Evaluation of Engineering Education: a Case Study based on the Experience of the Polytechnic School of the University of São Paulo

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***Abstract* - The process of evaluation of engineering education currently applied at the Polytechnic School of the University of São Paulo (EPUSP - Escola Politécnica da Universidade de São Palo) in Brazil is presented in this article. This process presents a major difference concerning traditional ways of evaluation; it takes into account the effective participation of the students in all curricular subjects, and not just the students' answers to standard-type surveys that are usually applied. The students are able to voice their opinions on the didactic material, the content of the lessons, or any other matter they might find relevant. A group of elected students acts as classroom representatives. Their duties include preparing the questions to the aforementioned survey, which is then self-administered by their colleagues. Further in the processes, these representatives analyze the data provided by the answers to the survey and perform statistical studies. As soon as this study is finished, they discuss its conclusions with the professors, in order to propose immediate changes. This evaluation process is coordinated by the institution in an autonomous way, free from any interference from the departments or the school board council, resulting in more flexibility and freedom to work with the students. The article also discusses the dynamics of the progress of the evaluation process. The main purpose of the article is to present the positive consequences of the process, such as the improvement of the quality of the dialog between docents and students and the development of awareness among them. The final goal of the evaluation processes, namely the improvement of the quality of education, is aligned to the necessity of having more attractive and competitive universities, a concern expressed in the international scenario and stated in the Declaration of Bologna.**

Index Terms – Evaluation of Engineering, Quality of education in engineering

THE NATIONAL SYSTEM OF HIGHER EDUCATION EVALUATION MODEL

The different approaches for the evaluation of an educational system usually create intense discussions about how to assure the quality of education at any level. They also present, in every level, complex questions about how to carry through analyses and how to find solutions for the problems diagnosed by the evaluation. This debate exceeds national borders and raises issues to be addressed globally.

Historically, in Brazil, this debate started in July of 1973, with the first officially divulged document by the Ministry of Education on evaluation, in particular on the curriculum. The text, written by João Batista Araújo e Oliveira and Mariza Rocha e Oliveira, was entitled "The evaluation function of making educational decisions". Since then, countless evaluation projects have been developed and applied. Currently in Brazil, Higher Education has been evaluated by the National System of Higher Education Evaluation (SINAES – Sistema Nacional de Avaliação da Educação Superior) that features a proposal of only one nationwide curriculum.

The SINAES was created in 2004 and is maintained by an autonomous institution, the Anisio Teixeira National Institute of Educational Research (INEP – Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira). Its objective is to develop a panorama of quality courses and institutions of undergraduate education in the country; which will lead to higher education improvement, provide guidance to the expansion of availability, and also promote the social responsibility of the Higher Educations Institutions (IES – Instituição de Ensino Superior).

The National System is guided by three evaluation axes: the institutions, the courses and the students´ performance. The system is comprised of a series of instruments that are coordinated by the National Commission of Higher Education (CONAES – Comissão Nacional de Avaliação da Educação Superior): the auto-evaluation, the external evaluation, the National Examination of Students´ Performance (ENADE – Exame Nacional de Desempenho de Estudantes), and the evaluation of the overall conditions of graduation courses (census and registration).

The results of this evaluations process also guide the Ministry of Education in the regulation of the courses. The processes of regulation are the courses' registration and

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renewal of registration. In unsatisfactory cases, a commitment between the IES and the Ministry of Education is established, in which goals to overcome the difficulties must be accomplished in a certain period of time. In extreme situations, this Ministry may not register or renew the register of a course or an institution.

Similar processes of evaluation are occurring in Europe. In the Declaration of Bologna, 1999, some actions have led to *the establishment of a system of efficient quality assurance, which is recognized among European and non-European countries* [1]. In Europe, during the decades of 80's and 90's, almost all countries had developed national or regional agencies that carried through the IES quality evaluation. In 1999, the European Network for Quality Assurance in Higher Education (ENQA) was created; it participated in the development of the Declaration of Bologna. In 2001, the Transnational European Evaluation Project led by the ENQA, intended to develop common systems of evaluation of the courses. However, the ENQA will not be used as a registration instrument [2].

IMPRECISION OF THE SINAES AND THE DCNS

The SINAES has the objective to promote internal and external evaluations. However, its methodology, practices and results raise some questions: how to promote an evaluation in a national scope, with compatible criteria of comparison, in a country with such dimensions and cultural diversities as Brazil? How can the same evaluation criteria - necessary to generate data and to direct the decision making process – be valid throughout the country and at the same time respect the identities and diversities of several institutions and localities? How can the same test evaluate students whose realities vary in such different ways? Moreover, how to guarantee the effectiveness of the actions that must be generated from the evaluations' results? In nationwide evaluations, a single standard is established (of knowledge, abilities, etc.), to enable the government to verify the quality of education that is being offered.

It is also important to note that, because the result of the evaluation is of public domain, it ends up influencing the students' decision in choosing a IES. Therefore, in addition to fulfilling its role as a guideline of public politics, the evaluation can also direct the students' choices, as future clients of colleges, in the growing market of private higher education in Brazil. Under this perspective, the evaluation becomes less an instrument of diagnosis and more of marketing, creating courses that just teach their students enough to have good performance in the ENADE, limiting the course itself and molding it.

How to evaluate an educational system having as a perspective, a model, which suppresses creativity and freedom? How to analyze specific realities in a nationwide scope and guarantee the quality of education, being that the model to homogenize the schools, creates a problem by eliminating regional characteristics and specifics of different courses, that identify and differentiate themselves from other courses?

Should law courses, for example, provide the same formation in different places of the country? Should the medical student from a coastal city have the same kind of courses that another student has who lives in the countryside? Should the engineer who graduated in a big city have the same kind of knowledge that an engineer who works in a smaller city in the rainforest area? In this direction, what sort of knowledge should be common to all and what sort would be specific knowledge? How is it possible to analyze the quality of education in relation to specific knowledge, since it is so varied and dynamic?

The first step in facing all these questions was taken in 2001 when the National Curricular Guidelines (DCNs – Diretrizes Curriculares Nacionais) were established in Brazil by the Chamber of Higher Education, an agency from the National Counsel of Education of the Ministry of Education. These guidelines have to be observed in the curriculum formation of the higher education courses in the Brazilian territory. As a result, a minimum curriculum was created to assure minimum quality to the courses and to enable transferences between IES. In many cases, due to corporative interests, the curricula ended up with too many disciplines of questionable obligatoriness.

Here, it becomes evident that such discussions are not separable from the social factors that interact with the educational system. The economy, culture, and politics directly affect what happens inside a classroom and influence the way the quality of education is analyzed. Therefore, to deal with education, it is necessary to observe what happens outside the institution. In accordance with Michael Apple, in the United States, 1985: *"...the fact that education is through and through a political enterprise withered. The questions we asked tended to divorce ourselves from the way the economic and cultural apparatus of a society operated. A 'neutral' method meant our own neutrality, or so it seemed."*[3]

For Apple, education is never a neutral assembly of knowledge that simply appears in the school's daily routine. The structural and educational contents come from a selective tradition, carried through by someone or a group that determines what is legitimate knowledge. This knowledge, in its turn, is generated by the social conflicts which organize and disorganize a nation. Many times, the professors do not recognize these relations, because they do not understand education as being relational, as product of historical social conflicts, placing themselves "*in a separate compartment, one that does not easily allow interaction with the relations of class, gender and racial power that give education its social meaning."*[4]

In Brazil, the path taken was to make the courses less homogeneous due to the trend to decrease their length and because other measurements were taken, such as putting into practice ways of learning that contribute to reduce the student evasion rate, implementation of scientific initiation programs, and the inclusion in the curriculum of ethical and humanistic dimensions involved in professional activity.

The Engineering course fits in this scheme: the DCNs of the Engineering Courses aim at having a contingent of students with the ability of systematically evaluating problems and their solutions. However, the formation whose priority is the transmission and absorption of an enormous amount of contents instead of the development of abilities is

still the predominant model the higher education institutes in Brazil.

The trend to give flexibility to the curriculum indicated by the DCNs is being followed by the engineering courses. However, the ideal curriculum recommended by the Chamber of Higher Education in the document CNE/CES/1.362/2001 has not been reached yet: "*it goes far beyond the conventional classroom activities and must consider complementary activities, such as scientific and technological initiation, ample academic programs [...] university extension courses, technical visits, scientific events, besides cultural, social and political activities*".

In Brazil's university scenario, the desired course structure has not become reality either. The desired course structure has to have a pedagogical project that considers not only the learning inside the classroom, but also the intellectual stimulation through the development of individual or in group projects, especially those capable of integrating different academic background knowledge. Most of the engineering courses in Brazil stick to established contents (30% of basic and 15% of professionalizing contents), rather than to promote the development of abilities the future engineer has to present.

EMANCIPATORY EVALUATION

In her 1988 book, "Emancipatory Evaluation: Challenge to the Theory and to the Practice of Evaluation and Curriculum Renewal", Ana Maria Saul proposed a new kind of evaluation based on three sources: democratic evaluation; institutional critique and collective creation; the participative research [5].

Opposed to the bureaucratic studies seen in North American programs, the democratic evaluation is a model that recognizes the pluralism of values. The appraiser, in this method, has the responsibility to intermediate the exchange of information among the school's protagonists, and to gather people's conceptions and reactions regarding the school's activity.

The institutional critique and the collective creation picture the methodology of the Emancipatory Evaluation in three points:

1. problematization of a determined reality, searching to identify the significant questions from students and professors;
2. critical retreat, in which a reflection on the educational practice is developed to improve professors and students' conscientization;
3. establishment of actions coherent to the previous discussions to necessarily expose a politic-pedagogical project [6] that will lead to the rethinking of the organizational structure and will enable a collective and solidary construction.

The participant research is based on Orlando Fals Borda's [7] six methodological principles, treated in his article "Theoretical Aspects of the Participant Research" of 1980:

1. authenticity and commitment of the appraiser;
2. non-application of preconceived ideological principles or ideas;
3. feedback to the participants of the process;
4. discussion among the collaborators in order to obtain scientific accuracy on what is done in the evaluation field;
5. rhythm and action-reflection balance;
6. employment of modest sciences and dialogue techniques that are useful in difficult situations or where there are few resources.

The Emancipatory Evaluation is based on qualitative data, characterized by participative and dialogical methods, with open interviews, debates, analysis and observations. The appraiser coordinates the evaluative work and promotes dialogue to find a critical analysis by the students and professors concerning the school´s problems.

For Saul, two types of evaluation exist: quantitative and qualitative [5]. For her, the quantitative one treats education as merely a technical process and has as objective only to verify if the daily pre-established goals have been reached. The results obtained in the quantitative evaluation are addressed to the responsible authority of the institution, thus serving as support to school planning, many times disregarding the interests and necessities of the students and professors.

Qualitative boarding has the purpose to understand a situation where human beings interact and react with conscious and unconscious behavior when confronted with different opinions, ideologies and positions. The qualitative evaluation does not aim only at comparing observed and quantified data to take care of pre-established objectives. However, descriptive and interpretative methods do not discard quantitative data. The contents of qualitative evaluation include opinions of different groups, allowing for comprehension of the participants.

In the type of evaluation proposed by Saul, the methodological procedures, although fruitful and deep, can hardly be applied with a very large number of students. The necessary time for its implementation does not favor regular and frequent discussion either, since the compilation of open interviews and qualitative data is lengthy. Having in mind a course as dynamic as engineering is, a more dynamic system of evaluation was necessary.

METHODOLOGY OF THE EVALUATION OF EDUCATION AT THE POLYTECHNIC SCHOOL

Since 2004, the Polytechnic School of the University of São Paulo (EPUSP) has been developing an evaluation process entitled Evaluation of Education in order to verify the quality of education offered. This process is similar to the Emancipatory Evaluation, but presents significant differences. The experience obtained from methods of evaluation developed in previous years at the Polytechnic School, the results and changes of the nationwide systems of evaluation, the proposal of the SINAES and the consequent proposal of creation of the CPA, besides the knowledge of the theories of educators and researchers in the educational area, have contributed to the current evaluation system at the Polytechnic School.

The model of Evaluation of Education at the Polytechnic School has as its main objective to develop the

dialogue between the student body and the professors, in order to improve the quality of education. This process has basically five stages: determination of the classroom representatives (RC – Representante de Classe); elaboration of an opinion questionnaire; application of the questionnaire; compilation of the data and the resulting report; and meetings between classroom representatives and professors.

The students, professors and the pedagogical coordinator all take part in this process. The students act as protagonists and the pedagogical coordinator coordinates the work in the evaluation process. Similar to an appraiser, the pedagogical coordinator promotes the meetings and assists in the activities with the professors and the students. The coordinator follows the methodological principles of Borda in the Emancipatory Evaluation.

The first stage is related to the way the students participate in the process. At the beginning of the semester, the pedagogical coordinator with the help of the professors verifies which of the students has an interest in becoming a classroom representative. As a maximum number of representatives per classroom are not stipulated, all those manifesting an interest can effectively become a RC. Thus the process does not constitute an election, but rather a collective agreement among the interested parties. Until the present moment, the Evaluation of Education was applied in the first four years of the five-year course; the meetings and activities, described as follows, are divided by year. The RCs of the 1st year interact among themselves, but they do not take part in the meetings with the RCs of the 2nd year. On special occasions that involve matters that affect all the courses of engineering in the Polytechnic School, meetings with all the RCs are organized.

The elaboration of an opinion questionnaire, application of this questionnaire, compilation of the data and the elaboration of resulting report, resemble to the first two acts of institutional critic and collective creation of the Emancipatory Evaluation. In this case, the problematization of the school situation through a reflection of both the professors and the students is developed.

In the first meetings of the RCs with the pedagogical coordinator, problems and questions of the students are discussed. As in the first methodological stage of the Emancipatory Evaluation, the reality is problematized and the pertinent aspects are discussed.

After this period of problematization, a questionnaire directed at the students, with questions about the professor's teaching skills, didactic material, interdisciplinarity, learning and contextualization is elaborated by the RCs. The professors also can suggest questions to be included in the questionnaire, which will be incorporated upon acceptance of consensus by the RCs. Only students and the professors' significant questions, that were discussed in the problematization of reality, are placed in the questionnaire. Every semester the questionnaire is discussed, the questions change from time to time, reflecting the necessities and difficulties characteristic of a certain time. Some questions continue to remain over time, as, for example, the didactics of the professor – which may enable the construction of a historical series. As the evaluation is separated by years and classrooms, the questionnaires may have different contents and formats for each year or classrooms.

Once the questionnaire is elaborated, it is applied by the RCs to the students after 8 weeks of lessons. The RCs also assist their colleagues in filling out the questionnaire in case of questions. Since 2004, the questionnaire presented qualitative and quantitative questions. It is anonymous and is filled out by hand on a sulfite paper sheet.

The RCs are responsible for the collection of the questionnaires, and with the assistance of a statistical tool, they calculate the mean and standard deviation of the quantitative questions. Even though the questionnaire is anonymous, it is possible to identify local problems, since the data of the filled questionnaires are separated by classrooms and by disciplines. This allows locating a specific problem in a discipline, a classroom or even with a professor.

Together with these results, the RCs writes an essay for each discipline in his classroom, presenting an analysis of the numerical results, comments and suggestions of changes. To write this essay, the RC analyzes the numerical data and the qualitative questions, citing commentaries of the other students, when necessary.

The final resulting reports are comprised of essays and also by the mean grades and standard deviations of the evaluated questions. This final document represents solely the opinions of the students on the quality of education, and in the first two years, they are delivered by the classroom representatives to its respective professors. From the third year on, the results of the evaluation are delivered to the Heads of the Department.

The fifth stage, meetings between RCs and professors, is the product of the Evaluation of Education. The dialogue in the meetings is the main result of the evaluation. In these meetings, the information is argued and a plan of action to be taken is discussed. As in the CPA of the SINAES, the auto-reflection of the professors and of the students in these meetings is stimulated. Prompt actions can be taken immediately, modifying the teaching method during the semester. Therefore, the following actions from this Evaluation of Education do not necessarily constitute, as in the Evaluation Emancipatory, a politician-pedagogical project, however they do not escape necessarily of being part of one.

The Evaluation of Education of Polytechnic School, different from the Emancipatory Evaluation, utilizes a qualitative approach, aimed to the understanding of a situation, such as a quantitative one, that is important for the decision making by school management. This process is repeated all semester, presenting continuity and transformation, accumulating experience of years past without hindering the implementation of new questions.

DATA ANALYSIS

In 2004, the Evaluation of Education was applied only to the first year students at the Polytechnic School. The evaluation has been advancing each year in the engineering course. In 2006, only part of the third year had been evaluated, and in

2007, the first four first years of the course will be evaluated.

One of the biggest challenges of the application of the Evaluation of Education in the Polytechnic School is the amount of professors, students and disciplines. The Polytechnic School has 473 professors, more than 4,500 undergraduate students and offers 17 courses of engineering. Some of the disciplines of the two first years are given by professors from other departments, such as Physics, Calculus and Linear Algebra. In the first year all the disciplines are the same for all the courses of engineering. In the second year, the course is divided into four Great Areas with basic and specific disciplines for all in each area. From the third year, each course has its proper structure of disciplines. In Table I, the amount of questionnaires answered by the students in the Evaluation of Education is demonstrated.

TABLE I
GROWTH OF THE PARTICIPATION IN THE EVALUATION OF EDUCATION IN THE POLYTECHNIC SCHOOL

	Amount of questionnaires answered	Sample Size
1st semester 2004	537	750
2nd semester 2004	521	750
1st semester 2005	982	1.500
2nd semester 2005	684	1.500
1st semester 2006	1.074	2.250

In 2004, the Evaluation of Education was applied only in the 1st year students. The sample was extended in 2005 to the 2nd year students and, in 2006, to the 3rd year students. The intention is to reach all the 5 years in 2008. The participation of 1st year students is already stable around 70% and there is an expectation of similar behavior with other year students. The fluctuation of the amount of questionnaires filled out has been due to a resistance and mistrust of professors in helping in the application of the questionnaires in some disciplines, but during the process, with constructive dialogues, this panorama has changed.

For Paulo Freire, "*pedagogical evaluation of students and professors are becoming progressively more dominated by "top down" forms of discourse that try to pass themselves off as democratic*"[8]. This does not mean to be against the evaluation, a necessary instrument, but "*struggle to grasp the theoretical and practical implications of such evaluations. We must see to what extent they may serve as an instrument for enabling teachers who are critical to put themselves at the service of freedom and not of domestication*".[8]

A democratic evaluation is necessary to have the participation of the professors and students in a horizontal dialogue, so all can participate equally and analyze, from their own point of view, the institution itself. This relation allows, through the dialogue, that the students have a voice and can present their points of view and motivations. On the other hand, the professor learns and reflects on his/her own actions when dialoguing with the students, observing the contents treated from a different perspective. [7]

In 2006, with three years of experience of data-collecting, recurrent subjects that indicated bigger problems in the Polytechnic School courses started to appear. One of the biggest problems was the lack of contextualization of the two first year disciplines, such as Calculus, Physics, Chemistry, among others. It was verified, in the meetings between RCs and professors, that the students feel a lack of approach of the contents of these disciplines with engineering. At the same time they perceived the importance of this theoretical base, they believe that if the professor was able to relate the theory with the application, it would be more motivating for learning and would initiate greater participation with the students in class.

This factor appeared initially in 2004, when it was noted that in some questions of some of the disciplines, the students indicated dissatisfaction. The results of the questions "were the frequency of the lessons important for your learning? (0=irrelevant 10=essential)" and "Independent of your result on the exam, do you feel that you are learning? (0=no 10=yes)", placed on the questionnaire of the 1st semester of 2004, for the students of the first year, as a result generated many discussions. At that time it was not possible to diagnosis what was not motivating the student, but the data of the questionnaire have been registered and the process continues.

In 2005, before the application of the questionnaires for the students of the 1st year, in the 1st semester, in meetings with the pedagogical coordinator the RCs had already commented the dissatisfaction of the students with some disciplines. Then, the question was included this year "On average, how many hours per week have you studied outside the classroom?", and together with the other questions, perceived that the problems continued with disciplines evaluated poorly in 2004.

In other debates, colloquies with the head management and internal commissions of the Polytechnic School, it was concluded that there was no clarity of intentions in some basic disciplines. Some professors of the Polytechnic School understood that these disciplines had to display in their curriculum examples of relations between the taught content and applications in engineering, while others thought that the first two year disciplines had to deal only with the basic concepts, without application. Without a consensus, the professors who teach basics disciplines, from other institutes than the Polytechnic School, gave the lessons without showing the application of concepts in engineering.

To evidence the fact, in the 1st semester of 2006 the second year students proposed this question: "Are you able to perceive the relations between the taught content and its application in engineering? (0=I do not perceive relation 10=I perceive relation)". From the results and discussions in the meetings it was perceived, that it is important to the student that the professor explicate, when possible, the application of basic knowledge in the discipline given, in the first years, thus transforming the lesson into a more stimulating content, leading to a greater participation and application.

This aspect was not raised by the RCs of the 1st year of the 1st semester of 2006. The RCs had commented that in that year the professors had already started to show applications of engineering in their lessons, which not necessarily meant the problem was totally resolved. Every year, new professors give classes in the Polytechnic School,

and in this rotation it is possible that the class reverted back to not having the explanations on the applications of basic concepts. A greater resultant action of the dialogues would be a curricular change as such that the course became more motivational for the students. In this case the elaboration of a political-pedagogical project became necessary; however, no orientation of engineering exists in the DCNs, commenting on whether the basic disciplines must contextualize their contents.

Perhaps the contextualization is a specific problem of engineering or only of the Polytechnic School. But this diagnostic is impossible to be implemented as a nationwide evaluation, equal in all courses in all places. Other factors have been also argued in meetings. A great majority of these factors is specific to the nature of the course. The Education Evaluation allows us to go into the details of the problem, resolving specific problems and generating an auto-reflection of professors and students.

CONCLUSIONS

In the evaluation system developed at the Polytechnic School it is possible to identify specific problems in both the school and the engineering course. Through dialogue as a result of analysis of data from the questionnaires, professors and students actively participate in decisions at the school, by contributing their personal desires and motivations for the improvement of the course. This dialogue generates a collective conscience about the importance of discussion and educational changes, resulting in researches and actions that modify the educational structure proposed by the institution.

This evaluation allows school activities to function dynamically. This is an important factor because an engineering course tends to adjust frequently due to the technological changes in society. These alterations remain as responsibility of the protagonists of the institution and not the government, promoting society's participation and diminishing the possible imposition of established models.

The maturation of the students who had been RCs and the increase of dialogue between them and some professors were visible in the three years of application of the Evaluation of Education. The RCs today participate in many extracurricular activities such as, commissions' representatives at the Polytechnic School, international interchange programs, scientific initiation, student's movement and others. This singular behavior might be considered only a reflection of a previous cause, but it can also be consequence of the work carried through. The professors are closer to the students, listen more and interact with the school administration, becoming more critical and demanding about the improvements at the Polytechnic School. It is already common to see some professors demanding for RCs in the very first week of the term. Some activities outside the classroom, such as technical visits, are being organized by professors and RCs, in order to indentify the most motivating external activities for a determined classroom or type of students.

The Polytechnic School, in the next months, will apply this evaluation at the end of the semester and will also develop a questionnaire for the professors to express their opinions concerning the course, with the intention to provoke discussions.

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