting to understand what engineering in terms of information is about, though it is a mistake to consider that the engineering learning process (in particular, the acquisition of the ability to solve problems) takes place following that conception. The way of organizing a branch of knowledge is different from its way of learning".

In a general way, the fragmented formatation of disciplines still prevails in the courses of engineering, which, most of the times, are ministered without the necessary contextualization regarding the specialty of engineering that it must pretentiously attend. In that case, one supposes "the learning process as the accumulation of knowledge and not as the integration of new parts learned from the previous ones". Such desintegration can be better perceived as much as "the majority of teachers don't even know, besides theirs, which are the other disciplines that are being given in the semester, both the previous and the following, and much less their programs" (Bringhenti, 1993).

Besides that, it is notorious the overload of class hours and the inflexibility of the current curriculums in the majority of those engineering courses. Adding to that are the issues related to the teaching methodology that are practiced, registering even the unpreparedness of the teaching body for the structuring of the teaching of disciplines. One verifies the prevalency of the famous "personal style of teaching" of the teacher, many times to the detriment of the "learning styles" of students (Felder, 1988), which accounts for the low productivity, demotivation and, consequentely, the evasion or change of course.

One must still take into consideration that one uses little of the potential resources concerning "information technology" in the courses, nowadays essential in modern organizations. In fact, what goes on is the sub-utilization of the computerized systems as a tool for the teaching/learning process and as a component of disciplines of the engineering courses. The CAD technology (Computer Aided Design), for example, essential to the development of engineering projects, still hasn't penetrated the majority of courses and, where it is taught, it goes little beyond the automatization of a few drawing activities merely as an "eletronic drawing board" (Oliveira & Naveiro, 1997).

The posed issues in the initial considerations are not restricted to the courses of engineering. "The university teaching is structured under standards that need to be urgently broken off with in its vast majority, as they do not anymore attend to the current necessities of their main clients: the *society*, the *organizations* and the *individuals* (students)" (Musetti, 1997).

In view of such scenario, this paper seeks to make a reflection based on the experiments carried out in the Technical and Projective Design Department (DDTP) of the Federal University of Juiz de Fora (UFJF), which offers basic drawing disciplines, concerned with graphic representation, for the first terms of the courses of Civil Engineering and Architecture and Urbanism.

One should also point out that such experiments served as a basis for the research projects that are being done by the authors of this in the master's degree courses (Borges) and in the doctorate (Oliveira), in the Area of Technological Innovation and Industrial Organization of the Production Engineering Program of the Engineering Programs Coordination (COPPE) of the Federal University of Rio de Janeiro (UFRJ), under the orientation of Professor Naveiro.

The Experiments

In face of the difficulty in making changes in the global character of the courses for which the DDTP offers disciplines in the UFJF, one decided to structure experiments in disciplines of the department itself, starting from the verification of the demotivation of the students for the study of those, linked to great difficulty in the learning of the same. One of the reasons for such situation was the difficulty on the part of the students in concretely understanding the practical application of those disciplines, due to being students in the initial terms of their courses, terms in which the so-called basic disciplines are ministered practically without effective contents of engineering and architecture in their own right.

Aiming to revert that scenario, experiments were carried out in two disciplines: Descriptive Geometry (GD), which took place from 1993 to 1996, when the author (Oliveira) moved away to take his doctorate, and

Architectonic Representation and Expression (REA), which began in 1996, being coordinated by the author Borges. Those experiments are detailed in Oliveira (1994 and 1996) and Borges & Arbach (1996).

In the Descriptive Geometry discipline, one decided to propose the realization of a "field work", to be carried out in an engineering enterprise (of services and labor) with the purpose of checking where the Descriptive Geometry would apply, or could apply, in the engineering design of the enterprise. That work was basically constituted by the following: enterprise profile survey; succinct description of the functioning of the enterprise and of how the engineering designs were developed or the labor done; analysis of the application of the content of the discipline in at least one engineering design of the engineering enterprise; and conclusions about the work and discipline in course.

The development of the field work occurred during the school year. From the four weekly class hours of the discipline, at least one was dedicated to the presentation and discussion of the report on the performance of the work stages. In those presentations, one would verify an expressive and profitable participation of the students, who turned out reflecting themselves in the expository classes of the official program of the discipline. The students began searching for identity between the presented topics and the application of the respective field work in course.

In the Architectural Representation and Expression discipline, the experiments took place with only part of the students (volunteers) that disposed themselves to do paralel work, within extension projects (Engineering and Architecture service rendering), which are carried out by teachers in charge of the discipline. That work is realized in a projects laboratory and does not officially constitute an integral part of the discipline. That laboratory was created in function of the need for improving the learning conditions of the students of the mentioned discipline in experimental character.

In that extension work, the students participate in the development of the architectural projects in all their stages. Thus the students are led to understand the architectural project as a whole, aiming to learn the contextualized application of the discipline, as well as its relationship with other fields of knowledge inherent in an engineering design.

The outcome of those experiments can be considered as positive, which can be verified through the commitment of students in the realization of the work, in the remotivation for the study of the disciplines, in the evident improvement of the learning, in the improvement of the understanding of the concepts and in the capacity to associate them to issues of practical application. This could be observed both in the interpellations of students during the expository classes and in the output of tests and exams. Besides that, the students started having a realistic perception of the habilitation that they had chosen right in the initial terms of the course, which would only happen before beginning with the study of the disciplines of the so-called "professionalyzing cycle", which, as a general rule, only takes place from the second half of the course on.

In the courses of Architecture, in general, the students get in contact with the design activities already in the second grade. Nevertheless, most of the times, the teachers of architectural project or planning consider the contents related to graphic representation of the project to be already of the students' domination, which proves to be problematic, with the verification of difficulties similar to those found by the students of engineering courses. In that case, one can perceive both the need for a better preparation on the part of the students, in relation to the practical applications of concepts and techniques studied in the basic disciplines, and for the continuity and deepening of the learning of those concepts and techniques during the course, particularly in the line of achitectural planning.

The disciplines, previously ministered only through expository classes, demanded from the student just the domination of its content for approval. With the realization of this work, the students were allowed to, from the content of the discipline, get in contact and dialogue about this applied content with directors, engineers, architects and the people of the office, as well as people in charge and workmen in the enterprise labor. Besides that, they had to study, reflect, discuss, negotiate within the staff and be creative for the development and structuring of that work. The presentation and discussion of the partial reports and the final presentation of the work would make it possible for those students, as well, to exert the ability of expressing, of synthesis and of organization of a piece of communication.

All the same, in the realization of those experiments, one can notice a series of barriers, among them can stand out: the excessive hour loading, where the students find it difficult to dedicate to the extra-class work; the difficulty on the part of teachers in providing a more personal assistance, considering that, in this process of learning/teaching a larger-than-traditional (blackboard and chalk) hour loading is required; the lack of laboratories and of sufficient and adequate spaces to the realization of work; and the discouragement of the teaching body, since the essential is the fulfillment of the curriculum disciplines "program", which is exigency of a more bureaucratic than academic character.

That cast of barriers cannot be easily transposed, for they're the result of a crystallized culture, which arises from a curricular structure highly practiced in the courses and of a pedagogical principle based on the "transmission" and "evaluation" of the knowledge, which reserves to students a predominantly passive role in the teaching/learning process.

The harmful effects of those barriers could be minimized in case various integrated disciplines could be involved in such experiments, as it happens nowadays in the North Carolina State University, through the IMPEC program - Integrated Mathematics, Physics, Engineering and Chemistry Curriculum, directed by Professor Richard M. Felder of that same institution, which is based on the integration and emphasis given to the inter-connections and applications in the solution of problems. The integrated course makes extensive use of the experimental activity and of the cooperative learning, in which the formal or traditional class is practically eliminated (Felder et all, 1996).

Those experiments, despite their limitation and barriers, show that there are concrete alternatives, even for the disciplines called "basic formation" or the "basic cycle", to achieve better results in the teaching/learning process.

Reflections based on experiments

Based on those experiments, one can make a few reflections about Engineering Education. If the global changes in the courses of engineering find lots of difficulty, one can make slow changes, even as a factor of gradual change of culture, considering that, one of the biggest barriers to changes, in a general way, is intrinsically linked to proceedings, principles and "ways of making" rooted deeply over the years, particularly on the part of teachers.

Those gradual changes, by the way, have already been occurring over the latter years. As an example, one could quote the alterations occurred in the form of articulation between the so-called "basic" and "professionalyzing", the adoption of the "curricular stage" and the "project oriented capstone courses", besides the implementation of "special training programs", among others, which translate themselves as attempts to improve the courses of engineering, mainly with regard to the acquisition of the so-called "practical knowledge" on the part of students.

As far as the "curricular stage" and the "project oriented capstone courses" are concerned, despite the distortions verified in certain cases, they can be considered as factors of real improvement in the courses. For being a concrete opportunity for the student to apply engineering knowledge, they end up striking against, principally, the difficulty of the student in transposing the theoretical knowledge to the real world. This is due to excessively theoretical presentation, especially in basic disciplines concerned with important phenomena and concepts for the professional formation, which turns out to produce "alienation between theory and practice, between concept and phenomenon and between science and reality" (Amorim, 1996).

In the USA, os trabalhos de final de curso arose and became prolific, according to Dutson et all (!966), by influence, mainly, of requisites formulated by ABET (Acreditation Board for Engineering and Technology) and also of the Industry, as an effort to improve the learning, developing the creativity of students, promoting the use of project methodology, the formulation and consideration of alternatives of solution, and the solution of realistic problems, among others. There, as well, these project oriented capstone courses have come across barriers, among others, related to the application of the theoretical knowledge.

In the initiatives quoted here, one can identify, among others, a search of balance between theory and practice in Engineering Education. Just the same, for one to achieve such intent, it is necessary that the disciplines be ministered taking into account its practical application in realistic engineering design, since the very first terms of the course of engineering.

The reference to the engineering design happens in function of considering it as a fundamental intellective activity of the engineer and the architect. One also understands that the engineering design is more than a cognitive process, although the specialized technical knowledge and the heuristic of designers are essential ingredients. It can be considered as arising from a social process that represents a synthesis of the different perspectives of the participants in the activities of the same (Bucciarelli, 1988 and 1994). These projective activities must go beyond the simple application of scientific and technological knowledge concerning the performance, the utilization and the functioning of determined artifact or enterprise.

From the approach that is made here to the engineering design, considered as a social process, one can assert that the learning of the disciplines called engineering and architecture basics, referred to in realitic applications, must occur, as well, as a social process, depending on the relationship constructed between theory and practice and between students and teachers.

That assertion still find echo in the studies done by various educators such as Piaget, Paulo Freire, Vigotski, Anísio Teixeira, among others, who show that the most promising path to learning is the one where the student acts as an active subject in the learning process, process which must be understood not as a training for the accomplishment of intellectual tasks, but as a process of knowledge acquisition that takes place fundamentally through the work and reflection (Amorin, 1996).

Final Conclusions

In a general way, considering that deeper alterations in the engineering courses demand time and resources and that the lack of tune between professional formation and the necessities of the job market becomes each time bigger, one must take more immediate precautions in the sense of realizing gradual alterations that, at least, will stop that process of getting out of step between what is taught in the Engineering Schools and what is necessary to attend the claims of society.

In that direction, one of the alternatives is trying to overcome the current pedagogic model, practiced in most Engineering Schools, replacing them with a model that presupposes the learning/teaching process as a social process, that stimulates the student to think and work taking into account all the aspects regarding the citizenship and not only the acquisition of technical-scientific knowledge. In this way, perhaps, it will be possible to start building an alternative that gets over the theory x practice dichotomy, present in the genesis of Engineering Education, starting to consider them as indissociable among themselves and in the social process, which must involve the formation and the action of Engineering.

Bibliografia

Amorim, F. S. & Naegeli, C. H. Integração Teoria e Prática no Ensino de Engenharia: a Construção de um novo Modelo Didático. In: *Proceedings II Encontro de Ensino de Engenharia*, Rio de Janeiro: UFRJ, 1996.

Andrade, E. P. & Mello, J. M. C. Re-pensando o Conhecimento do Engenheiro. *Revista de Ensino de Engenharia*, n 16, dez/96, Brasília: ABENGE, 1996

Borges, M. M., & Arbach, J. M. L. A Experiência da "Oficina de Desenho" na UFJF - In: *Proceedings I Congresso Internacional de Engenharia Gráfica nas Artes e no Desenho*, Florianópolis/UFSC, 1996.

Bringhenti, Idone O Ensino na Escola Politécnica da USP: Fundamentos para o Ensino de Engenharia. São Paulo: EPUSP, 1993

Bucciarelli, L L An ethnographic perspective on engineering design *Design Studies, V. 9, n∫ 3*, Oxford: Butteeworth, 1988

Bucciarelli, L. L. Designing Engineers. Cambridge: The MIT Press, 1994

Dutson, A. J. & Outros. A Review of Literature on Teaching Engineering Design Trough Project-Oriented Capstone Courses. *Journal of Engineering Education, American Society for Engineering Education*, V. 86, No. 1, jan/1987

Felder, R M & Porter, R L Teaching Effectiveness for Engineering Professors. Coletânea de trabalhos dos autores publicada pelo Collegge of Engineering, North Carolina State University, 1994

Felder, R M & Silverman, L. K. Learning and Teaching Styles in Engineering Education. *Journal of Engineering Education, American Society for Engineering Education*, 1988

Felder, Richard M. & Outros. IMPEC - Integrated Mathematics, Phisics Engineering, and Chemistry Curriculum. Raleigh: North Carolina State University, 1996 Internet: (http://www2.ncsu.edu/ncsu/pams/physics/pcep/impec/impechome.html)

Fundação Vanzolini Revista Engenheiro 20001 n 1 (1996) e n 2 (1997). São Paulo: USP, 1997

Latour, Bruno.. Science in Action. Cambridge, MA: Harvard University Press, 1989.

Musetti, M A. A Integração das disciplinas do Curso de Engenharia de Produção através de um cenário vitual de manufatura. In: *anais do XXV Congresso Brasileiro de Ensino de Engenharia*, Salvador: UFBA, 1997.

Oliveira, V. F. & Naveiro, R. M. O Ensino e a Aprendizagem do Processo de Projeto nos Cursos de Engenharia. In: *Proceedings 17º Encontro Nacional de Engenharia de Produção e 3rd International Congress of Industrial Engineering – ENEGEP 97*, Gramado/UFRGS, 1997

Oliveira, V. F. & Naveiro, R. M. The CAD Systems Operators: Professional Formations and Ergonomics Problems. *Proceedings of the 12th International Conference on CAD/CAM Robotics and Factories of the Future, CARS & FOF '96*, London (UK), 14-16 August 1996.

Oliveira, Vanderlí F Aplicação da Geometria Descritiva em Projetos de Engenharia. In: *11° Simpósio Nacional de Geometria Descritiva e Desenho Técnico, Graphica 94*, ABPGDDT. Recife: UFPE, 1994.

Oliveira, Vanderlí F. Considerações sobre o Ensino e a Aprendizagem de Projetação na Engenharia. In: Anais II Encontro de Ensino de Engenharia. Rio de Janeiro: UFRJ, 1996.

Segre, Lidia M. Cambios tecnológicos y organizativos y sus impactos sobre la cualificación professional. Volver a pensar la educación. Espanha: Morata, 1994.

Thiollent, M. J. M. 1994. Os processos cognitivos e normativos da tecnologia e suas implicações na pesquisa e no ensino. In: *Proceedings COBENGE 94*, ABENGE e UFRGS, P. Alegre, p 373-381.

Vincenti, Walter G. What Engineers Know and How They Know It: Analytical Studies from Aeronautical History. Baltimore and London: The Johns Hopkins University Press, 1993.