Journal of Management & Technology

ISSN 2358-3126

"SEMESTER INTERDISCIPLINARY PROJECTS APPLIED IN A INDUSTRIAL ENGINEERING GRADUATION"

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Abstract: To include interdisciplinary projects in the learning process provides a development to the students that goes beyond the acquired knowledge and develops the expected competencies for the profession according to the proposal of each project. This article, developed in a private higher education institution in Brazilian avant-garde in use of active methodology in teaching applied to the production engineering graduation, presents the Project Led Education (PLE), teaching methodology that through a project, integrates disciplines of a specific school year. The projects, distributed over the first eight semesters of the course are described with their contributions of each discipline respectively and the used evaluation process highlights the importance of application the projects in relation to the general curriculum of the course, and besides, to leave suggestions for future research proposals.

Keywords: *Interdisciplinary Project, PLE, Industrial Engineering, Methodology.*

1. INTRODUCTION

The development projects in the learning process has been increasingly used in higher education institutions from all over the world in order to better prepare the students to the labor market. In the case of engineering courses, this need is even more evident. So, connect the project disciplines content becomes a challenge for teachers and students, especially integrating all curriculums. So that, result the interdisciplinary projects. In this scenario, establish projects during the school year are very relevant in the development of students not just in the related content and in preparing the egress skills training. Identify the project that encompasses most of the courses taken at the same time is a challenge for teachers.

Interdisciplinary project is part of real life and its introduction is necessary in regular programs establishing different ways of providing learning providing cooperation among the students no matter how difficult it is your organization (POLUTNICK, 2013).

Importantly how characteristic of the interdisciplinary project active student learning, because the practical realization of the work is fundamental result of this teaching process. The interdisciplinary projects effectively contribute to student learning, it consists of a methodology that emphasizes teamwork, solving various problems and theory / practice articulation, in carrying out a project that culminates in the presentation of a solution / product from a real situation, related to the future professional context (POWELL & WEENK, 2003).

Thus, the research question is linked to the definition of projects related to the program content of the subjects of that semester and its relevant contributions to solving them. For such, establish a matrix (disciplines x contributions) that can drive the attendance of the desired content.

The objective of this paper is to present the half-yearly interdisciplinary projects of Industrial Engineering Graduation carrying out a case study in a higher education institution which Lourenço Jr & Veraldo Jr. (2015), searching the avant-garde of this educational process, working in a structured and progressive manner, covering all areas of courses. Participant in a national consortium, the institution has a solid basis for the application of the methods, teacher training and, more recently, scientific researches.

2. THE INSTITUTION

The UNISAL (Salesian University Centre of São Paulo) is private, confessional and philanthropic, incorporating a set of existing Salesian University Institutions in countries many around the world. It is a medium-sized institution for Brazilian standards, with about 13,000 students on four sites. The Salesian charisma through youth education comes from the founder of the congregation, St. João Bosco, the inspirational of all your actions. The integration of knowledge, dialogue between faith and reason, the continual search for truth, ethics training, and the spirit of freedom in love, mutual respect and the promotion of human rights characterize and enliven the UNISAL as a center of knowledge that gives taste for study and research and promotion of the acquisition of true wisdom of life.

According to Lourenço Jr & Veraldo Jr. (2015), the current model of training of engineers provides to the student a "two-dimensional" representation, narrative of a reality that is three-dimensional and complex. Disconnected from this reality, the theory loses his role as a major tool for your understanding. The consequence is that the new courses from conception were defined from other paradigms.

As a result, in 2010, the Lorena site decided to create courses in the engineering areas. Began the course of Industrial Engineering in 2011 and then with courses in Civil Engineering, Electrical, Electronic and Computer in 2012 to finally, in 2013, include the Mechanical Engineering course in its portfolio

From the beginning, there was the conviction of the need to introduce practical and contextual content from the beginning of the course as an essential factor for the assimilation of theoretical concepts from the perspective of his creative practical application. In addition, duty would be an important motivating factor for the students, helping to reduce dropout rates. The combination between the so-called theoretical and practical activities enables the future professional to intervene in reality, mastering its nuances through simulated activities such as exercise, work, case studies, practical rarely associated with the theoretical content of the courses.

3. RESEARCH METHOD

The research method of this paper refers to a study of case in a higher education institution in which interdisciplinary projects applied to the course of Industrial Engineering will be presented. According Westbrook (1995), in the studies of case, the researcher documents a situation in the organization. The main trend is that they try to explain why a decision or set of decisions were taken, as were implemented and with what results achieved (YIN, 2001).

4. INTERDISCIPLINARY PROJECT

Is evident in engineering courses, the adoption of interdisciplinary projects is promoting a learning performing activities in which students work in a collaborative and integrated manner for a period of time in which they learn to solve a real and challenging, beside to produce a final product to complete their learning.

These learning features based on project, which increases the opportunities for interdisciplinary learning, help students see the connections between apparently unrelated domains, and facilitate a custom of organizing knowledge process (COLE, 2000). According to Thomas & Mergendoller (2000), the grounds for understanding the driving questions and tasks that lead to the production of an finish good promoting the motivation of students for the construction of an internalized structure of all related perspective concepts, ideas and methods research. (PRINCE & FELDER, 2007).

Frazen (2013) reports that the methodologies based on active learning geared towards engineering are accomplished in different ways. Some methodologies are based on problem solving (such as PBL - Project Based Learning), others prioritize work from projects (PLE - Project Led Education), still others are ways of organizing the learning process (Project Work).

According to Powell & Weenk (2003), the PLE is a methodology of active character and collaborative, able to improve the process of teaching and learning, in a direct link between theory and practice through a project that culminates in the presenting a solution to a problem related to a real / professional situation.

The proposal of project realization is to have a unique overall objective. According to Liam et al (2009, a), all teams must develop the same design theme to create similar evaluation conditions. However, proposed projects should be open enough to allow for different solutions, establishing the development of the student's initiative and his ability to take decisions with incomplete information, redundant or distorted. For this purpose according to the authors, it is important that these teams should be large enough to impose difficulties both in design and in the coordination of activities. This purpose improves the development of various transversal skills such as: leadership skills and project management skills, etc.

According to Lourenço Jr et al (2014) its main features are the focus on student learning and its active role in this process, to the development of not only technical skills but also transversal skills or "soft skills". Through the methodology it is possible to create conditions for students to develop these skills, integrating and applying the knowledge from various disciplines in a common project, playing a central role in their own learning. This process is focused on the following objectives:

1. To promote student-centered learning;;
2. To promote teamwork;
3. To develop a sense of initiative and creativity;

4. To develop communication skills;
5. To develop critical thinking;
6. To relate multidisciplinary content in an integrated manner.

Thus, Lourenço et al (2014) state that the PLE is therefore in an active learning methodology based on projects developed from a recurring problem in the professional area of the engineer. In a scenario where innovations in the field of engineering evolve rapidly, it is also necessary changes in project proposals from certain periods. According to Lima et al (2009, a), the approaches of learning projects should be changed periodically, and may be characterized by different application modes. Managing this process is equivalent to manage different operations in each edition with scarce resources during a predefined time. This type of feature is the fundamental difference between project management and operations management and reinforces the need to manage these processes as projects.

In the evaluation process of the interdisciplinary project, Lima et al (2009, b) there are two distinct components: technical knowledge set for each discipline and evaluated at the end of the semester usually through theoretical examinations; and skills of the professional profile involving student participation in projects which evaluate the group work, communication through oral presentations. The skills represent a key role in the formation of the student and have a significant impact on their performance if the evaluation is continuous feedback from the teacher or project tutor, thus evolving the student's learning process.

5. THE SKILLS

The skills that students should acquire through the completion of interdisciplinary project are largely specific to courses of direct support to each project. However, students also develop-expected soft skills, offered by the completion of a group in multidisciplinary project (LOURENÇO et al, 2014). According to the authors, group work in a multidisciplinary project provides unique learning moments. This methodology focuses on the development of the following soft skills:

1. Project Management Skills: Research Capacity; Decision Capacity; Organization Capacity; and Time Management;
2. Team Work Skills: Autonomy; Initiative; Responsibility; Leadership; Troubleshooting; Interpersonal Relationship; Motivation; and Conflict Management;
3. Development of Personal Skills: Creativity / Originality; Critical spirit; Self-evaluation and Self-Regulation;
4. Communication Skills: Written and Oral Communication.

6. PROJECTS APPLIED

According to Lima et al (2009, a), the Industrial Engineering course adopted as part of its Educational Plan the implementation of an interdisciplinary project every semester. The projects are proposed, discussed and defined by the Board of the course, at the meeting preceding the semester in which will be applied.

Each project is named by a teacher responsible for integration with other disciplines and teachers in facilitating condition. Is elaborate a Semester Disciplines Contribution Matrix, ie, a graphic arrangement able to explain how each discipline contributes (or not) to the specific project. The same teacher is responsible for the definition of a work schedule over semester as much as the control points, evaluation and criteria.

6.1 1st Semester - Rube Goldberg Machine

Description: The project consists of designing and building a Rube Goldberg machine that must use at least five concepts of physics, mainly mechanics (kinematics), in order to break an egg.

Table 1 Matrix contribution of the subjects of the 1st Semester

Subjects	Contribution
Physical I	Concepts and laws of mathematics of physics (kinematics and others).
Calculation I	Expressions and mathematical operations used in physics, especially kinematics.
Lineal Algebra	Equation of the line and vectors on a plane.
Fundamentals of Mathematics	Expressions and mathematical operations for solution first/second order
Introduction to Industrial Engineering	Teamwork, assigning responsibilities and skills, planning and scheduling

Evaluation process: Delivery of partial and final reports account for 50% of the grade. The final presentation of the project makes up 25% and the machine prototype development the other 25% of the final grade.

6.2 2nd Semester – Building a Homemade Battery

Description: The project consists of designing and building an electric battery, from homemade materials and commonly available in the home every day, which allows the student to carry out series of associations and in parallel, note the materials tend to form ions and enable the creation of current and other electrical phenomena.

Table 2 Matrix contribution of the subjects of the 2nd Semester

Subjects	Contribution
Physical II	Laws of electrical phenomenology. The physical components of the experiment
Calculation II	Logical reasoning and theoretical prediction of the event through fundamental equations
Drawing	Design and technical drawing of the device to be built
Science and Technology Mat	Identification of physical properties of each of the components used in the project

Evaluation process: Delivery of partial and final reports account for 50% of the grade. The final presentation of the project makes up 25% and the battery prototype development the other 25% of the final grade.

6.3 3rd Semester – Cosntruction of a Wind Power Generation

Description: The project consists in setting up a mini wind power generator with recyclable materials, preferably, which works to apply the strength of a resulting air displacement. Wind power generation should be sufficient to feed / LED's light up a model of a residence with at least the following rooms: living room, dining room, bedroom 1, bedroom 2, kitchen, and bathroom, requiring LED room and at least two street lamps where the model is located. For each chamber, a circuit must be mounted with switch to turn on / turn off its LED. The number of LEDs depends on generator power, but the project will supply energy to light at least 8 LED's (6 rooms + 2 poles of the street). The model must be limited to the maximum size of an A2 sheet.

Table 3 Matrix contribution of the subjects of the 3rd Semester

Subjects	Contribution
Physical III	Concepts and magnetic field equations. Ampere's law. Faraday-Lens law.
Calculation III	Expressions and operations for calculating the voltage to be obtained by the generator.
Applied Electricity	Basic electricity concepts (charge, current, voltage, power), circuits, DC generators.
Science and Techn Mat II	Identification of the physical properties of each of components used and their relationship
Materials Resistence	Concepts of stress and strain, strength, toughness, ductility of the materials used.
WAC	The preparation of pertinent reports to project in various phases as learning opportunity

Evaluation process: Delivery of partial and final reports account for 50% of the grade. The final presentation of the project makes up 25% and the prototype development of wind generator the other 25% of the final grade. In order to award the project note is required to participate with success in the WAC activities (Writing Across Curriculum).

6.4 4th Semester – Tesla Coil

Description: The project consists of building a Tesla coil with defined large to fit on a square base 1 meter side and the height of the coil limited to 50 cm. It is strongly recommended, establishing itself as an evaluation criterion of the project, the use of reuse and recycling materials. The Tesla coil would produce the largest possible spark - respecting the constructive limits in this project - breaking the dielectric strength of air and optionally closing an electrical circuit to light an ordinary light bulb.

Table 4 Matrix contribution of the subjects of the 4th Semester

Subjects	Contribution
Physical IV	Concepts and electric field equations and Faraday's Law.
Calculation IV	Expressions and operations for calculating the voltage to be obtained by Tesla Coil.
General Mechnics	Operations to calculate the mechanical elements constituents of the project.
Methodology of Research	Theoretical foundation. Formatting reports. Organization and writing of reports
ADM and Organization I	Activity schedules, work organization, duties and responsibilities and interaction as a team.
WAC	Written and oral communication design, drafting of reports.

Evaluation process: Delivery of partial and final reports account for 50% of the grade. The final presentation of the project makes up 25% and the development Tesla coil prototype of the other 25% of the final grade. In order to award the project note is required to participate with success in the WAC activities (Writing Across Curriculum).

6.5 5th Semester – Building a Catapult

Description: The project s to build a catapult which should be optimized using necessarily DOE technique - Design Of Experiments, in order to achieve the greatest horizontal distance pitch. The projectile to be launched by catapult is a common tennis ball will default to all groups. The energy required to throw the projectile must be obtained exclusively from the by tension, torsion or gravity.

Table 5 Matrix contribution of the subjects of the 5th Semester

Subjects	Contribution
Information Systems	Expressions and operations for calculating the voltage to be obtained by Tesla Coil.
Accounting	Operations to calculate the mechanical elements constituents of the project.
Information Systems	Theoretical foundation. Formatting reports. Organization and writing of reports

Evaluation process: Delivery of partial and final reports account for 50% of the grade. The final presentation of the project makes up 25% and prototype development of catapult the other 25% of the final grade.

6.6 6th Semester – Water Level Control System

Description: The project consists of designing and building a level control system fluid, in this case water. The system should be able to trigger the discharge of water from a lower reservoir to a higher reservoir whenever the upper reservoir level is below a preset minimum. You should also repress the water until the level reaches the preset maximum. Water discharge will only be triggered if the lower reservoir holds a minimum amount of water.

Table 6 Matrix contribution of the subjects of the 6th Semester

Subjects	Contribution
Automation and Control	Sensors, actuators and control system.
Economic Engineering	Economic and cost aspects in the construction of the prototype. Economic viability.
Technology of Polimers	Materials used as the fluid reservoir and the construction of the sensor and discharge motor

Evaluation process: Delivery of partial and final reports account for 50% of the grade. The final presentation of the project makes up 25% and the control system prototype development the other 25% of the final grade.

6.7 7th Semester – FMEA applied to real cases in Maintenance Management

Description: The project deals with a real case-problem, which will be prospected by each group, that is, the students themselves will seeking real maintenance problems in their companies or have enough information for the study. Means for real-case problem, the breakdown of an equipment or component that generated an unscheduled stop in the manufacturing sector, impacting on availability. The groups will use mostly, but not limited to this tool, the FMEA – Failure Mode Effect Analysis

Table 7 Matrix contribution of the subjects of the 7th Semester

Subjects	Contribution
Maintenance Management	Understanding and application of typical maintenance indicators.
Quality Management I	FMEA application (Failure Mode and Effect Analysis) is a product or process
Operational Research II	Failure Tree Analysis, Reliability, Failure Rate, MTTR, MTBR, MTTR, Availability.
Planning and Control I	Production Planning, production scheduling ,alternative unavailability of the machine.

Evaluation process: Delivery of partial and final reports account for 50% of the grade. The final presentation of the project makes up 25% and the banner of making the other 25% of the final grade.

6.8 8th Semester – Proposed Commercial and Operational Co-packer

Description: It consists of the design and idealization of an operational and commercial proposal for co-packer (company responsible for the packaging of products to its customers for the purpose of marketing and distribution of products, usually manufactured by the customers themselves) to a multinational known from actual data provided by the company. The project is exclusively educational and pedagogical purpose for which the data, drawings, specifications, texts and any other, in any medium in which they are registered, provided during this work will be treated as reserved and confidential material, being absolutely forbidden its use, reproduction or disclosure by any means, to third.

Table 8 Matrix contribution of the subjects of the 8th Semester

Subjects	Contribution
Management Costs	Operational and management costs. Financial business plan.
Ergonomics and Health	Layout and ergonomics of jobs. Work instructions.
Quality Management II	Control and quality management. Inspection plan.
Logistics of Materials	Input control systems pulled or pushed, indoor logistics, handling of materials.
Planning and Control II	Capacity analysis, design and line balancing, productivity, control of production.

Evaluation process: The project will be carried out continuously, both the merits of the production engineer competencies as the knowledge acquired, as follows: individual evaluation and collective skills of students participating in the project; Individual evaluation of knowledge acquired from the project participants students (30%); Final Report Review (20%) and final presentation of projects for examination board (50%).

It is worth noting that, for each project, one of the participating disciplines is defined as the integrator being responsible in the conduct of the project throughout the semester. Thus we have as integrative disciplines of projects: Physics I (1), Science and Technology of Materials (2nd), Applied Electricity (3rd), IV Physics (4th), Statistical Methods Applied to Engineering (5th) automation and Control (6th), Maintenance Management (7th), Planning and Production Control (8th).

Importantly, the 9th and 10th semester of the course there is no interdisciplinary projects. In this case students are dedicated to preparing the course conclusion work (TCC) while evaluation a qualification process through presentation (at the end of the 9th) and a defense process in which the delivery of the text is included (the end of the 10th).

According to Poweel & Weenk (2003) this methodology, student teams develop an open design based on the contents of almost all the subjects of that semester. The development of the project through the PLE implies a considerable number of coordinating activities for the responsible teachers. Plan content support of the courses involved in the project; plan the knowledge and project evaluations; establish milestones and delivery of projects; establish evaluation process among peers; establish feedback as partial and final deliveries.

7. FINAL CONSIDERATIONS

At the end of the realization of eight interdisciplinary projects there that are encompassed 37 disciplines for a total of 47 of the course, ie almost 80% contribute to the development of projects through program content, as evidenced in each of the frames. This shows the importance of implementation of the active learning method, experiencing real situations of the labor market.

As established in the PLE method, the final evaluation of interdisciplinary projects carried out in the institution is made by peers, or teachers of the participating disciplines are responsible for evaluating the final work. This result is shown by the students through a prototype, including an oral presentation (evaluation of the final report is the responsibility of the professor of integrative discipline). Importantly, in some cases, professionals from fields relevant to the project are invited to contribute to the real view of the said labor market environment. Thus, the final evaluation of the project is characterized both the academic part, the professional part.

Frazen (2013) reports that the projects developed in PLE allow the student already gets to the professional field with some practical knowledge and also with all the issues that go beyond the professional activities, as areas of responsibility and time management and people. In addition, The ideals of PLE come just to reinforce this idea that the engineer is a professional who had changed his identity and need to account for a number of skills that go beyond the own knowledge of their training area.

Despite the increasing use of the limitations refers to the virtual tool that is used for follow-up of the projects, in the case of the institution, MOODLE. According to Guerrero et al (2013), the Moodle virtual platform is strategic in supporting the integration and monitoring of the teacher who, through this tool, according to the management of access to software, facilitates active student learning. In this tool, not only project activities are carried out in a practical and organized, but also facilitates teacher-student interaction, promoting agility necessary feedback and records of discussions over the development.

Thus, coordination is needed based on the true team spirit, according to Lima et al (2009, a) after the entire goal is to share the responsibilities and decisions interacting with the commitments and achieving greater interdisciplinary. Developing time management processes ensures control of activities facilitating the organization and mainly featuring the management of communication and staff management, allowing the identification of different roles among the members. After all, in the professional environment is like. According to Sodhi & Son (2008) in addition to the demand for skills such as communication, leadership, project management and teamwork, employers require the use of spreadsheets and database. They recommend that educators should be aware of the skills that employers are seeking after all, specific skills are essential for graduates as requirements in the area, regardless of sector, job or degree.

Thus, future studies should deepen the identification of skills in interdisciplinary projects establishing evaluation processes that allow the analysis of the labor market needs along with the expertise to develop the projects. The use of virtual platform for the monitoring of projects should be expanded not just for industrial engineering but also for other courses of the institution, ensuring organization and control necessary for the educational environment.

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