Evaluation Processes in Tune with New Personal and Professional Perspectives

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***Abstract* – The Escola Politécnica da Universidade de São Paulo (EPUSP) / Polytechnic School of the University of São Paulo in Brazil implemented a curriculum reform in 1999. The proposed structure should guarantee the formation of an engineer more in tune with the new societal realities and demands in Brazil and worldwide. This entailed that the formation of an engineer should no longer be concentrated just around technical knowledge, but also on a whole set of skills and attitudes. One of the most significant changes in the new structure was the implementation of the discipline PNV-2100 Introduction to Engineering in the first semester of the course. Activities were also proposed under this new conception. Helping students to learn an engineering design method was among the objectives of the discipline and it was decided that the themes chosen for the project had to be deliberately polemical and citizenship-driven. The discipline also aimed at allowing the student to develop certain skills and attitudes, such as teamwork, written and oral communication, social and environmental awareness, ethical judgment and stance. The algorithm employed to attribute final grades to students includes evaluation of project reports and peer's evaluation of oral presentation in different stages. Therefore, the algorithm incorporates a large part of the objectives of the discipline, and reflects an expressive participation of students in the evaluation process.**

Index Terms – Teaching techniques, student learning, learning evaluation

INTRODUCTION

When teachers are preparing a teaching plan for a discipline in an engineering course, they have to determine a process to evaluate the students' learning and will employ analytical quizzes, lists of exercises for homework and development of projects or a research. If one delves deep into the process analysis, some questions will certainly arise, such as: Is this the only possible procedure to employ in the evaluation of the student's learning? How efficient is it?

These questions lead to different answers but it is possible to say that the traditional procedure is, at the minimum, unable to stimulate skills and attitudes society currently expects from engineers, besides their technical knowledge.

The evaluation of the students' learning should be discussed within a systematic teaching plan involving, not only a specific choice of methods for teaching, but also a selection of desired learning outcomes. It must be pointed out that among the teaching activities, the evaluation of the students' learning is the one which causes the most discomfort to some teachers.

Abreu and Masetto [1] investigated this problem and presented a proposal about learning evaluation. It should be related to the learning process and should be performed coherently with the desired objectives. It should be continuous to allow a prompt restart of the learning process, whenever necessary until the objectives are reached. In addition, it should be focused on the student and the professor's performances according to the course plan, requiring from the professor, as well as from the student, the ability to observe and retain information.

In the scenario of traditional teaching techniques where learning is understood as repeating, copying, reproducing and memorizing ready answers, the evaluation is applied to check whether the student is able to recall and reproduce answers seen before, but not to measure if they have learned the processes of knowledge acquisition and investigation.

Nowadays, however, different teaching techniques have been used in different areas to improve knowledge absorption. Learning is now understood as a process of knowledge building, which involves information and memorization, understanding of the discipline contents, logical thinking, analysis and synthesis capacity, critical view and an autonomous elaboration of ideas. Taken as a whole, teaching methodology gives priority to the effective learning achieved by the student.

It is important, therefore, that engineering professors watch closely their students' learning process, trying to record information about how, why, when and how much they learn, and make use of these data to improve the teaching process, implementing corrections in the learning process and performing as an efficient interlocutor between the students and the discipline content.

This paper describes the implementation experience of a non-conventional learning evaluation procedure in the discipline Introduction to Engineering, offered to students in their first semester, and also how the learning evaluation is related to the discipline objectives. The paper begins with a brief description of procedures used to evaluate the student's learning at the EPUSP.

THE LEARNING EVALUATION EXPERIENCE AT THE EPUSP

At the Polytechnic School (EPUSP), a discipline teaching plan may include different activities such as lectures, practical classes, seminars, researches, design, etc. The students' learning evaluation in each discipline, however, is essentially based on the grades given by professors for quizzes and homework.

Nevertheless, the need to change the evaluation procedures has often been pointed out in engineering education conferences, due to a strong modification in the profile of incoming students as well as in the organization and infrastructure of engineering schools. If the traditional teaching approach and the conventional process of learning evaluation continue to be applied, there is a considerable risk that Brazil will exhibit a delay, compared to other countries, in terms of university development.

The teaching approach should be able to conceive the genesis and the development of knowledge and will lead to a new way to see the universe, life and social relationships. Therefore, if there is a significant change in the social relationships, the evaluation approach, should also be changed, Becker [2].

Nakao [3] described some innovative experiences with learning evaluation at the EPUSP, such as weighting the questions of an analytical quiz in terms of the discriminatory capacity of each question, or giving permission to the students to solve their problems during the application of quizzes, or introducing group projects evaluated by the students themselves. Those experiences had shown an active, sometimes enthusiastic, but mostly responsible participation of the students in the evaluation process.

Nakao and Lindenberg [4] pointed out that evaluation techniques should be understood as a feedback instrument for students and professors, providing information about the success of the learning process. They should supply students and professors with data that would enable learning correction and progress.

According to Perrenoud [5], the evaluation process is a component of a didactic project, which allows professors to control each of their students' work in order to achieve the desired outcomes. Nakao [3] stated that, if the evaluation process is fair and flexible, it will never be an obstacle or the unique element to induce a student's learning. The satisfaction with a job well done and the passion for knowledge will lead students to pursue the same objective as their professor does.

THE EXPERIENCE WITH LEARNING EVALUATION IN INTRODUCTION TO ENGINEERING

The focus of this paper is to describe the procedure used to evaluate the students' learning in the discipline Introduction to Engineering, focusing on its non-conventional characteristics. First of all, the teaching planning of the discipline, the definition of its objectives and the description of the activities are presented.

Formulation of the teaching plan

At the end of 1990s, as the result of a long-term discussion, the EPUSP started to implement a curriculum reform. A significant change in this reform was to reintroduce a common first year for all engineering career courses. The Introduction to Engineering (IE) discipline was included in the first semester program, along with the traditional disciplines of Mathematics, Physics, Chemistry, etc.

The group of professors (IE team) in charge of preparing the discipline teaching plan had a six month period to work on it with the assistance of a pedagogical coordinator. Being aware of the new societal realities and demands, the IE team rejected the use of traditional teaching techniques. Traditional techniques make use of presentations with questions and answers and audiovisual resources, and tend to keep the students in a passive attitude. Therefore, the IE team decided to investigate new teaching techniques, taking as a premise that the formation of an engineer should no longer be concentrated just around technical knowledge, but also on a whole set of skills and attitudes. After three months of work, a preliminary teaching plan proposal for the discipline was ready to be presented and discussed in a larger group of professors. It comprised of the definition of the main objectives of the discipline, the course content and the teaching and learning conceptions. At that time it had already been decided that the 750 students would be divided in 22 classes (today 24), which would require the participation of professors from different departments of the EPUSP.

The discussion in the larger group, though not always smooth, was profitable and produced a final proposal, less revolutionary, but that met the consensus of the professors who would teach the discipline. As a result of the whole process, two guiding texts for the discipline were prepared: the Professor's Manual [6] and the Student's Manual [7].

The discipline was offered for the first time in 1999, and since then, a series of modifications have been introduced into the teaching plan. The goals have been redefined, the learning evaluation processes have been altered, and therefore, the guiding texts have also been reviewed.

The guideline of this project has always been to enable students, right from the beginning of their first semester, to learn an engineering design method, mainly the aspects concerning the identification of the needs and expectations and the description and definition of the problem, the formulation of the most adequate alternative, and the establishment of criteria to evaluate and select the most adequate solution.

It was decided that the students would learn the design method by developing an engineering project. The themes chosen for the projects have been deliberately polemical and citizenship-driven, such as: management of solid waste and reduction of waste disposal; electrical energy savings in commercial and residential buildings, and reduction of water consumption in these buildings.

The discipline activities are, therefore, concentrated on the development of a thematic project in a different scenario for each three classrooms. The students are required to work, organized in teams, on a class project divided into two phases along the semester.

The discipline also aims at the development of the students' attitudes and skills, such as teamwork, planning, programming, controlling, written and oral communication, creation of alternatives and decision criteria, economic, social and environmental awareness, and ethical judgment and stance.

IE activities involve lectures and class discussions, teamwork, and inter-group and inter-classes competitions intermediated by a professor. The groups have to prepare two partial project reports and also present them orally to be evaluated by the class and the professor. At the end of the semester the class prepares a final report that integrates and consolidates the contribution of the different groups. There is a continuous evaluation and feedback of the students' learning.

The 750 students that enrolled in the EPUSP were divided in 22 (24, now) classes. Since part of the evaluation process contemplates a competition among classes, there has been concern about an even distribution of students' potential in the different classes.

A description of the criteria adopted to evaluate the students' learning is presented below.

Evaluation Criteria

It has been assumed, from the beginning, that the evaluation criteria of the students' learning would not be based only on the grades that teachers give to the students in quizzes and assigned homework.

In Introduction to Engineering, the evaluation procedure covers a large range of mechanisms. The students are evaluated by their classmates in inter-groups competitions and by students from other classes in inter-classes competitions. The reports are comparatively evaluated by docents and the final classroom projects are evaluated by a committee of docents.

The evaluation process was designed as an integral part of the teaching plan. There is a continuous follow-up of feedback that comes from the professor, the classmates and the student themselves and from other elements that could be participating in the process. All this information will help the student to learn in a broader sense, by learning content and by developing specific skills and attitudes.

As the evaluation procedure is integrated into the learning process, it is possible for the teams' professors in their weekly meetings to perform an appropriate analysis of the different components of the learning process which are student and professors' performances and the teaching plan in its application.

After a couple of years of continuous improvements the algorithm that provides the students' final grade includes most of the discipline objectives. Thus, there has been a change in the paradigm of the teaching and learning process, which now focuses more on learning than on teaching, and as far as the evaluation issue, is concerned, the student is no longer a passive element, but rather the main character.

In the Student's Manual [7] there is a detailed description of the items that enter into the composition of the students' grade, namely the class and group factors, the participation coefficient and the prize. Although quite long, part of its description is reproduced below because it is considered very relevant for the comprehension of the evaluation experience.

Definition of the Factors

Class factor (f_t): The class factor is a component of the evaluation process, which arises from a competition at the end of the semester among three partner classes**.** The partner classes have the same project and present their final report to the students of three other partner classes and to a professors' committee. The evaluation process is the following:

- A team of 5 students, selected by each class, present a synthesis of their project;
- At the end of the 3 presentations the committee and the audience questions the teams about the main aspects of the project and they are given an opportunity to defend their ideas;
- Based on the project presentation and the answers given by each team, professors and students evaluate, in a comparative way, the projects of the three classes, defining their rank.

In such a way, the classes receive a grade for the class factor according to their rank in the competition: 1.0 for the first position, 0.95 and 0.9 for the second and third ones. As a matter of fact, there are two grades, one given by the students, $f_{ta,}$ and other given by the professors, $f_{td.}$. The class factor is therefore given by:

$$f_t = (f_{ta} + f_{td})/2$$

In the class following the presentation, and also in the last class of the semester the professor presents his class his comments about the competition and the students' participation in the evaluation process, and emphasizes a discrepancy between the evaluations performed by the students and the docents whenever it is noted.

Group factor **(f_g):** In each class, assuming a standard number of 32 students, 8 groups of 4 students are formed to work on the class project. For each two groups of the class, called mirror-groups, the same sub-theme of the class project is assigned. At the end of each phase there is a group competition, where the mirror-groups submit their work to be evaluated by the whole class. The students will have already received instructions on oral communication techniques that have to be used in the project presentation.
According to their peers' evaluation, the students receive a grade for the group factor: 1.0 if the group wins the competition and 0.9 if it looses. At the end of semester each student will have two grades in the group competition, f_{g1} and $f_{g2.}$ The group factor is therefore given by:

$$f_g = (f_{g1} + f_{g2}) / 2$$

In the class immediately after the competition, the professor gives feedback to the students about their performance in the presentation as well as in their peers' evaluation.

Prize (p): At the end of the semester the class has the opportunity to award a prize to those students who had most contributed to the development of the class project.
The rules for award distribution are the following ones:

- A maximum of 5 students may receive a prize equal 0.1;
- A maximum of 7 students may receive a prize equal to 0.07;
- A maximum of 9 students may receive a prize equal to 0.03.

The professor does not participate in the process of award distribution, but imposes a time limitation on the task.

Participation factor (fp): This factor incorporates the professor's evaluation of the students' performance along the course but it still leaves some room for student participation in the evaluation process. The professor's participation is mainly related to the analysis of intermediate (group) and final (class) reports. The professor's evaluation includes two parts, a conceptual and a formal. The first concerns the project quality developed by the group and if the students have correctly learned the several steps of the design method. The latter concerns the clarity and the consistency of the written report measuring the students' ability in written communication, which is an objective of the IE.

In the evaluation of the partial group report, the professor gives a grade $f_{pp,}$ which may vary from 0.0 to 1.0, but usually is not smaller than 0.7. The group may divide the given grade equally among the participants or may divide it in a different way, if it is understood that there was a more relevant contribution of one or more members to the project development. At the end of the semester, each student has two grades of the Partial Participation Factor, f_{pp1} and f_{pp2} corresponding to the two phases of the project development.

The professor makes his comments on the group's reports, giving feedback to the students concerning what has to be improved, both in terms of the project itself and in the written report. At the end of the project phases the mirror-groups should integrate their work, using the professor's feedback in order to provide a unique report of the class sub-theme project.

The final class report shall incorporate, in an integrated form, the sub-theme projects. The professor evaluates this report, checking whether the integration was good, and gives a grade for the final participation factor, f_{fp}, which is applied equally to all the students in the class.

There is a third component that enters into the evaluation of the student participation factor, f_{vp}, and it is related to the student's behavior during a technical visit that the class makes to an industry company.

The participation factor is then given by:

$$f_p = (f_{pp1} + f_{pp2})/2 * f_{pv} * f_{pf}$$

Final grade N_f: The final grade is calculated by the following expression:

$$NF = 10 \times (f_t \times f_g + p) \times f_p$$

Special Remarks:

- The composition of the class groups in each phase of the class project is defined by the professor;
- The student's attendance is controlled in every class;
- An unjustified absence of a student in the classes allocated for inter-group or inter-class competition implies that he will receive a grade of zero for the group or class factor;
- A student may receive a grade higher than 1.0 for the participation factor in each phase of the class project. This happens, for instance, if the professor gives a grade of 1.0 to the group report and the participants of this group decide not to evenly distribute the participation factor;
- The final grade will be constrained to 10.0
- The professor may always question the student's evaluation, and vice-versa, in a rational way.

FINAL COMMENTS

This paper gives an example of how to incorporate and explore evaluation processes in tune with new personal and professional perspectives on engineering course disciplines. It must be pointed out that there is a consistent connection between discipline objectives and course activities and procedures used to evaluate students' learning. For example, class projects developed by students are evaluated because one of the main objectives of the discipline is to help students learn an engineering design method. The students will certainly study other disciplines along their course which will cover the same subject; since it is understood that experiencing the design of meaningful engineering projects is an important contribution in providing a good engineering education.

All other discipline objectives have also been contemplated in the planning of course activities. A large range of evaluation techniques have been used, and in general, they have contributed to the student's motivation.

The authors believed that the results obtained were good but they decided to have the student's point of view as well.

In 1999, 276 students, out of 750, answered the IE evaluation questionnaire at the end of the semester. The answers presented comments concerning the presentation of the different engineering specializations, inter-class competition evaluation without the participation of the professors, the large amount of formal work and the rotation of professors through out the term, and they were used to introduce corrections in the teaching planning in 2000.

In 2001, only 91 questionnaires were collected. Answering a question concerning the contribution given by the discipline to the development of skills, 80% of the students said that it was good or very good. The participation of students in the evaluation of inter-group and inter-class competitions was considered bad or very bad by 20 % of the students. However, more than 80 % of the students considered that in an overall sense, the discipline was good or very good.

In 2002, 320 students answered the questionnaires and criticized student performance in the evaluation of the

competitions and the non-homogeneous criteria adopted by the professors in the evaluation process. In the overall evaluation the satisfaction level was a little bit behind the 2001 one.

Since 2003, a normalization procedure has been utilized to define the grades of the partial participation factor, in order to take into account the different evaluation criteria of the professors and since 2004 a committee of three professors has evaluated the inter-class competition in order to minimize the discomfort felt with the exclusive peers' evaluation.

The development of a thematic project has helped the students in valuing the technical subjects and also in understanding the engineering mission. By working on themes like Water and Energy they have developed a social conscience and responsibility. Even, without a deep technical knowledge, the students, by means of appropriate research in books, technical journals and web sites, have presented classical, creative and, sometimes, innovative solutions for the proposed projects.

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