A New Program for the Civil Engineering Course at the Federal University of Minas Gerais - Brazil

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Abstract *- This paper presents the experience of the task group responsible for the modernization of the civil engineering program at the Federal University of Minas Gerais (UFMG) in the last two years. Firstly, it is presented a general overview and the insertion of engineering in the modern world, highlighting questions like jobs, economy globalization and scientific and technological development. A brief diagnosis of the actual civil engineering course is presented, covering aspects like evasion, course program and fragmentation of the disciplines throughout the course. Then, the paper describes the proposal for modernizing the civil engineering teaching program and the methodology for he implementation of the new curriculum. In this context, the main methodological experiments and activities for the implementation of the new curriculum are detailed.*

As the main results of the modernization process it can be pointed out: i) the reduction of assisted lectures in class, from about 4100 to 3615 hours, with other 135 hours spent on extra class assisted work; ii) the implementation of three extra class multidisciplinary integration works, aiming at the integration of disciplines, students and teachers; iii) the strengthening of the human and social areas and also a better integration of the engineering student within other University environments; iv) a more flexible curriculum, with the offer of around 60 disciplines within the engineering and humanity areas to be chosen by the student; v) a better equilibrium within the six engineering areas (structure, Materials/edification, transportation, hydraulics/ water resources, geotechnics and environment). Other results of the curriculum include a better distribution of the disciplines along the course, as well as the addition of more professional disciplines since the beginning of course.

With this new proposal, it is expected a significant contribution towards the formation of a citizen-professional, fully aware of his social role as an engineer in the society. Based on a strong scientific, technical and humanist formation, it is expected that this new professional could face the challenges of his profession and of his insertion in the business market.

Introduction

We will, hereby, in this introduction, try to summarize some basic points concerning the insertion of engineering and engineering education in the modern world. This task must be carried out through the analysis of the present context regarding, not only the overall aspect of social behavior, but, also, the specific aspect of technological development as well as the society and technology exchange. Such analysis of the present context will enable us to become aware of relevant factors and their implications on the definition of trends for the "new teaching".

The high speed of knowledge evolution, mainly concerning technological aspects, is one of the most important among the various factors. The following consequences and conclusions can be drawn:

- the quick outdating of contents and techniques, as opposed to the increasing importance of the kind of teaching that enables the individual to become an independent learner;
- the need to replace the technique of merely providing information by the teaching technique that leads to the development of skills;
- the importance of providing the professional with scientific investigation methodology, which applies to the technological field, as well as providing the new engineers with a tool to step into the unknown, making it easier for them to acquire new techniques and to exercise a continued education;
- the need for the professional to acquire a steady basic knowledge concerning science and engineering science. Such knowledge will also constitute a facilitator element of the acquisition of new technologies which, though new, are based not only on the same principles of the physical, chemical and biological sciences, but also on the mathematical instrumental.

From the understanding of the present context and the identification of the factors that are relevant for the definition of trends and their implications for the teaching goals, we can say that in what concerns the desired stereotype of the new engineer, must be emphasized the importance of professionals holding characteristics such as:

- broad education that provides him with sensibility for humanistic, social as well as environmental issues - the liberal teaching;
- steady basic education on science and engineering science;
- capacity to work in "multidisciplinary" groups ;
- knowledge of the basic techniques of management and administration of the resources used in the profession;

- knowledge of the computer science as a tool for the professional exercise and self-improvement;
- ethic-professional formation.

It is fundamental the development (acquisition) of skills for the "new professional". Some of these skills are:

- capacity to attain and systematize information;
- capacity to construct mathematical and physical models from systematized information;
- ability to critically analyze the models used on the study of engineering issues;
- ability to elaborate and assess problems of engineering and to reach solutions;
- ability to interpret, elaborate and execute projects;
- ability to manage and operate engineering systems;
- ability to summarize, added to the ability to understand, interpret and express either through the oral, written or analytical forms;
- ability to spatial thinking;
- ability to operate numerical problems;
- critical capacity concerning dimensional measures concepts;
- capacity to consolidate theoretical knowledge.

The paper will, in the following topics, identify and describe some methodological experiments (*and the mechanisms to be used on each experiment*) concerning:

- curricula format;
- teaching methodology *(approaches)* and
- curricular content, for the implementation within the new curriculum.

The experiments hereby approached are aimed at meeting the present reality of engineering teaching and the needs originated from the present social, technological and economical contexts.

Finally we emphasize the importance of the behavioral aspect on the projects on modernization of teaching. In what concerns this topic we would like to point out that the greatest challenge regarding the setting up of changes lies on the necessary stimulus to the transformation of the way the academic staff view teaching. No doubt this is a relevant fact as to the determination of the speed in which changes will come up. Mann Report (USA-1918); Wickenden Investigation (USA-1930, 1935); Hammond Studies (USA- 1940, 1944); Grinter Report (USA- 1955); Burdel Report (USA-1956); National Action Agenda for Engineering Education (USA- 1986); The Federal Education Council Resolution 048 (Brazil- 1976) constitute important documents on the teaching of engineering in the USA and Latin America which show that many of the present values had already been realized decades ago, although not yet fully consolidated. Unless there is a change in behavior there is no way to set up a new teaching experience no matter how consistent it is. We believe that the stimulus to changing arises from the understanding that such changing is necessary and that understanding comes from knowledge. It is rather important that the whole academic community gets involved in the process of modernization of teaching. Such involvement may be encouraged by events which make possible the homogenization of the information level of the participants and eventually by sharing the construction of the new project.

Course Diagnosis

The Civil Engineering Course of the Federal University of Minas Gerais has completed 84 years of existence. During this time it has experienced several curricula reforms, with the last one dating from 1990. The course is actually structured in 10 semesters divided in two cycles. The first cycle, named basic cycle, comprehends the first four semesters of the course, when the subjects related to the basic sciences, which are fundamental to the next cycle (professional cycle), are taught. In this last one, the subjects related the general and specific professional education are taught, covering the following six areas: materials/ edification; hydraulics/water resources; geotechnics; transportation; sanitation/environment and structure. In the 9th semester, the student must choose one among the five emphasis that are offered: i) materials/edification; ii) transportation; iii) hydraulics/water resources; iv) sanitation/ environment; or v) structure.

A deeper knowledge of the course was achieved through the introspection methodology, which consists of gathering information from a critical analysis of the course itself. This aimed the definition and specification of the contents of the large areas to be covered in the course, as well as the identification of the complementary contents and common characteristics of the professionals to be formed. The main activities developed according to this methodology were:

- compilation and actualization of all disciplines' programs, in order to have an updated database of the course;
- interview with all lecturers involved with the under-graduate program (from the basic and the professional cycles), aiming to know their expectation in relation to a new course reform and also to embrace as many as possible lecturers in the process;
- regular meetings with five departmental task groups, that had as the main purpose to position the departments in relation to process in course, as well as in order to collect information about the appropriateness of the disciplines' programs and credits.

From this analysis, there were many important outcomes, such as:

- the total course duration varies from 4,035 to 4,140 hours distributed in the following way: basic cycle with 1,545 h (38%), professional cycle with 2,160 h (53%) and the emphasis with 330 to 435 h (9%). This represents an average of 27.5 hours of classes per week, which is considered very high for the standard of a modern course that pursuit the allowance of more time for the student to develop extra class work;

- other important aspect was observed in relation to the credits'distribution among the civil engineering areas in the professional cycle, being detected a reduced amount of credits in some areas, specially in sanitation/environment and, in a minor scale, in hydraulics/water resources, when it is desired to have a better equilibrium among the various areas;
- in relation to the course program, the following main deficiencies were found: i) existence of an excessive partition between the basic and professional cycles, negatively contributing for the student indifference and course evasion, this one reaching 33.6% in the last 5 semesters (UFMG, 1996); ii) existence of an excessive partition among the disciplines of a same semester; iii) absence of a discipline that could give to the student a general overview of the course; iv) existence, in some semesters, of an excessive number of disciplines of a same area; v) absence, in some semesters, of disciplines of specific areas; and vi) excessive number of disciplines in a same semester.
- in relation to the disciplines, the course diagnosis indicated that a large amount of the programs were not updated, as a result of changes that were introduced by the lecturers;
- finally, after a long process of discussion it was concluded that it is not possible to form a specialist engineer in only 5 years. Hence, an under-graduate course should allow the engineering professional a fundamental and broad formation, in all civil engineering areas, but aggregating an emphasis in a specific area. That was referred as a flexible emphasis, reinforcing the concept of continuing education, thus expecting from the engineer to pursuit a complementary formation after the undergraduate studies, therefore allowing his transformation in a true specialist.

Proposal For The Modernization Of The Civil Engineering Course

The conceptual basis for the project of teaching modernization in the civil engineering course is in accordance with a broader project of curricular modernization that is going on within the Faculty of Engineering at the Federal University of Minas Gerais (UFMG), that comprises all engineering courses. However, the project of a new civil engineering course sustains its own identity, preserving the aspects that are peculiar to the course.

Some proposals for the modernization of the course are presented bellow, with a more detailed analysis being carried out in the Results' section:

- minimization of course duration, in order to allow the student more time for extra-class work, therefore contributing for a better knowledge retention;
- vertical and horizontal integration of the knowledge areas, therefore avoiding the disciplines on being knowledge's tight compartments along the course. This is even more critical if we look the two course cycles (basic and professional), where the disciplines are grouped in two large and partitioned blocks, with none or minimal integration. Hence, the vertical integration aims to provide a greater interface among the disciplines of the basic and professional cycles, therefore allowing the student a better contact with the teachers and disciplines of the professional cycle since his entrance at the University. A significant advance on this matter was achieved with a complete review of the course program and with the implementation of Multidisciplinary Integrating Works (see discussion in the Results' section);
- change of the teaching philosophy, currently centered on the teacher, to the one centered on the student, aiming to transform the student in the main agent of the learning process. The main purpose consists on the guiding of the students to search, outside the learning room, the complementary information to the full absorption of the discipline contents. This transformation will demand from the teaching body a deeper knowledge of new teaching techniques and the implementation of new didactic/pedagogical methodologies.
- modification of the course contents, in order to incorporate new knowledge attributes which are necessary for the engineer formation, such as: environment, process control and automation, production engineering etc.;
- reformulation and modernization of the didactic laboratories, having as the main objective to adequate the several laboratories to the new teaching philosophy proposed for the civil engineering course. Three main aspects reinforce this need: i) the reduction of course duration from about 4100 hours to 3750 hours, which aims to stimulate the students' extra class activities; ii) the search of a better equilibrium and refinement between theory and practice, by offering a major number of classes in experimentation and demonstration laboratories; iii) the incentive to the creation of permitted (open) laboratories, applicable to a range of disciplines offered in the course;
- implementation of the Engineering Social Work Program, as an instrument that is capable to complement the engineer professional formation, exposing the student to the reality of the poor population, therefore being capable to satisfy their demands through the engineering practice. On the other hand, it is also intended to fulfill one slot that is often detected in the formal structure of many courses: *the development of a practice that is not directed to a simulated reality*. In a broader perspective, this instrument aims also the achievement of a society demand towards a public university, through a practical integration of teaching and extension work.

Methodology

The methodology used for the modernization program of the civil engineering course consisted of many steps, as described bellow.

- realization of 28 seminars throughout the years of 1994 and 1995, focussing the several aspects concerning curriculum format, teaching methodologies and tendencies for the future;
- establishment of a Commission within the Course's Collegiate, composed by representatives of five departments and also by one student, which was responsible for the conduction and implementation of all activities;
- engagement of a task group, in order to give support to the work developed by Collegiate Commission;
- set up of a comprehensive timetable and program of activities, detailing the several phases of work to be carried out during the process of the course modernization;
- definition and specification of the course objectives;
- identification of the contents (major areas) that should be covered in the course;
- definition of the course structure.
- definition of the pedagogic strategies that should be focussed in the teaching process;
- Production of a final document, containing all detailed information about the disciplines and the course itself.

More details regarding the methodology used during the process of modernization of the course can be found in [3].

Main Results

Reduction Of The Course's Routine Time Charge

The experiment on the course's routine time charge minimization had as the purpose to enable the development of other important activities for the students. In this case, such reduction will allow the students to develop work in an autonomous basis or in group and be involved with scientific initiation, monitoring activities and PET (training special program) and PAD (improvement learning program) programs. Moreover, it still can be mentioned: the practices in open laboratories, apprenticeship performing at engineering enterprises and search/analysis of information. In this sense, the course routine time charge was reduced from about 4100 hours to 3750 hours, depicting a reduction of about 10%. Thus, the new average weekly routine time charge per semester turns to be approximately 25 hours. In order to render effective such changes, there was a re-arrangement of disciplines with the removal of overlays and re-evaluation of the contents of their respective programs. Another important feature concerning the reduction of the school routine time charge was the exclusion of the 5 emphasis existing by the Course's end. On this process, the reduction of the routine time charge does not implied on the contents reduction, causing the need for adaptation of the teaching body to the new reality with the implementation of new didactic/pedagogical methodologies. In this case, the main purpose consists on the guiding of the students to search, outside the learning room, the complementary information to the full absorption of the discipline contents. Hence, it is expected, for the new curriculum of the Course, a change of the teaching philosophy, currently centered on the teacher, to the one centered on the student.

Implementation Of The Multidisciplinary Integrating Works (TIMs)

The multidisciplinary integrating work will be constituted as an innovative and indispensable methodological instrument within the reach of the goals defined for the Course and the consolidation of teaching and apprenticeship strategies. Conceptually, the work shall allow the vertical and horizontal integration of the knowledge areas, simultaneously with the student's progress alongside the course. Therefore, the disciplines would stop on being knowledge's tight compartments, now becoming to constitute cells (connected sub-domain) along the periods. The vertical integration of such cells will allow the conjoint view of the course. Some basic guidelines for the implementation of the TIMs were sketched, such as: number of TIMs = 3 (6th, 8th and 10th periods), discipline's interface with these works, achievement of the work by groups of students guided by teachers from the different areas of the knowledge, evaluation in global terms (graphical and written expression), and in specific terms (oral defense), including individual mark for the members of the group. But, the final detailing for these works shall be developed through a teachers Commission established by the Course's Collegiate for its due implementation and follow up of the activities.

Strengthening Of The Human And Social Sciences Area

Insertion of a greater list of disciplines from the human and social sciences with increase from the current 30 hours to 120 hours. In this case, in a common agreement between the Faculty of Engineering and the Faculty of Social Sciences of the Federal University of Minas Gerais, an extensive list of disciplines were made available to the students. Therefore, the choice of the disciplines to be coursed to achieve the routine time charge in the human area will also be under the student's responsibility, the agent of its professional formation process.

Curricular Flexibility Rendering Process

Aiming to allow the student to get a distinguished formation to comply, in part, with its future needs, it

was made available an extensive list of disciplines from the different areas of the all fields Engineering involving many departments of the Faculty of Engineering of the Federal University of Minas Gerais. Moreover, in the Physics area it was made available 6 laboratory disciplines where the student is free to choose one of them to complete its curriculum. As mentioned earlier, the charge on the human sciences area is also part of the flexibility rendering process.

Balance Among The Six Engineering Areas Connected To The Course

The Course's curricular modernization process made possible a redistribution of the routine time charges of the six knowledge areas in the professional cycle (Materials/ Edification, Transportation, Geotechnics, Hydraulics/water resources, Sanitation/environment, Structures). In this case, a better balance among these areas was reached with increments in Hydraulics/water resources, Sanitation/ environment and Transportation, and reductions in Structures and Materials/Edification.

Conclusion

With this new proposal, it is expected a significant contribution towards the formation of a citizen-professional, fully aware of his social role as an engineer in the society. Based on a strong scientific, technical and humanist formation, it is expected that this new professional could face the challenges of his profession and of his insertion in the business market.

References

1) Borges, M.N. Metodologia e Conceitos para o Novo Currículo do Curso de Engenharia Civil da UFMG. *Seminário interno*, 1996.
2) Chernicharo, C.A.L.; Heller, L. & Galvão, T.C.B. Proposta de Implantação do Internato Curricular no Curso de Engenharia Civil da EE.UFMG. *Seminários de Modernização do Ensino de Engenharia na UFMG,* 1995, 4 pp.
3) Coelho, M.M.L.P. & Chernicharo, C.A.L. Experiência na Reformulação do Ensino de Engenharia Civil da UFMG. In: *Anais do XXIV Congresso Brasileiro de Ensino de Engenharia - COBENGE/96*, 1996, Vol 1, pp. 75-94.
4) Colegiado de Coordenação Didática do Curso de Graduação em Engenharia Civil da UFMG. Reforma Curricular do Curso e do Ensino de Engenharia Civil da EEUFMG - Diretrizes Básicas, 1993, 3 pp.
5) Universidade Federal de Minas Gerais (UFMG). Modernização do Ensino de Engenharia da UFMG. Proposta da Escola de Engenharia apresentada à FINEP em atendimento o Edital do REENGE, out/1995.
6) Universidade Federal de Minas Gerais (UFMG). Evasão em Minas Gerais. Dilemas e Perspectivas, 1996, 82 pp.