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THE COOPERATIVE CURRICULUM IN ENGINEERING: CURRICULAR INNOVATION AND PROFESSORS DEVELOPMENT[1]

O CURRÍCULO COOPERATIVO EM ENGENHARIA: INOVAÇÃO CURRICULAR E DESENVOLVIMENTO PROFISSIONAL DE PROFESSORES2

MASETTO, Marcos Tarciso
Livre Docente em Educação pela Universidade de São Paulo- USP
Docente no Programa de Pós Graduação em Educação da Pontifícia Universidade Católica de São Paulo- PUC-SP – Brasil.
mmasetto@gmail.com

PRATA-LINHARES, Martha Maria
Doutora em Educação pela Pontifícia Universidade Católica de São Paulo- PUC-SP
Docente na Universidade Federal do Triângulo Mineiro- UFTM - Minas Gerais - Brasil
marthaml@terra.com.br

KELLER-FRANCO, Elize
Mestre em Educação pela Pontifícia Universidade Católica de São Paulo- PUC-SP

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2 Baseado em trabalho apresentado no 54th World Assembly of The International Council on Education for Teaching- ICET, 2009, em Muscat.

Docente no Centro Universitário Adventista de São Paulo -U N A S P- Brasil
elize.franco@unasp.edu.br

GAETA, Cecília
Doutora em Educação pela Pontifícia Universidade Católica de São Paulo- PUC-SP
Docente no Centro Universitário Senac de São Paulo- Brasil
ceciliagaeta@uol.com.br

ZUKOWSKY-TAVARES, Cristina
Doutora em Educação pela Pontifícia Universidade Católica de São Paulo- PUC-SP
Docente no Centro Universitário Adventista de São Paulo -U N A S P- Brasil
cristina.zuko@gmail.com

SCHULZE, Thiago Rodrigues
Mestre em Educação pela Pontifícia Universidade Católica de São Paulo- PUC-SP – Brasil
thiagoschulze@hotmail.com

SUMMARY
This study offers the opportunity of discussing studies that a Brazilian research group, made up of researchers from different universities and students, has been carrying out concerning cooperative courses in Engineering in Brazil. Investigation is concentrated in the observation of its innovative curricular characteristics and the professional development of the professor which is required for carrying out this new curriculum. It is based on bibliographical and case studies, documental analysis, individual and collective research, participation of the group members in seminars and specific events connected to the theme.

Key words: Professional development**.** Cooperative curriculum. Curricular higher education innovation. Engineering education

RESUMO
Este artigo oferece a oportunidade de discutir os estudos que um grupo de pesquisa

brasileiro, formado por pesquisadores de diferentes universidades e estudantes, vem realizando sobre cursos cooperativos em Engenharia no Brasil. A investigação concentra-se na observação das características curriculares inovadoras e do desenvolvimento profissional do professor que é exigido para a realização deste novo currículo. É baseado em estudos bibliográficos e de caso, análise documental, pesquisa individual e coletiva, participação dos membros do grupo em seminários e eventos específicos ligados ao tema.

Palavras-chave: Desenvolvimento profissional de professores. Currículo cooperativo. Inovação curricular. Educação superior. Educação em engenharia.

INTRODUCTION

To share reflections about the Cooperative Curriculum in Engineering and teaching development for higher education is a very rich opportunity of probing into the studies we have already been carrying out in the Post-Education Programme: Curriculum of the Pontífice Universidade Católica de São Paulo (Brazil).

This Post-Education Programme hosts a Research Group called "Teacher Development and Curricular Paradigms", registered in the Conselho Nacional de Pesquisa – CNPq (National Board for Research), coordinated by Prof. Dr. Marcos Tarciso Masetto and made up of post-graduate students and researchers who are masters and doctors.

This Research Group began its activities in 2005 and established as its goals to investigate and identify innovative projects in higher education teaching and to go more deeply into theoretical issues concerning innovation, curriculum, and teacher development. It is based on bibliographical studies and case studies, document analysis, individual and collective research, participation of the group members in seminars and specific events related to the theme. It publishes articles in journals and chapters in collections, showing the result of its investigations.

This paper offers the opportunity of discussing one of the studies we have been carrying out about "Cooperative Courses in Engineering", its characteristic of curricular innovation and the development of the professors required for carrying out this new curriculum. The starting point was to think about the socio-historic, educational, professional and political contextualization, which today involves discussions about the development of the engineering professionals.

A KNOWLEDGE OR LEARNING SOCIETY

Knowledge today is presented as an almost infinite multiplicity of production sources. If until a short time ago we could say that the universities constituted the great and privileged '*locus*' of research and scientific production, today, and since a while back, investigations and the subsequent production of knowledge have their beginnings also in other spaces: research organisms and institutes which are disengaged from universities, industrial laboratories, enterprises, public and private organisms interested in projects that conduct intervention in reality and those who carry out programmes and government policies in all levels. Today, we actually build up knowledge in professional activity offices, and even in our home desks, thanks to computers.

At the same time as the sources of production and knowledge are multiplied, access to it has also been transformed: immediate access in real time to journals, articles, books, talks, conferences, sites and the researcher and specialist him/herself who is responsible for publishing the information. Due to this, science areas have come together: the phenomenons which are to be understood, explained, require more than one approach, one specialist, one explanation: multidisciplinarity and interdisciplinarity are called in to work together for the development of science. Knowledge and interaction between the exact and human sciences becomes a demand for world development, but not disconnected from the human community, its progression and development of the peoples.

Due to this, there are those who call this society the "learning society". Learning meaning development of the whole man and society in its educational, political, ethical, economic, cultural aspects, individual rights and social responsibilities, in short, of human citizenship itself. This explains learning through life, "life-long learning", which goes beyond the school spaces and is present during all human existence.

This new world of knowledge is presented to the engineering professor. Before, he could consider him/herself as an "expert" in a specific area of knowledge that he commands, understands, synthesizes and thus, it represents the body of information which will be passed on and transmitted to students who will then become competent engineers. Nowadays he asks him/herself how he/she can keep him/herself up to date

and work with a universe of information which is available to everybody, including the students, which can bring new information and queries into his/her classroom, and how to share with the students during his class schedule and established programme. How can he help the student to get access through Internet and, in a critical manner, obtain information which may be relevant? Finally, the great question: what does a student need to know to become a competent engineer?

At least professors are now beginning to think: what is then, the role of an expert in a certain subject, who must teach the student the most he can in this subject? How is it possible to work the different items of subjects in a classroom?

Hargreaves also asked himself the same question and dares to answer it indicating some clues. For him, professors will find themselves in the need of:

> promoting deep cognitive learning, learning to teach by means of ways in which they were not taught, committing themselves with continued professional learning, working and learning in teams with partners, developing and making things take shape starting from collective intelligence, building an aptitude for change and risk-taking, stimulating trust in the processes. (HARGREAVES, 2004:40)

THE PROFESSIONALISM OF THE ENGINEER

Another world which presents itself to us is the professionalism of the engineer. In the under-graduate engineering courses, the profile of the students about to graduate is normally well defined, keeping in mind the specific professional activities that behoove such a profession, and the curriculum organization normally attends this demand. However, the engineer's training today is called into question by this world of professionalism.

The performance needs for an engineer today are new, different from the traditional ones, as well as the demands that are put on him, due, certainly to the technological innovations and the advances of computer science. The engineer's inset in the professional activities connected to his work continues demanding specificities, but more and more it also demands collaboration from other areas which will allow for a better understanding of the phenomenons and find better solutions for the problems

which are presented do them. The definition of the engineer's profile nowadays is under crisis; just as all the careers that try to respond to professional challenges of the contemporaneous society are also.

The Curricular Directives (CNE/CES, 2002) that are the guide for curricular organization in the development of an engineer in Brazil nowadays, try to extend these professional competencies.

The 3rd Article expresses thus:

> The Under-graduate Engineering Course lists as the profile of the graduating student/professional, an engineer with a generalist, humane, critical and reflexive development, able to absorb and develop new technologies, stimulating his critical and creative performance in the identification and solution of problems, considering their political, economical, social, environment and cultural problems, with an ethical and humanistic view, in attendance to the demands of society.

These guidelines are not only decorative. They are in earnest. The 8th Article determines:

> The implantation and development of the curricular directives should guide and offer curricular ideas to the Under-graduate Engineering Course that should be accompanied and permanently assessed, in order to permit the adjustments that may be necessary to its improvement.

According to Saccadura (1999),

> The modern engineering profession includes a great diversity of knowledge, competences, roles carried out and professional standings. From civil engineering to electronic engineering, from mechanics to telecommunications, a varied technological universe has been developed, allowing the engineer to carry out roles such as administrator or "manager", alongside more traditional missions such as an object or system designer, or of a production manager. The engineer may be a researcher, or a product or service salesman. From a civil servant to a member of staff in a private enterprise or independent consulter, the professional situations of the engineers also show great diversity. (SACADURA, 1999:16)

This world of professionalism of the engineer is also noticed by the professors in this area, if not by means of the documents put out by the Ministry of Education, at least

by the changes in the performance of engineering which can be noticed by those who work as such.

The scenario of contemporary society induces professors to worry about their classes and the manner how they have been traditionally been working. They see that it is no more possible, in a scenario so full of innovation and change to maintain the conventional pattern of classes, as if nothing had happened. The teaching professionalism must also be reviewed.

As we mentioned above, these two worlds among us today, which are connected, the world of knowledge and the world of professionalism, demand a review of the engineer development curriculum, as well as the manner in which we face the teaching performance in the engineering courses.

Based on these issues, we will discuss 'Cooperative Courses in Engineering" as a valid alternative for the development of professionals in this area, in the context of the knowledge and learning society and as a incentive to reflection on the teaching performance.

COOPERATIVE EDUCATION IN THE CONTEXT OF ALTERNATIVE CURRICULAR PRACTICES IN ENGINEERING

In the scope of an alternative curricular organization which aims at re-signifying teaching in Brazilian engineering due to current tendencies, some universities have faced the challenge of implanting a different development proposal by means of Cooperative Education.

This proposal is involved in development of personal and professional competences in the complexity of the real world, by means of a formative process that promotes a close integration between teaching institutions and professional environments, mixing academic and traineeship modules. There is a reorganization of time and space promoting the student's learning outside the classroom, integrating the higher education institution and, promoting a work in partnership between the teaching academic and the engineering companies.

This curriculum is called Cooperative as it allows for cooperation among enterprises that are part of the agreement and teaching institutions, aiming at the development of professionals who are qualified for fast transformations and technological innovations in the working area. Experience with this curriculum, introduced in England at the beginning of the last century in the engineering course, was extended to the University of Cincinnati (USA) and in 1957 to Waterloo (Canada). In Brazil, in 1989 at the Escola Politécnica da Universidade de São Paulo (University of São Paulo Politechnic School), it was incorporated into the courses of Computer Engineering and Chemical Engineering; in 2001 it was introduced into Materials Engineering at the Federal University of Santa Catarina (UFSC) and in 2002 at the State University of Amazonas into the course of Mechanical Engineering.

The curricular organization divides the school year into three periods of four months, alternating periods with classes at the university and traineeship in engineering companies and other productive areas. This brings important alterations in the organization of conventional educational time and space. In this curriculum structuring, the students in cooperative courses gain an enriched understanding of the academic programme, opening the possibility for articulation of theoretical and practical aspects related to the teaching of Engineering. The alternate sequence between the academic and traineeship modules, favours the building of knowledge in a dialectic relation between the academic world and the professional world, where queries, problems, cases and challenges found in the professional environments in which the traineeship is carried out, may constitute the starting point and arriving point of the learnings that occur in the development of an engineer.

Traineeship under this model, inset all through the course, and constituting an enlargement of the traditional school spaces, is a distinctive aspect of the cooperative curriculum.

> Traineeship is put in a position of distinction, because it offers the learner a development of his/her professional competences, working in the correct environments of his/her future profession. At the same time as practice and theory are integrated, traineeship helps the student to live the environment, the scenario, the characters, the groups, the colleagues, the physical environment, the problems and

> the day to day queries of his/her profession. (MASETTO and PACHECO, 2007)

Traineeship is frequently not understood as an opportunity of learning, introduced only at the end of the course in a dichotomic relation between theory and practice. Quite often it is understood only as a bureaucratic demand.

In the cooperative courses under development in Brazil, the introduction of the traineeship in the curriculum follows distinct formats, and it may occur from the first year of the course or starting in the third year. In the first case, as the course has the duration of five years, it is divided into 15 four-month modules, and of these, nine modules are academic, and six are traineeship. In the second possibility, the students study four academic semesters and then they continue in four-month modules which alternate academic modules and traineeship modules. These two possibilities are represented in the table below:

AM - Academic Module; TM - Traineeship Module; P – Four-month period

1P (January – April); 2P (May- August); 3P (September – December)

Year	**Example 1**			**Example 2**		
	1 P	**2 P**	**3 P**	**1 P**	**2 P**	**3 P**
1	**AM1**	**AM 2**	**TM1**	**Two academic semesters**		
2	**AM 3**	**TM 2**	**AM 4**	**Two academic semesters**		

3	**TM 3**	**AM 5**	**TM 4**	**AM 1**	**AM 2**	**TM 1**
4	**AM 6**	**TM 5**	**AM 7**	**AM 3**	**TM 2**	**AM 4**
5	**TM 8**	**AM 8**	**AM 9**	**TM 3**	**AM 5**	**TM 4**

Table 1 - Examples of the format of the Cooperative Engineering Courses - Masetto and Pacheco (2007)

A point to be highlighted as significant is that in a curriculum structured like this one, during the five years of the course, the student accumulates at least two years of experience in different productive engineering environments. Such involvement in the working world offers the scenario for the development of a new professional profile.

Research carried out in 2002 by the Association of Polytechnic Engineers from the University of São Paulo (EPUSP), showed that in the comparative analysis among the groups of students from the various courses in polytechnic schools, those from the cooperative courses showed favourable development concerning decision making and performance time. This data coincides with the studies carried out by professor Brighenti when he compared the profile of the under-graduates from EPUSP in 1997 in their traditional courses, with the students of two modalities of cooperative courses. These last ones showed a better performance than those from the conventional courses in terms of professional and personal maturity, critical sense, ability to apply theory to practice, professional and personal discipline, initiative and leadership, entrepreneurship, ability for communication, human relationship, and commitment with society (MATAI and MATAI, 2005).

The same author calls attention to the fact that the rate of school evasion in the cooperative courses practically does not exist.

The emphasis put on the student learner who is active, autonomous in his/her search for knowledge, able to build his/her learning in a critical, responsible and committed manner, by means of the articulation of academic experiences and real, concrete situations, re-contextualizes and re-positions the professor's role and demands a teaching performance which is also distinguished.

Research carried out in 2004, involving 143 students from cooperative courses at EPUSP, in order to define the ideal profile of a professor, lists as most significant the

following competences: a strong sense of identification, dedication, involvement and alertness in relation to his/her own activities; ability to involve and motivate other people in the solving of problems; demonstration of creativity in the performance of work, breaking surpassed rules and paradigms; appreciation for working in groups, in teams and with people in general; ability for negotiation and demonstration of respect for other people's opinions; interest in professional matters that goes beyond the specific activities of his/her functions; strength and stability of character and a strong moral standing; persistence in reaching goals and purposes; flexibility, ability to face obstacles and problems in a rational, logical and constructive manner; knowledge of how to point out, critically, aspects that need to be corrected and improved in the performance of people with whom he/she has a daily relationship. (MATAI and MATAI, 2005).

The re-conceptualization and alterations proposed in the cooperative projects show a different assessment process, which must be continuous and intentionally planned. In the assessment of student learning, the proposal involves offering help in the sense of re-orientation of learnings, as the tutor-professor, while tutoring the student during the traineeship in a professional environment, has the opportunity of assessing and altering the direction of the learning situations in the academic environment, incorporating elements which can be taken up again or extended in the theoretical modules. In order to close the final grade in the traineeship, there is need to discuss the opinions of the tutor-professor, the supervisor engineer in the engineering company, and read the report written by the students.

Assessment in the cooperative curriculum aims at effective involvement of the student in his own learning project, in terms of self-development, self-knowledge and also self-assessment. The professional environment is well adequate for this assessment process and enables the student to identify his/her weak and strong points, becoming more aware of his/her personal and professional potential with critical indicators to build up his own history.

FINAL CONSIDERATIONS

This short analysis of Cooperative Courses points to two final considerations.

The first relates to identifying in this proposal, a curriculum that can respond to the reflections that were made at the beginning of this study about Professionalism of the Engineer in a Society of Knowledge and his development in this area. We affirm that involving the engineer in his/her professional activities is still something that demands specificities, but more and more, it also demands cooperation in other areas of knowledge in order to allow for a better understanding of the phenomenons and reach more efficient solutions for the problems which appear, thus making his/her development up to date.

The second, equally valid and instigating, is that we can identify the fact that this proposal only managed to show itself as an alternative in the development of engineers for our days, because it demonstrated daring and courage for innovation in the curricula issue, altering important and fundamental aspects for this development.

It assumed the contextualization of a development of engineers in a knowledge society; made clear professional profiles correspondent to competence and citizenship; it moved the focus away from the process of instruction and transmission of information and experiences, which has been carried out with priority in universities, to the process of construction of significant knowledge and a professional practice which is up to date, based on professional experiences in environments of engineering businesses. The manner of carrying out this learning was collaborative, a situation in which the professor, the students and professionals, discover meanings for information researched, and rebuild this knowledge in a critical manner.

Curricular organization set value upon the integration of theory and practice right from the beginning of the course, re-signifying traineeship. The practical and theoretical activities, planned in an integrated manner, showed an increasing complexity as development was carried out. The contents were reorganized in order to attend the four-month periods in the university and the engineering companies.

With perspicacity and innovation, it was able to make use of space and time, both in the four-month periods in the university as in the four-month periods in the engineering companies, not submitting to the traditional 50 or 100-minute classes per subject, but opening space and time necessary for investigative and professional activities.

We must not forget the alterations built around the roles of the professor, the student, the groups of students and the professionals in the engineering companies, giving appreciation to the team working relation which also showed co-responsibility.

This new curriculum also offered incentive for a change in the attitudes of the students by means of planning concrete activities which guaranteed to them, and also demanded of them, participation, work, research, communication and discussion with other colleagues and with the professor, individual and group production, performance in the practical part with integration of the theoretical studies, abilities and attitudes and values to be developed, integration of the various areas of knowledge.

As to the professor, we may highlight a break in the paradigm of teaching functions, under two aspects: (i) while demanding a new role of the professor, (he is also a learner), as an intellectual researcher, critic, citizen and planner of learning situations; mediator and one who offers incentive to the students in their learning processes; working in a team and in partnership with the students and his/her professor colleagues; (ii) while opening perspective to the professor in reviewing his/her practice due to the students' experiences in the traineeship, integrating theory and practice effectively.

And finally, all the working methodology and assessment process was significantly altered. Methodology, giving more space to strategies and techniques that favour the students' participation, interaction among them, the professor, reality and the professionals in the engineering companies, a collaborative effort in the construction of knowledge and learning while working (practice).

The assessment process integrated to learning, as a motivating and incentivizing element with continuous feedback, offers new learning opportunities to the student, motivating him to new learnings.

It is important to highlight that such an innovating curriculum produced significant alterations in many points simultaneously, which allowed for the obtainment of the results shown in the researches mentioned in the text. These confirmed that the students of the cooperative courses showed a favourable development in relation to making a decision and performance time, professional and personal maturity, critical sense, ability to apply theory to practice, professional and personal discipline and

initiative and spirit of leadership, entrepreneurship, ability for communication, human relationship, commitment with society (MATAI and MATAI, 2005).

We cannot omit considering the fact that the proposal of the Cooperative Courses promotes a series of reflections about how to prepare and implant a curriculum for the development of an engineer for our new times. It may seem a challenge impossible to be reached. Surely this was also the feeling of other pioneer groups in this area two or more decades ago. But, they believed in their dream and made it come true.

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Marcos Tarciso Masetto
Graduado em Licenciatura em Filosofia pela Faculdade Anchieta de São Paulo, Mestre

e Doutor em Educação em Psicologia da Educação pela Pontifícia Universidade Católica de São Paulo (1982). Defendeu sua livre docência na Faculdade de Educação da Universidade São Paulo (USP). É professor associado (livre docente) aposentado da Faculdade de Educação da Universidade São Paulo. Atualmente é professor titular da Pontifícia Universidade Católica de São Paulo e da Universidade Presbiteriana Mackenzie. É líder do Grupo de Pesquisa Formação de Professores e paradigmas curriculares.
Endereço eletrônico: mmasetto@gmail.com

Martha Maria Prata-Linhares
Licenciada em Educação Artística pela Universidade de Brasília- UnB, Mestre e Doutora em Educação:Currículo pela Pontifícia Universidade Católica de São Paulo. Doutorado Mestrado em Educação Revista Profissão Docente UNIUBE – Universidade de Uberaba ISSN:1519-0919 www.uniube.br/propep/mestrado/revista/ Revista Profissão Docente, Uberaba, v.10 n. 22, 2010 ,sanduiche na Faculdade de Educação da Universidade de Queen's em Kingston, Ontário, Canadá. É professora do Departamento de Educação na Universidade Federal do Triângulo Mineiro-UFTM. Coordena o Centro de Educação a Distância e Aprendizagem com Tecnologias de Informação e Comunicação- CEAD da UFTM.
Endereço eletrônico: marthaml@terra.com.br

Elize Keller Franco
Graduada em Pedagogia pela Faculdade Adventista de Educação do Instituto Adventista de Ensino e Mestre em Educação (Currículo) pela Pontifícia Universidade Católica de São Paulo. É assessora pedagógica do Centro Universitário Adventista de São Paulo -U N A S P e docente na graduação e pós- graduação.
Endereço eletrônico: elize.franco@unasp.edu.br

Maria Cecília Damas Gaeta
Graduada em Pedagogia pela Universidade de São Paulo, Mestre e Doutora em Educação-Currículo pela Pontifícia Universidade Católica de São Paulo na linha de pesquisa Formação de Professores. Coordenadora acadêmica dos cursos de pós-graduação em Docência para o Ensino Superior e Gastronomia, Turismo e Hotelaria do Centro Universitário Senac de São Paulo.
Endereço eletrônico: ceciliagaeta@uol.com.br

Cristina Zukowsky Tavares
Graduada em Pedagogia pelo Centro Universitário Adventista de São Paulo UNASP e Mestre e Doutora em Educação (Currículo) pela Pontifícia Universidade Católica de São Paulo. É professora titular do Centro Universitário Adventista de São Paulo UNASP atuando na formação inicial de docentes para o Ensino Básico e Superior no Curso de Pedagogia, Licenciaturas e Pós Graduação Lato Sensu. Fez estágio científico em Portugal, na Universidade do Minho, durante o doutorado.
Endereço eletrônico: cristina.zuko@gmail.com

Thiago Rodrigues Schulze
Graduado em Turismo pela Pontifícia Universidade Católica de Campinas Mestre em Educação (Currículo) pela Pontifícia Universidade Católica de São Paulo. Doutorando

no Programa de Pós Graduação em Educação Currículo da mesma instituição.
Endereço eletrônico: thiagoschulze@hotmail.com

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