THE PROJECT-BASED LEARNING AS A TOOL FOR DEVELOPMENT OF SOFT SKILLS IN ENGINEERING CURRICULA

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Abstract. *This paper addresses the challenge of developing new pedagogical tools, trying to contribute with other approaches to the continuous improvement of the graduate teaching, reporting the implementation of the project-based learning on the Mechanical Engineering course at the University of Brasilia. The project-based learning thread allows the students to have articulation with the professional reality, relationship between theory and practice, developing their soft skills, such as the accomplishment of collaborative activities, the explanation of ideas and problems in an accessible way, oral and written communication, the conduction of meetings, decision making, conflicts management and projects management. This study shows that the development of soft skills can happen by creating an environment for the development of multidisciplinary projects, allowing opportunities for the construction of technical and non-technical knowledge, and its application in engineering problems. It can be done without changing the curricula. The experiences considered three different aspects: involvement of students from different grades; a great number of students; and little interference from the professors, as students are expoected to be autonomous in their work. They took place at the first and second semesters of 2007 and 2008 and the findings are extremely satisfactory, pointing out an increase of student's motivation and commitment and more autonomy, responsibility and assertiveness in making decision throughout the projects.*

Keywords*: engineering education; project-based learning; soft skills*

1. INTRODUCTION

For some time now the Ministry of Education, through its curricular guidelines has been signaling towards the need of under degree courses with flexible curricula, student-centered pedagogic approach, emphasis on transdisciplinarity, social and political integration, environmental conscience and link between theory and practice, as to allow the future professional acquire articulation with the professional reality during his/her formation process (MEC, 2002).

Several of these premises are also demanded in the job market, which also requires complementary abilities (soft skills) such as leadership, entrepreneurship, team work, good oral communication and writing capacity (INOVA, 2006)

While the World Engineers Convention, WEC-2008, the initiative managing committee of INOVA Engineering launched the proposal for the Brazilian Program of Technological Acceleration in Engineering (Brasiltec, 2008), a document that suggests measures for the implementation of specific actions from the Federal Government to unite companies and engineering schools towards competitiveness and innovation, inherent attributes to technological training. The document is the result of a great concern for the lack of the so called, complementary abilities or "soft skills", and for the distortions in the engineering under graduation course, specially, for the need of updating curricular contents.

A lot has been discussed in terms of implementing changes in the curriculum in order to assist those needs and mainly, in terms of how to form engineers, who besides acquiring the technical, managerial and humanistic capacities and the necessary behavioral attitudes, acquire continuous learning capacity, and have a constant concern with an international view, without missing dimension of regional and local problems. Several actions have been proposed.
In the new campuses (created after the curricular guidelines) the curricula is more flexible and already contemplates contents and proposals towards this goal. However, they will not be discussed in this work.

In already existing courses, changes are slower because curricular structures are more rigid, and most of these actions have a restricted character, with few effective results. The question raised is the following: "How to maintain contents that enable appropriate scientific and technological formation and at the same time, build an engineering curriculum, tuned with the new paradigms of global education without increasing student's permanence time in the course?"

The present work will present the proposal being implemented in the Technology College from the University of Brasília. The objectives of this proposal insert, initially, in an interdisciplinary context, in which methodology is applied based on participatory interaction that includes the construction and agreement of a common axiomatic to a group of related knowledge fields. The common axiomatic will be the development of an engineering project whose theme will be defined based on the demands of society, market, or the institution. The field of related knowledge will be represented by subjects (mandatory or not) involved in the project during the academic semester. There is the possibility of inclusion of subjects from courses given in the Technology College, tending to a wider field in the medium and long term, involving other knowledge areas.

2. PROPOSAL

The proposal consists of creating an environment for the development of multidisciplinary projects, allowing opportunities for the construction of technical and non-technical knowledge, and its application in real problems.

It is based on a group of actions and tasks established with the main objective of accomplishing synthesis activities and integration of knowledge to be associated to the development of transverse abilities, such as team work, leadership and management required from the future professional in the engineering curriculum indirectly, or without the need of altering the contents of already existent subjects, which can be done through oriented learning by projects, having as a reference the methodology which has already been developed and tested in the Mechanical Engineering course in the Technology College from the University of Brasília. Such activities are denominated Integrating Projects.

The themes for the projects will be chosen according to a close search with the public and private productive section as to identify and characterize the needs that involve knowledge related to engineering activities.

A set of subjects from the engineering curriculum or "target-subjects" is chosen according to the projects to be accomplished. Fig. 1 shows an outline, in which the Integrating Project is used to aggregate knowledge motivated on the curricular contents apprehended (technical or scientific) and to develop traverse competences, which are stimulated during the solution of problems to be solved as a result of the applied methodology and collaborative work.

Teachers of target-subjects participate in the orientation, supervision and assessment of activities. One of them will act as the general coordinator of the Integrating Project, and the students will execute the projects.

The applied methodology presupposes that the executive groups or project teams are constituted of their own norms of conduct, which consist of ethical and professional commitment codes and may act autonomously, assuming responsibility over decisions taken. The teams are formed of students from target-subjects from different semesters and of external students to these subjects, as volunteers. The members of the teams are chosen by the teacher coordinating the activity, based on common schedule availability among students. The team size depends on the number of target-subjects involved and the number of students in each subject, which, in general, has been between 8 to 12 participants.

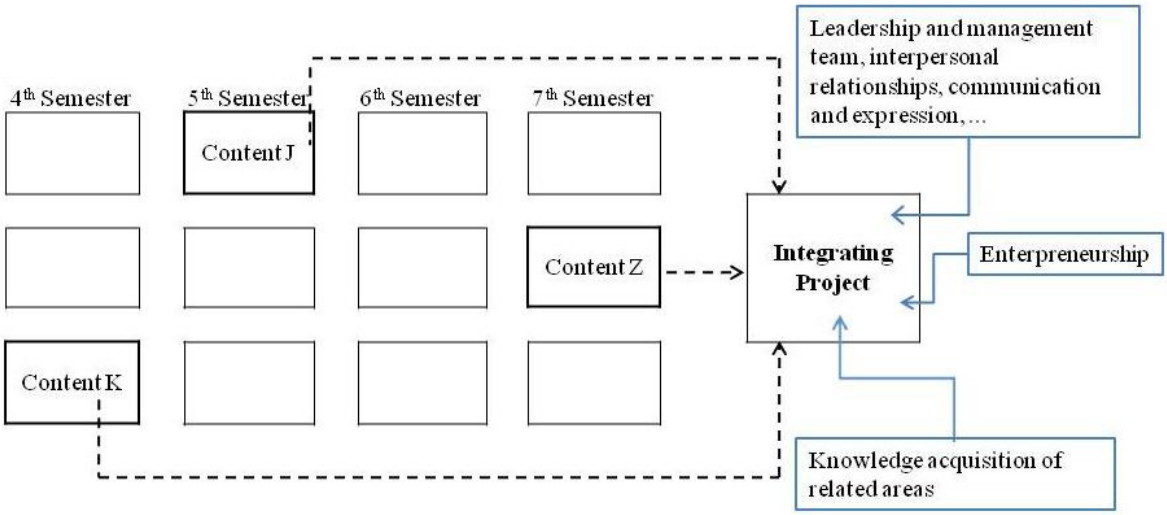

Figure 1. A Representative Scheme for an Integrating Project.

Besides the project development and tasks related to its follow up and control, lectures, mini-courses and motivational games (dynamics of integration) are applied to motivate and complement the formation.

As a result of those actions, one may observe: a favorable environment to the development of traverse competences, students' motivation due to the involvement in the solution of real problems, a greater interaction between university-

company, an egress profile in accordance to the pedagogic project proposals of courses in the Technology College, the incentive to the research of new methodologies for teaching engineering, the use of educational procedures that favor transdisciplinarity, the integration of different areas of knowledge and technical and didactic improvement of teachers and tutors involved. Thus, this study aims at contributing with other focuses for the improvement of undergraduate teaching.

3. CONTEXT

The proposal of the present work had as a guiding approach the studies and works developed at the time of discussion of the pedagogic projects for the Technology College courses, motivated by the Curricular Reform Commission of TC.

One of the study groups concentrated on the elaboration of proposals for the implementation of synthesis and knowledge integration projects, PBL type activities (problem based learning). Such activities, discussed in several meetings, revealed to be essential resources to complement the professional formation, by contextualizing the acquired knowledge into theoretical subjects, enabling social, economical and environmental approaches with the use of transverse themes, or by simulating situations lived in the work environment. It is presupposed that it is a way students benefit from a favorable learning environment to the development of abilities and competences, not usually frequent in subjects in curricular schedules.

Although some experiences already accomplished in the Mechanical Engineering Course could be characterized as synthesis and knowledge integration activities, they had little reach and/or low regularity.

One of the conclusions from the discussion events promoted by TC was that it would be necessary to conduct regular experiences that would affect a whole class, and that should occur with some frequency during the course in order to have their efficacy proved.

With that in mind, experiences were conducted in subjects in the Mechanical Engineering and Mechatronics Course, in the first and second semesters of 2007, as well as in the first and second semesters of 2008, with the support of the curricular reformulation commission from ENM (Mechanical Engineering Department) and ENM teachers. The diagnosis of the first experience contributed to the study and the elaboration of a teaching-learning procedure based on projects that was being searched by Santana (Satana et al., 2008), and the following experiences were the result of the methodology proposed by Santana in his Doctoral thesis research study (Santana, 2009).

According to Santana,

> "There is no doubt that students nowadays need both, technical knowledge (scientific) as well as non technical abilities for achieving success in their careers. This need is determined not only by the work force demands, with people presenting high performance to plan, work in teams and communicate, but also by the need of helping everyone acquire social responsibility and mastering of their new functions as citizens of a world going through constant changes and getting more and more globalized."

Various authors have been investigating this thematic in search and experimentation of new teaching-learning methods that may provide students the opportunity of full development, or in the implementation of environments that simulate situations in the professional practice and their interactions with the environment and society still considering cultural, economic and political aspects.

Alternative methods have been researched and implemented such as: Project Based Learning, PjBL, or Project Led-Education, PLE (Carvalho et al., 2007, Prince, M.J. and Felder, R.M., 2006)

4. METHODOLOGY

The methodology construction began from the analysis of knowledge focused on the use of a pedagogical strategy for teaching-learning, which uses the concept of projects, including the life cycle development with work flows, structured documentation, identification of roles and responsibilities, supported by technological tools and an empirical evaluation of the project results.

Figure 2 shows the Integrating Project development process covering the three basic steps of the method: pre-project, project and post-project. It also shows the project stage detailing its deliveries.

The pre-project stage is accomplished in a period that precedes the outset of the school semester and consists in performing the Action Plan (Student's Guide), by teachers and mentors, that will be presented to students at the beginning of the next step. This document consists of information about the objective to be reached, students involved in the project, the theme to be developed, the main milestones of the project, related subjects, assessment methods, and spaces to be used, and the control points. In developing the Action Plan the techniques of total quality (TQM), called 5W1H were taken into account.

In the project stage of methodology, a thematic project is executed by teams throughout the semester, during approximately 15 weeks. The students, mentors and teachers take part in this stage. This stage is divided into five phases with defined goals for better management control, which constitute the life cycle of the project. The required

documents, instruments and tools available in each phase are shown in Table 1 and the sequence of related actions is shown in Table 2.

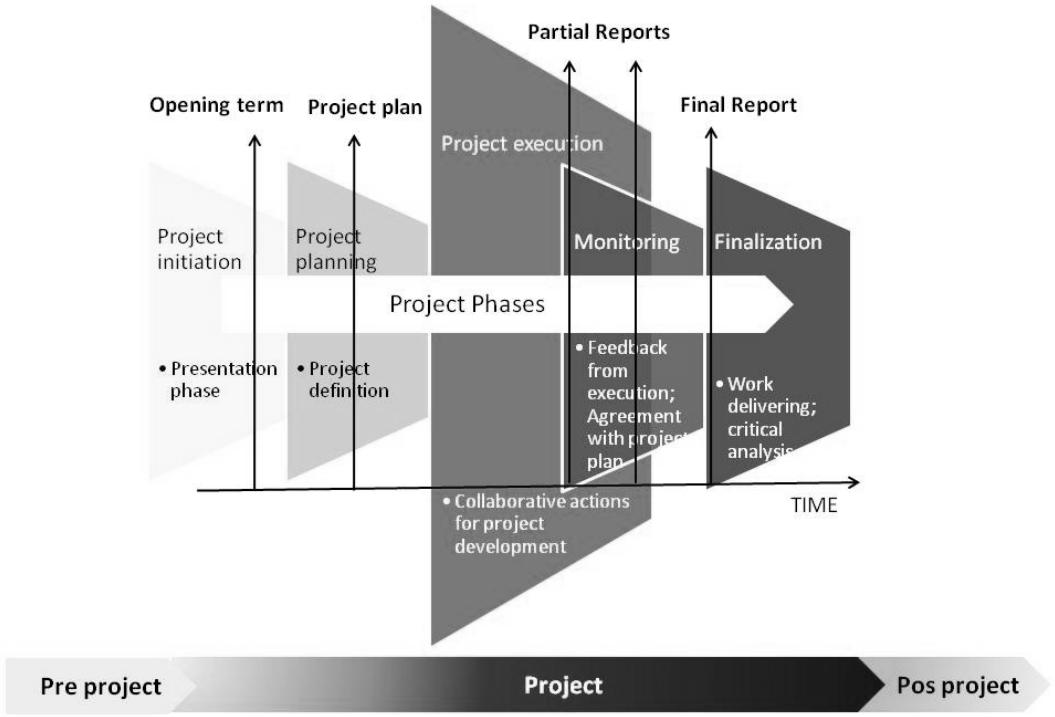

Figure 2. Project phases for an Integrating Project. Adaptado de Romano et al (2005).

Table 1. Documents, instruments and supporting tools related to project phases.

	PROJECT PHASES				
	Project initiation	Project planning	Project execution	Monitoring	Finalization
Documents	-Student's guide -Personal identification and availability -Agreement term of team -Opening term of project	-Project plan	-No documents	-Partial reports	-Final report
Instruments	-Dynamics of integration -Polls on various topics -Assessment form of maturity	-Lectures on project management -Polls on various topics	-Dynamics of integration -Polls on various topics	-Soft skill assessment forms	-Soft skill forms - Maturity assessment form - Educational process assessment form
Supporting tools	e-learning tools (Moodle, dotProject, and other tools adopted by students)			-Peer review	-Peer review -Teacher Final Opinion

The phases of project stage are:

- Project initiation: it is related to the basic activities - presentation of the work methodology, team arrangement, fulfillment of lectures on Project Management. In this phase the Action Plan (the Student Guide) is presented by teachers, the Personal Identification and Availability form is filled in by the students (the teachers will use this

information to organize the teams). The Agreement Term (rules of conduct established by the team) and the Project Opening Term (general information about the project and the team, deliverables, assumptions and constraints) are written by teams. The duration of this phase is three weeks.

- Project planning: the work teams prepare the Project Plan. This plan aims at the definition, preparation, integration and coordination of all activities to be undertaken in the project. In this phase, a mini-course on control and monitoring tools of projects is carried out. The duration of this phase is three weeks too.

- Project execution: the work teams perform collaborative actions and complete the work specified in Project Plan to fulfill the objectives and product deliveries. This phase involves the coordination of people and resources including the integration and implementation of project activities. The duration of this phase is seven weeks.

- Monitoring: verification of compliance by comparing the progress of the project with the Project Plan; identification of problems and adoption of corrective actions, if necessary, to control the implementation of the project. At this phase it is important to define the control points - meetings in which the teams present the progress of projects. The meetings are scheduled in the Student Guide, with the exception of one, which is reported 48 hours in advance. The follow-up elapses in parallel with the implementation.

- Finalization: completion of all formal activities with the final report delivery. In this phase is also made a critical assessment, on both a collective and individual way and involving the analysis of the product, the process of implementation and the participation of the teams. The duration of this phase is one week.

Dynamic integrations and polls on various topics are provided during the phases: project initiation, project planning and project execution with goals of integration and motivation of participants.

The third and final stage of the methodology is the post-project, which is characterized by data organization of experience, analysis of results and dissemination of final grades and the team classification. Only the teachers and monitors take part in this phase.

Templates for all documents and some other tools can be found in the work of Santana (Santana, 2009).

Table 2. Actions that characterize the project phases.

PROJECT PHASES	TEACHERS	STUDENTS
I. Project initiation	1. Class presentation 2. Provide Student's Guide 3. Distribute the Personal Identification and Availability form 5. Define work teams 6. Register students/teams in dotProject program 8. Provide the dynamics of integration 10. Provide the Agreement Term 12. Present the project theme 13. Provide the Project Opening Term 15. Provide the lectures of project management	4. Complete and deliver the Personal Identification and Availability form 7. Register the user in the Moodle system 9. Participate in the dynamics of integration 11. Complete and deliver the Agreement Term 14. Deliver the Project Opening Term 16. Participate in the lectures
II. Project planning	17. Provide the document model for the Project Plan	18. Complete and deliver the Project Plan
III. Project execution	19. Orientate the students	20. Execute the Project Management Plan
IV. Monitoring	21. Perform the control points	22. Fulfill the Educational Process Assessment form 23. Present the project partial report
V. Finalization	24. Evaluate the final presentation of the teams	25. Present the final results 26. Deliver the final report 27. Fulfill the Educational Process Assessment form

5. IMPLEMENTATION

The aspects that differentiate the proposal implemented in this work from those that were related in the literature as learning oriented by projects are: the large number of students involved, the different levels of knowledge of the participants - students come from different grades - and the substantial team autonomy for performing the work - performance on demand. These aspects are also the assumptions established by the Curricular Reform Commission of TC for deployment of synthesis and integration activities in order to influence the profile formation of the TC engineering egress (Souza and Silva et al., 2007, ENM, 2008).

The synthesis and integration activities here established according to the methodology described by Santana (Santana, 2009) are the Integrating Projects mentioned before. These Integrating Projects were included in the pedagogic project proposal for the mechanical engineering course (ENM, 2008). The document foresaw the creation of three mandatory subjects in order to grant credits to students that participate in the projects according to three different approaches: 1) emphasis in planning and in the organization of tasks for a collaborative work; 2) emphasis in the process of project development and 3) emphasis in the product project. These activities were forecasted in the curricular structure after the first semester and before de eighth semester.

Experiments conducted in 2007 were implemented in the form of virtual courses. The classes were arranged within the Moodle environment with students enrolled in the target-subjects. The projects were part of the evaluation of the target-subjects and no additional credits were imputed for them at this time, despite the overload of work allocated to students.

Presently, there is no way we may include mandatory credits in the curriculum without a complete restructuring. Thus, an optional "free-time" subject was created, with 2 non-theoretical credits for the activity Integrating Project 1. This semester still, the activity Integrating Project 2 will be formalized, granting 3 non theoretical credits, in a semi-presential way. The Integrating Project 2 activity is being presented in an experimental way, as a virtual subject in the Moodle environment. It is worth pointing that they are subjects with no content; credits are attributed to tasks developed in relation to the project developed.

Table 3 shows a summary with main information related to the interventions done. The first one in 2007 was not well documented and organized. The methodology as presented was applied from second semester of 2007 to second semester of 2008. In the first semester of 2009, all students had already passed by the experience and methodology needed to be adapted to sequence the original proposal.

Table 3. Summary of interventions.

INTEGRATING PROJECT IMPLEMENTATION					
SEMESTER	**SUBJECTS**	**STUDENTS**	**MANNER**	**PROJECTTHEME**	**FORMS**
1st/2007	-statics -dynamics -mechanics of materials -hydro-pneumatic systems	120	Virtual subject	-various	no forms
2nd/2007	-thermodynamics -mechanical system project	72	Virtual subject	-Stirling engine	370
1st/2008	-machine component design -thermodynamics	68	Integrating Project 1	-hot forging press	340
2nd/2008	-thermodynamics -dynamics -hydro-pneumatic systems -machine component design	53	Integrating Project 1 (optional)	-grain separator -pumping device	313
1st/2009	-machine component design -thermal machines	80	Integrating Project 2 (virtual subject)	-CNG compressor	ongoing

6. ASSESMENT METHODS

Individual assessments (IA), collective assessments (CA) and teacher final opinions (TO) were considered for the team member evaluation in the Integrating Project grade (IPG), after the oral presentation of project results (Eq. 1).

The elements considered in the project evaluation are related to internal aspects of team work as creativity and originality, organization of activities, oral and written communication, professional behavior, and its technical, economic, social and environmental feasibilities. The teacher final opinion is an average of the scores of all teachers involved in the process (one of the teachers is designed to assess only the non technical aspects). This evaluation considers the evolution of the aspects mentioned, which are raised at control points, in the final presentation, and in the reports delivered during the experience.

Positive and negative stimuli are used in order to motivate students to participate in all activities. A binary system of assessment in which each activity or action brought, or each requested delivery, is punctuated with grades 0 or 10, is considered, not allowing later deliveries as those agreed in the Student Guide and the Project Plan.

The grade given to the student consists of a weighted average:

$$IPG = (0.1\ IA) + (0.4\ CA) + (0.5\ TO) \quad (1)$$

6.1. Self-assessment and peer review

These types of assessments are made through work team Soft Skill form (Tab. 4). The comparison between these two methods provides information that allows educators to see if the goals are being met. This way, it would be possible to perform corrections if necessary and to stimulate discussion about the results.

6.2. Assesment of the "Target-subjects"

The grade obtained in the Integrating Project is considered part of the target-subject. The criterion for this is free, established by each teacher in the subject.

7. DEVELOPMENT OF SOFT SKILLS

The best way to generate competence is to expose the student to contextualized activities that permit their forthcoming - gradually and organized. Special attention should be given to the relevance of learning methodologies, which immerse students in a conducive environment to innovation and promotion of direct contact with the world outside universities (Long and Telles, 1998 apud Santana, 2009).

The way found to quantitatively assess the development of soft skills was through the comparison of data evolution in Soft Skill form of work team, explicated in Tab. 4. This form was used by students for self and peer evaluation and also by teachers to assess students. Whereas grades were set from 1 to 5 (fully disagree to fully agree) allocated for each item, the evolution of the numerical quantities of grade 5 of each item was evaluated, and the arithmetic mean based on the number of interventions was calculated.

Table 4. Soft skills assessment form.

SKILLS	Team member A/ Team member B/ Team member C/...:
1. Team leadership	1.1 facilitates problem resolution 1.2 encourages other students to the project 1.3 influences the team members
2. Team management	2.1 shows cohesion in the actions taken 2.2 conducts the activities effectively 2.3 gets positive results
3. Communication in general	3.1 displays appropriate posture ahead 3.2 expresses himself adequately 3.3 shows satisfactory content
4. Related areas	4.1 knows how to administer 4.2 considers the non-technical aspects 4.3 worries about the environment
5. Entrepreneurship	5.1 searches for new possibilities 5.2 is willing to accept personal sacrifices 5.3 always shows self-confidence

Figure 3 shows the averages obtained for the development of soft skills in each control point and the in final presentation.

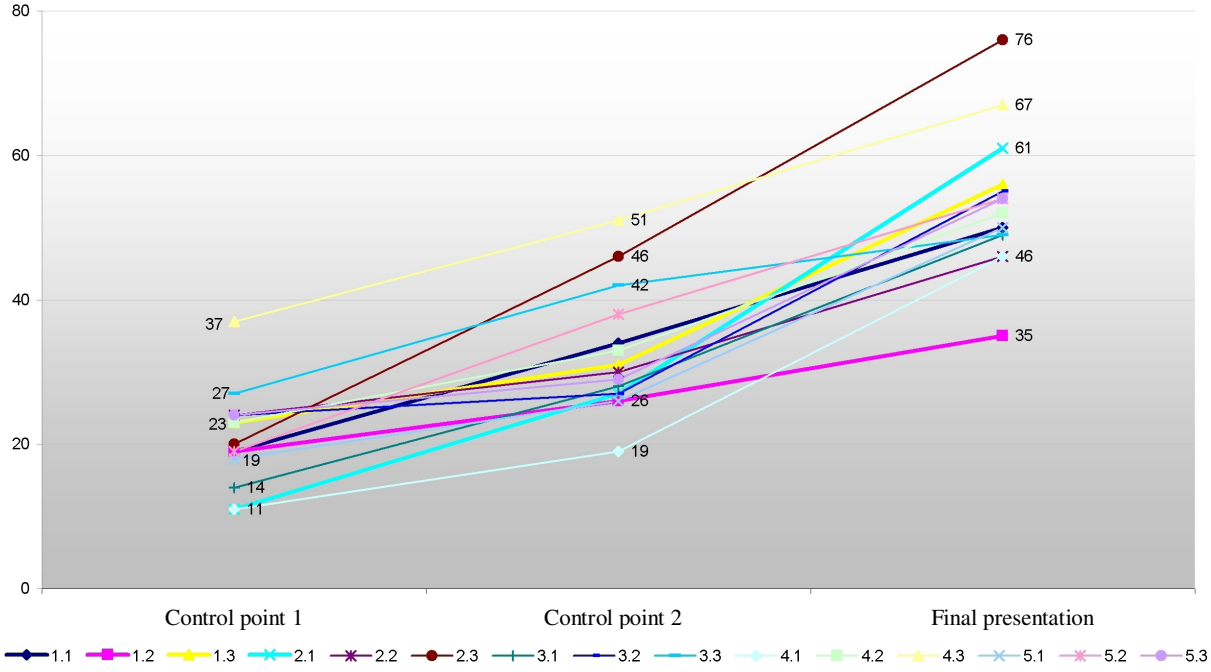

Figure 3. Soft skills evolution. Santana (2009).

8. FINAL CONSIDERATIONS

This paper shows a way to promote the development of soft skills in engineering curricula regardless of the implementation of curricular reforms. At the same time, activities of synthesis and content integration will be introduced in accordance with the curriculum guidelines for engineering courses established by Ministry of Education These activities were considered very important to consolidate learning by the Technology College teachers.

The application of knowledge apprehended in several subjects and autonomously will be demanded from participants for the development of engineering projects. These activities don't interfere in the target subjects or in the schedule, but they can be used as part of their assessment as an incentive to participation. The target subjects are those teachers agreed in taking part of, motivating their students to integrate the project teams.

The development of skills related to leadership and teamwork, professional relationship, communication, conflict management and the management of projects were found throughout the semester with three replications. Studies have continued to monitor the performance of these students in subsequent courses.

It is important to emphasize that although it is a procedure that can be replicated for each semester; the action to perform a project is a unique experience and achieving objectives or not is a result that requires more than scientific and technical skills.

9. REFERENCES

Brasiltec, 2008. “Proposta do programa brasileiro de aceleração tecnológica em engenharia”. In: World Engineering Congress - WEC 2008. Proposta elaborada pelo comitê gestor da iniciativa INOVA. Brasília, DF.

Carvalho, D., Lima, R. M., Flores, M. A., and van Hattum-Janssen, N, 2007. “A case study on project led education in engineering: Students' and teachers' perceptions”. European Journal of Engineering Education, 32(3), 337 - 347.

ENM (2008). “Proposta do projeto pedagógico do curso de graduação em engenharia mecânica”, elaborada pela comissão de reforma curricular do ENM, Faculdade de Tecnologia, Universidade de Brasília.

INOVA, 2006. “Propostas para modernização da educação em engenharia no Brasil”, Programa Inova Engenharia, CNI/SENAI/IEL.

MEC, 2002. “Diretrizes curriculares nacionais dos cursos de graduação em engenharia”, Conselho Nacional de Educação, Resolução CNE/CES de 11 de março de 2002, 12p., <http://portal.mec.gov.br/cne/arquivos/pdf/CES11202.pdf>

Prince, M.J. and Felder, R.M., 2006. "Inductive teaching and learning methods: definitions, comparisons and research basis", Journal of Engineering Education, 123 – 138.

Romano, F., 2005. "Modelo de referência para o gerenciamento do processo de projeto integrado de edificações". Gestão & Tecnologia de Projetos. vol. 1, nº 1.

Santana, A. C., 2009. "Uma metodologia para a implantação da aprendizagem orientada por projetos, na engenharia, com foco nas competências transversais". Tese (Doutorado). Faculdade de Tecnologia, Universidade de Brasília.

Santana, A. C., Dias Junior, T., Carvalho, J. D. A., Abdalla Junior, H., 2008. "Uma metodologia para a implantação da aprendizagem orientada por projetos, na engenharia, com foco nas competências transversais". Proceedings of XXXVI Congresso Brasileiro de Educação em Engenharia, 09 a 12 de setembro, Sâo Paulo, Brasil.

Santana, A. C., Dias Junior, T., Carvalho, J. D. A., Abdalla Junior, H., 2008. "A project-based learning (pjbl) approach as a pedagogical tool for enhancing the soft skills in engineering", Proceedings of ASEE, Global Colloquium on Engineering Education, 19-23, October, Cape Town: South Africa.

Silveira, M. A., 2005. "A formação do engenheiro inovador: Uma visão internacional". PUC-Rio, Sistema Maxwell. ISBN: 85-905658-2-3.

Souza e Silva, M. F.; Viana, D.M. ; Romariz, A.; Del Menezzi, C.; Barbosa, M., 2007. "Procedimento para definição do perfil de formação dos egressos a partir da percepção do corpo docente e discente". In: XXXV Congresso Brasilieiro de Ensino de Engenharia, 2007, Curitiba. XXXV Congresso Brasilieiro de Ensino de Engenharia. Curitiba.

10. RESPONSIBILITY NOTICE

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