A program for the professional development of Brazilian engineering students: origin and development

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Abstract

This paper presents a support program for the professional development at the Escola Politécnica da Universidade de Sao Paulo-Brasil as an additional effort for further directed training aiming to a desired profile for the future engineer. The motivations of the program are presented as well as its progress and achieved results. The relationship with the special concept of ingenuity (Analytical intelligence, creative intelligence and practical intelligence) and the work that is developed in a first year of the engineering formation through a discipline named "Introduction to Engineering" is presented. The pedagogical activities are designed with an orientation to important social and environmental issues. The PBL - Problem Based Learning methodology is used.

From 2002 to 2008 this program involved 6,000 people (undergraduate and graduate students as well as the teaching staff). Each participant, at the program commencement, filled a questionnaire with option choices so as to identify the personal behavioral characteristics. The result is a diagnostic which is delivered to the participants as a Professional Career Manual to be evaluated throughout the program. The personal behavior report is composed by 20 professional skills (management and interpersonal characteristics). The Professional Career Manual is to be filled each year of the students engineering formation. The activities include self-knowledgement exercises and a life project workshop. The life project can be brought up to date in a web site of employability. The program has been developed in partnership with the alumni association, the school direction and the teaching staff. The project is an effort aligned with the school strategical vision and tries to fulfill an old demand of the student body, aiming to the improvement of the future engineer's profile.

1. INTRODUCTION

This study describes the genesis and the evolution of a professional development program for undergraduate students of the Polytechnic School (POLI) of Universidade de São Paulo (USP), Brazil. The purpose of this program, developed by the Association of Polytechnic Engineers (AEP, an alumni association) together with the POLI-USP board of directors and faculty, was to complement the education of future engineers. The concern about expanded education is old and was already discussed in the POLI 2015 Strategic Plan (Escola Politécnica, 2003). A similar concern is found in publications by authors such as Newmann (1999), Guskin (2003) and Berry (2003), and by institutions such as the National Academy of Engineering (2003, 2004 and 2005). These references all point out the need to update the Pedagogic Projects of Engineering Schools. The purpose of the experiment conducted at the Polytechnic School of USP was to complement the education of future engineers.

2. History of the AEP/POLI professional development program

2.1. POLI 2015 Strategic Planning

In 2003, members of the board of directors, faculty and employees of the Polytechnic School (POLI) of the Universidade de São Paulo (USP) and especially invited members of other representative social groups with whom engineers interact developed the POLI 2015 Strategic Plan, which outlined what should be expected of the School in the year 2015. One of the components of this Plan is its statement of a vision of future, which describes the student profile of graduates from our School.

The POLI 2015 engineer shall have a broad education, both systemic and analytic, based on solid knowledge of core engineering sciences and on a culture of continuous learning. POLI 2015 engineers will be competent in human relationships and in communications, and will have an ethical attitude and a cultural and social commitment to Brazil."

This vision points to the need for pedagogical and educational actions that complement the education provided in traditional academic settings.

2.2. AEP (Association of Polytechnic Engineers) Strategic Planning

At that same time, AEP also defined its strategic planning. Their mission was stated as: *"To promote the integration of students, alumni and faculty of the Polytechnic School of USP, to support the development of their full technical, professional and social qualifications, and to contribute to the development of society."*

Aligned with this mission, one of their main objectives was to make professional development tools, based on self-knowledge and career projects, available to students. Their initiatives, therefore, have several converging points with the POLI 2015 vision. In 2002, the Mapcom (Competencies Mapping), a two-stage program, was developed. Its first stage consists of the application of a 100-item questionnaire in which participants have to choose one of the alternatives for each item. The balanced analysis of choices generates a self-knowledge report, an outline of each participant's profile and a current picture of their professional standing according to 20 competencies. This report provides indications and directions to interpret the questionnaire scores. In the second stage, an advanced workshop is conducted for students, during which participants further develop their self-knowledge and prepare a Career Project according to a standard guideline prepared by engineers, either part of the faculty or not, who act as preceptors. The career projects can be stored in an employability site (www.vagas.br) and may be updated at any time. The purpose of this connection with the corporate world and of the use of the web is to make students familiar with situations that will be part of their future everyday life.

Table 1 – Population served by the Mapcom program

	Participants							
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**Total**
Undergraduate students	523	465	1,032	914	941	1023	645 (*)	5543
POLI-USP Departments(**)				38	60			98
Graduate students						58		58

* Up to June 2008, not including senior students. (**) Faculty and employees

3. A key competence: Ingenuity

3.1. The Sternberg model: an expanded concept of intelligence, or intelligence for success

Robert Sternberg, a cognitive psychologist, is one of the most renowned specialists in intelligence. His expanded concept of intelligence (2003), called successful intelligence (2000), is more relevant than the traditional intelligence quotient (IQ). This broad concept of intelligence brings together three types of thinking: analytical, creative and practical. In his publications, Sternberg describes each type of thinking and provides practical exercises to develop the components of each type.

The Mapcom program is an attempt to bring the expanded concept of intelligence closer to the ingenuity concept. The theoretical bases for this approximation may be found in the publications of the National Academy of Engineering (NAE, 2004, 2005, 2006). According to the 2004 publication (p. 53-57), the attributes of the engineer of 2020 are: strong analytical skills – principles of science and mathematics; creativity – synthesis of a broader range of interdisciplinary knowledge; and practical skills or ingenuity – skills in planning, combining and adapting data to solve problems. Other attributes listed in that document are: good communication with multiple stakeholders, knowledge of principles of business and management, (interdependence between technology and economics), social responsibil-

ity (impact of technology applications on society), leadership, dynamism, agility, resilience, capacity for continuous and broad learning. Most of these attributes are part of the competence model adopted by the Mapcom program, as described by Yonamine et al. (2007). In the 2005 publication (p. 131-134), Sheppard describes three types of learning that are fundamental for professional preparation: intellectual training in analysis – to understand fundamental concepts; (2) skill-based apprenticeship of practice – in laboratories and projects; and (3) an apprenticeship in the mission, ethical standards, social roles and responsibilities of the profession. The 2006 NAE publication stresses the importance of increasing diversity in engineering education and expanding it to other areas of knowledge.

3.2. The 20-competencies model

The tool used in the Mapcom program is based on a model with 20 professional competencies grouped in three categories, as shown in Table 2. Two tools are available in corporate market, and both are based on the same model: the Administrative Behavior Verification, (VECA, in Portuguese) questionnaire, and the Inventory of Work Attitudes (IAT, in Portuguese). Companies apply these tools to examine administrative competencies.

These 20 competencies directly contribute to the envisioned engineer's profile described in Ingenuity (2004) and to the development of ingenuity according to the adaptation of the Sternberg concept (2004).

Table 2 – Model of 20 professional competencies

Categories	Competencies
Managerial	Planning, Organization, Control, Decision-making, Conformity, Delegation
Interpersonal	Leadership, Communication, Autonomy, Consideration, Confrontation, Involvement
Personal	Persistence, Openness, Rhythm, Tonus, Mobility, Self-control, Self-exposure, Sense of Achievement

The application of this questionnaire provides a diagnosis expressed as a score. These scores should be read carefully and balanced according to specific contexts: not all high scores are always positive, and not all low scores are always negative. This relativity is stressed in our advanced workshops.

One of the fundamental benefits of this tool is to provide terms and concepts that enable the understanding and discussion of competencies. The acknowledgement of actions for the development of competencies and the assimilation of a jargon help students to understand the professional world.

3.3. PNV2100 Course - Introduction to Engineering

The PNV2100 – Introduction to Engineering discipline is offered at the Polytechnic School of USP in the first semester of the engineering course. It adopts principles that contribute to the preparation of the engineer of the future (Nakao and Brinati, 2007). The course objectives are:

The object-oriented pedagogical activities involving socially relevant themes and the use of a problem-solving method contribute to the development of ingenuity (Table 3). This point of convergence between the Mapcom

    01. Promote the understanding of what engineering is, particularly in terms of:
- Identification of needs and desires that require engineering actions;
- Description of problems;
- Preparation of alternative solutions;
- Selection of solutions

    02. Development of certain skills and attitudes, such as:
- Team-work skills;
- Skills to plan, program and control;
- Skills to communicate in written and orally;
- Ability to create alternatives and criteria for decision-making;
- Consideration of economic, social and environmental aspects;
- Evaluation skills and ethical attitudes; Capacity to judge and negotiate.
- Capacity to judge and negotiate.

program and the PNV2100 – Introduction to Engineering course is discussed in the advanced workshops, in which students analyze their profiles in comparison with the three types of thinking and the steps to ingenuity (Table 4).

Table 3. Full Intelligence and Ingenuity vs. Mapcom Competencies

Expanded concept of intelligence or ingenuity	Mapcom Competencies
Analytical intelligence	Planning, Organization, Decision-making, Communication
Creative intelligence	Willingness to change, Flexibility, Achievement, Autonomy
Practical intelligence	Performance, Attention and priorities, Performance time, Delegation, Conflict management

Table 4. The steps of the Ingenuity Method vs. Mapcom Competencies

Steps to Ingenuity	Associated competencies
Perception of the problem	Planning, Performance, Willingness to change
Problem Definition	Planning, Organization, Communication, Conflict management, Persistence, Achievement, Autonomy
Generate alternatives for solutions;	Openness to innovation, Flexibility, Communication, Persistence, Achievement, Autonomy
Selection of alternatives	Decision, Planning, Communication, Performance, Conflict management
Solution specification	Planning, Organization, Delegation, Communication, Performance, Conflict management
Implementation	Self-exposure, Achievement, Persistence, Rhythm, Control, Delegation, Autonomy, Leadership, Operational intensity, Mobility

4. Project guidelines for the life and career workshop

The individual report is handed back to students in class during one of the PNV2100 classes. When reports are returned with the individual profile, the students are invited to participate in the advanced workshop to understand the report results better and to take greater personal advantage of the program. Each participant receives a Career Manual, which has 100 pages with useful information, such as phone numbers of the School institutions, permanent calendar, weekly calendar, ideas database - blank pages and spaces to plan their life project and their careers. The Career Manual is a fieldwork notebook, designed for continuous use as a self-management tool.

The advanced workshops begins with exercises to promote reflections upon values, motivations, dreams and competencies that are worth being developed, recommendations for the development of competencies, and indications of propitious situations and contexts. After that, an exercise is conducted to rescue dreams, which are translated into a vision that is modeled as an "objective tree" – objectives articulated as means and ends and grouped into short, medium and long term.

For each objective, an action plan (project) is defined using the 5W + 2H model: Why (what for, purpose) What (specific, expected results), Who (persons in charge and participants in the process), When (dates, deadlines), Where (places, areas, life domains), How (what resources and activities) and How much (amounts, indices).

5. Improvement under way in the program of professional development

Since 2008, some changes have been introduced to expand our professional development program.

Continuity

The program used to be applied only to freshmen and seniors, and will now be also offered to students in the second to the fourth school years, using new self-knowledge tools. After each participation, students will receive a new Career Manual for the evaluation of previous projects and the preparation of new objectives and projects.

Mentoring

A mentoring service will be offered to senior students that participate in the career project workshop. Mentors are experienced volunteers that will provide support for students that are planning and preparing their career management. This module was under preparation and expected to be tested with a pilot group in the second semester of 2008. Its implementation was planned for 2009.

Alumni

The Polytechnic School of USP has already graduated 18 000 engineers in its 115 years. Its database with addresses of those that are still working is being updated as part of one of the projects defined in the AEP strategic planning. Such updating will make it easier to extend our services to alumni, and will follow the same approach used for students, including competence mapping. Many of the current professors of the Polytechnic School of USP graduated from the same school; as they participated in this program of professional development, they were also able to review their knowledge of the tools available in the corporate market. The same benefits may be made available for those that, for any reason, did not keep up with recent changes, which demand that engineers have and develop the skills and competencies described in the curricular guidelines issued by the Ministry of Education (MEC, 2001 and MEC, 2002).

Longitudinal data analysis

Starting in the end of 2008, longitudinal studies of the change in individual profiles will be possible. Many of the 2004 freshmen graduated in 2008. Therefore, the individual data of those that participated in the program as 2004 freshmen and as 2008 seniors will be available for comparative studies between these two time points.

6. Resources

The AEP resources used for the AEP/POLI professional development program are: a part-time consultant; an administrative consultant; four collaborating professors; and trainees as required. External consultants may be hired if necessary. Since the beginning of the program, costs have been fully covered by a sponsoring organization that recognizes the importance of this program and the benefits it generates for society.

7. Main difficulties of the program

Despite good index of satisfaction (92.5% consider great or good) of the participants, obtained by means of evaluation after the workshops, some difficulties were reported:

a) Accuracy of instruments for assessment of individual profile. It is difficult to find such instruments that have statistically proven accuracy. Several options were tested in the professional market and one that was chosen, after empirical tests, proved to be more valid for the proposed purpose (self knowledge). To reduce risk, there is a warning that the results are confirmed by people who know the individual well.

b) Availability of time for the students of last year - most of these students are already working part-time or on stage and has little time to come to school on the scheduled times for the workshops. This condition has resulted in the need of extra hours to accommodate the students that were interested.

c) Level of maturity of students entering. Students in first year have a maturity level that does not understand the importance of effective service. This fact has been noted when these students arrive in the 4th. and 5th. year and realize that they did not take the activity very seriously.

8. Conclusions

The AEP/POLI professional development program started in 2002 after alumni detected gaps in their university

education. The program was initially offered to seniors, and later to freshmen. From 2009 on, it will be offered to all students and will include a mentoring service. A significant number of people (5,699) had participated in the program up to June 2008. For Polytechnic School faculty and employees, it has been an opportunity to keep up-to-date. According to Garcia (2003), the national curricular guidelines at different educational levels and other official educational documents in Brazil stress the need to manage teaching and learning as a process that develops around the axis of student competencies and skills rather than conceptual contents.

Accumulated experiences may provide subsidies for initiatives to complement the education of future engineers.

The Polytechnic Engineers Association (AEP/USP www.aep.poli.usp.br) has sought to make a difference as it fulfills its educational role.

References

01. BERRY, F.C. The future of Electrical and Computer Engineering Education. IEEE Transaction on Education, Vol. 46, No. 4, November 2003.

02. ESCOLA POLITÉCNICA da Universidade de S. Paulo (2003). Plano Estratégico Poli 2015. Publicação interna. São Paulo: 2003.

03. GARCIA, L. A. M. Competências e Habilidades: Você sabe lidar com isso?

04. http://www.educacaopublica.rj.gov.br/biblioteca/educacao/educ23g.htm acesso em nov/2003.

05. GUSKIN, A. e MARCY, M. Dealing with the future now: principles for creating a vital campus in a climate of restricted resources. CHANGE, July / August 2003. AAHE - American Association for Higher Education.

06. MINISTÉRIO DA EDUCAÇÃO. Diretrizes curriculares Nacionais dos Cursos de Engenharia. Parecer CNE/CES no. 1362, 12 de dezembro de 2001.

07. _____. Diretrizes curriculares Nacionais dos Cursos de Engenharia. Resolução CNE/CES no. 11 de março de 2002.

08. NAKAO, O. S.; BRINATI, H. L. Como incorporar e explorar processos de avaliação em sintonia com as novas perspectivas pessoais e profissionais, em disciplinas de um curso de Engenharia?. In: Marcos Tarciso Masetto. (Org.). Ensino de Engenharia - técnicas para otimização das aulas. São Paulo: Avercamp, 2007.

09. _____ Evaluation Processes in Tune with New Personal and Professional Perpectives. In: International Conference on Engineering Education, 2007, Coimbra. Proceedings of the International Conference on Engineering Education. Coimbra : Universidade de Coimbra, 2007.

10. NATIONAL ACADEMY OF ENGINEERING Visions of engineering in the new century. Washington. DC: The national academies press, 2004.

11. _____Educating the engineer of 2020: adapting Engineering Education to the new century. Washington. DC: The national academies press, 2005.

12. _____Bridge: linking engineering and society. Washington. DC: The national academies press, 2006.

13. NEWMAN, F. Intellectual Skills in the information age. In: The futures Project: Policy for higher educations in changing world, Columbia University, 1999.

14. STERNBERG, R. A inteligência para o sucesso pessoal: como a inteligência prática e criativa determina o sucesso. Rio de Janeiro: Campus, 2000.

15. STERNBERG, R.; GRIGORENKO, E. A inteligência plena: ensinando e incentivando a aprendizagem e a realização dos alunos. Porto Alegre: Artmed, 2003.

16. YONAMINE, R.K.; NAKAO, O. S.; SOUZA, E. P. Desenvolvimento de Competências numa disciplina da Escola Politécnica da USP. In: XXXV Congresso Brasileiro de Educação em Engenharia, 2007. Curitiba, Cobenge 2007. Anais. Curitiba: Positivo DVD/CD/Graffitti, 2007.