Evaluation criteria of student´s performance in a Production System Projects courses of the University of Brasilia

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Abstract

One of the main challenges of education is to align theoretical knowledge with practical knowledge. PBL is a methodology that seeks to align these aspects. The University of Brasília has adopted PBL in "Production System Projects" (PSP) courses of the Production Engineering Undergraduate Major. The evaluation of the competencies developed by students is based on a Decision Tree methodology. The tree has two macro criteria: Technical Competencies and Transversal Competencies. Transversal Competencies evaluate individual abilities. Technical Competencies measure the content domain of the knowledge area. This article details the evolution of the methodology that is being used for the evaluation of the educational process of PSP courses. In the evolution proposed, the sub-criteria are divided to evaluate the technical knowledge of the students in a complete and detailed way, that allows us to verify the performance of the students, as well as to monitor their progress.

Keywords: project management education; student's evaluation; problem-solving skills.

1 Introduction

During the past few years, there has been a significant change in the professional role of the engineer, due to the new trends established by a globalized job market. In order to educate professionals ready to meet that new market's demand, the University of Brasilia has implemented an innovative Industrial Engineering major, since 2009. Based on the principles of active learning methodologies, such as Project Based Learning (PjBL) and Problem Based Learning (PBL), this new engineering degree has a different structure, which contemplates courses that are focused on managing a real project. Along each course, students have to deliver a feasible product to a real customer, dealing with challenges and constraints that are present on the routine of a professional engineer, including budget restrictions, time limits and conflict management. These courses are called "Production System Projects" (PSPs) and they are designed to stimulate students to develop their transversal skills aligned with the necessary knowledge of a modern engineer.

Considering the innovative aspects of these learning methodologies and the structure of the new Industrial Engineering major at the University of Brasilia, this paper aims to propose a compatible and integrating tool for assessing the students' performance and their evolution during the academic program. Additionally, in order to provide a quantitative analysis, weighted evaluation criteria are illustrated based on the "Production System Projects" course structure. These criteria are being used as a framework with the purpose of generating the student's final grade. Thus, it will be possible to quantitatively evaluate each student's accomplishments and accurately reflect these values in their respective GPA.

This paper provides an overview of an innovative evaluation methodology, which has been used in the Production Engineer major at the University of Brasilia. The implementation of the proposed methodology aims to enable the professors to measure each student's performance and growth, and compare it to what is expected from graduated professionals. Therefore, it supports the education of a better engineer that fits the job market and its new tendencies.

2 Overview of competence-based evaluation

The shift in the role of the engineer in a newly globalized and competitive society, has changed the way of thinking and practicing in undergraduate education institutions around the world. Current studies (Mesquita et al, 2009) show

the importance of additional competencies on top of the usual technical competencies. These other group of competencies, such as: adaptability, teamwork, creativity and communication, are recognized as a key factor for the employability of newly graduated engineer. The challenge now is how to make possible for engineering students to develop the ability to lead groups of people, solve problems, plan and organize, to encourage teammates and the ability to learn by themselves. (Nair et al, 2009; Becker, 2006; Moesby, 2005).

All these changes in engineering education led to a new challenge in evaluation methods. Fernandes et. al (2012) show a different notion of competencies evaluation centred on students, on a process of feedback, self-regulation and learning self-evaluation. This approach favours the integration of learning and evaluation, through active student involvement in the evaluation process. In this kind of evaluation approach it is important to keep the focus on the learning process, without ignoring the products, based on participation and integration of evaluation in the learning process (Fernandes, 2005).

To achieve these results in a PBL environment the evaluation must be based on a continuous evaluation of project process and products delivered by students. Since some of the key features of the PBL is based on teamwork, interdisciplinarity, development of critical thinking, interpersonal communication and project management (Powell and Wenk, 2003), the evaluation process must include tools that allow students to perform a self-evaluation besides those evaluations done by professors.

In PBL methodology several actors are involved in the evaluation process: tutors, professors/specialist tutors, and students. Each of them has a specific view of the competencies evaluation. Professors/Specialist Tutors are involved mostly in the evaluation of the project products and the technical competencies required for the project. Tutors have an important role in the evaluation of the learning process, and not necessarily the evaluation of the learning outcomes (Veiga Simão et al, 2008; Alves, Moreira and Souza, 2007). Students also enroll in the evaluation process by evaluating themselves and the other teammates in a peer evaluation activity. The evaluation process must therefore include project reports, oral presentation and peer evaluation at least in the middle and in the end of the project course. Thus, students can reflect about their work, compare it with their teammates by providing feedback to improve their workforce (Fernandes et al, 2012).

The PSP program evaluation method presented in this paper shows an adaptation case of the current evaluation methods to a Brazilian education situation based on the principles described above.

2.1 Evaluation model of Production System Projects courses

The chain of PSP courses represent the main structure (the spine) of UnB's production engineer major. It is compounded by 10 courses, started with 3 basis courses: introduction to production engineer, value formation on production systems and methodology of project on production systems, in this order. This last one prepares the students to use project management tools that will be required at the PSPs. Then PSP 1 to 7 altogether with its anchors courses.

The PSP courses - Production System Project - are courses based on the PjBL methodology, where the students will team up in small groups, usually from 3 to 7 members, to do a project that will solve a real problem related to an anchor course. The anchors are taught during the same semester as its PSP, driving students to not only keep up with the professor's class, but also to do researches withing the course, assuming an active learning attitude.

Except for the first PSP, PSP1, the chain of courses works with 3 deliveries on each, the first two courses will evaluate the evolution of the students, while the final result will be evaluated in the last course. On the first courses, once students are not yet familiar with the methodology, the learning process is the main concern, so it has higher supervision and weights. As the students get more mature about the process, the results become more important, so the weights for the learning process fall gradually from 80% to 20%, while the weights for the final deliveries rise, gradually from 20% to 80%.

PSP1 works with only one delivery, so it takes a different evaluation process that will be explained later on.

3 Research methodology

In order to define the criteria and the way to evaluate students in the courses of Project of Production System, which will be further described, we have developed a hierarchical decision tree based on multicriteria analysis methodology, called Multicriteria Decision Aid.

Following this methodology, it was possible to identify and prioritize criteria effectively relevant to the courses of PSP's, ensuring a complete, operational, non-redundant, isolable and understandable decision tree.

The research used to define criteria presented in the hierarchical tree was based not only on Participatory Learning methodologies, specifically Project Based Learning and Problem Based Learning, but also on methodologies that do not necessarily have this emphasis.

The PMBOK, Project Management Body of Knowledge, for example, was heavily used to help clarify and define Project Management Competencies to be evaluated in the courses of PSPs (PMI, 2008). Much of the criteria of the tree were obtained through studies of all Knowledge Areas described in the PMBoK and their characteristics.

The studies of theories developed primarily by Bloom, known as Bloom's Taxonomy, and then revised by Krathwohl (2002), were used to guide the definition of criteria related to technical knowledge and the sub criteria of them.

Finally, one last issue used as a methodology for performing this work. It was used to verify aspects that can be improved and aspects already well developed in the courses of PSP's, in order to facilitate the understanding of real development needs that students have throughout the course. This was performed during practical experience, both made by professors, acting as coordinator advisor or expert of the courses, and by students.

4 Production System Projects courses evaluation

Each of the seven PSP courses is linked with a theoretical course (anchor course) such as Statistical Probability, Engineering Economics, Information Systems, Planning and Production Control, Quality Management etc. The professors act as tutors for each project and a specialist professors in technical competencies (related course), in project management and transversal competencies.

The evaluation system of the courses PSP is based in criterion such as project management, content anchor course, transversal competencies and final article. See figure 1.

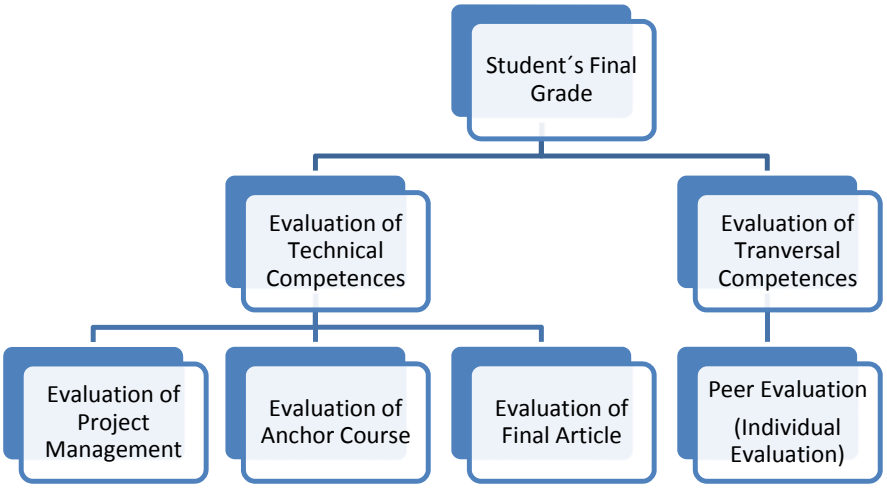

Figure 1: Evaluation scheme of Production System Projects courses at the University of Brasilia, Brazil

The technical competencies involved are the ability to plan a project, to organize and to manage time, to ensure that the activities will be carried out in the prescribed time, to attend to the content of the anchor course and to elaborate an article aiming publication.

With respect to the transversal competencies, the students are evaluated as the autonomy, initiative, creativity, critical spirit, responsibility, leadership, solving problems, interpersonal relationship, motivation and conflict management.

4.1 Evaluation PSP1 course

The final grade of the PSP1 course is composed by grades of oral presentation and summary writing, corrected by peer evaluation. The oral presentation and summary writing are evaluated by professor tutor, project and professor specialists.

The composition of the final grade (FG) is **FG = ((0,2.PO +0,8.SW)*FC),** where PO is the oral presentation, SW is the summary writing and FC is the correction factor for individual evaluation (peer evaluation validated by tutor professor and professor of behavior area). The PSP1 course has only one control point with oral presentation.

4.2 Evaluation of others PSP courses

In the same manner as the PSP1 course, the final grade for each delivery is composed by grades of oral presentation and summary writing, corrected by peer evaluation. The oral presentation and summary writing are evaluated by professor tutor project and professors specialists.

The composition of the final grade (FG) is as follows: **FG = 0,2.PP ((0,2.PO +0,8.SW)*FC) + 0,4.PI ((0,2.PO +0,8. SW)*FC) + 0,4.PF ((0,2.PO +0,8.SW)*FC),** where PO is oral presentation, SW is summary writing and FC is the correction factor for an individual evaluation (peer evaluation validated by tutor professor and professor of behavior area). PP, PI and PF mean Preliminary Project, Intermediate Project and Final Project and they are the control points of the course.

4.3 Oral presentation

The criteria considered in the oral presentation are presentation structure and graphic presentation, communication, imagination, technical content, group integration and delivery time. Each criterion has a different ponder, but the bigger ponder is of the technical content followed by presentation structure and graphic presentation, and communication. If the student loose the oral presentation, he/she looses 20 percent of the grade.

4.4 Summary written

The evaluation summary of PSP1 course is composed by SW = (0,5 (EDAP ➔ PM) + 0,3 (ETR ➔ SP) + 0,2 (ESA ➔ SM)) where EDAP is the evaluation of the project report/document and PM is project management, ETR is the evaluation of the technical report and SP is a statistical probability and ESA is the evaluation of the scientific article and SM is the scientific methodology.

After 30% of the course, there is a control point in which students deliver the documents, opening project term (TPO) and the project management plan (PGP) and they are validated by specialist professor in statistical probability and by professor of design methodology. After validation, the students continue with the development of the project and deliver the summary writing at the end of the course.

To others courses, the evaluation summary writing varies with the delivery. In delivery of Preliminary Project (PP), the evaluation is PP = (1,0 (EPP ➔ PM)) where EPP is evaluation of project plan, basically the evaluation in this phase is due only with the project management. In Intermediate Project (IP) the evaluation is PI = (0,2 (EDAP ➔PM) + 0,8 (ETR ➔ QM)) where QM is quality management. In the last delivery Final Project (FP) is evaluated by FP = (0,2 (EDAP ➔ PM) + 0,6 (ETR ➔ QM) + 0,2 (ESA ➔ SM)).

4.5 Transversal competencies – PEER evaluation

The peer evaluation includes all soft skills that students should develop over the projects of production systems during the course of production engineering. This evaluation is applied to each project delivery and is used to collect the students perception of others during the course, thereby helping professors to better diagnosis the development of transversal skills of each student in another perspective. The peer evaluation generates inputs for professors to be able to improve with each student individually their shortcomings and difficulties during work performance.

The peer evaluation spreadsheet is divided into six criteria within the macro criteria of transversal competencies: Communication, Leadership, Effectiveness, Professionalism, Capacity Management, and Cognitive Skill.

Communication criteria evaluate the communication timing of the information provided by the student, the use of media, interpersonal relationships with others involved in the project and the language addressed during work. The leadership criterion takes into account the motivation, good interpersonal skills and proactive student. The effectiveness criterion weighs the willingness to solve problems, to perform tasks assertiveness and resilience of the student. The judging criteria professionalism attendance and punctuality at meetings, on-time delivery of activities / tasks and the ability to work in teams. The criterion for project management measures the ability of planning, organization and resource allocation. Finally, the criterion of cognitive skill aims to evaluate the student's ability to identify problems and propose improvements and to use tools and techniques to carry out the work.

Therefore, the proposal of using this type of evaluation is to share the responsibility to review with students that was previously restricted to professors. According to Romao (2001), knowledge is a process of discovery conference

between the student and the professor, so the importance of sharing the responsibility of evaluation and feedback of students.

4.6 Closing workshop

Each PSP course ends with a workshop whose objective is to obtain feedback from students about the performance of the course. The points that are discussed with the students are related as difficulties and learning obtained in project management, with relation to the transversal competencies and with regards to the performance of the course. The results are well positive, the student´s suggestions are used as improvement in the learning process.

5 Conclusion

This research has shown the importance on defining criteria that need to be used in order to judge students ability in assimilating project management skills in courses of engineering education. It is very important that this evaluation is taken from a formal perspective, theoretically based and methodologically proven, so that both students and professors can agree upon and trust on the evaluation process.

This case study has also showed that the use of PBL as a means to teaching project management is like hand in glove. Also, the use of engineers desired profile from the industry and the project management best practices are an effective parameter towards which we may drive engineering education. The use of Multiple Criteria Decision Analysis (MCDA) in the definition of the method and also to design a decision tree has helped us define the specific technical knowledge to evaluate students' skills.

Both the skill for project management and the transversal skills, derived from the anchor courses, have been identified and are used effectively to help construct not only an evaluation template but helps define a new profile needed by students in order to meet the requirements of the new engineering student and the future professional profile.

We hope that the proposed method of defining these criteria can be useful not only for professors working with the same challenges of identifying and evaluating their students, but mostly to help reinforce engineering curriculum in seeking for more effective teaching methods and reaching successful educational results, mostly with the use of PBL and PjBL as their main tool.

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