Increasing value in engineering learning: Design and evaluation of a Peruvian project

Maria Pinedo*, Eliodoro Carrera


Abstract

This paper deals with the design and the implementation of the first phase of the Experiential Engineering Project (EEP) and with the assessment of its impact as a pedagogical strategy for training in industrial engineering. The EEP has been designed to contribute to the job competitiveness of the future Engineers providing value to their employability and self-employment generation based on ethical and responsible action. The first phase linked the curriculum subjects to the work areas of industrial engineering through activities and deliverables whose results were analyzed quantitatively and qualitatively using descriptive statistics as an assessment tool. The results show that the EEP has had a significant positive impact on the process of learning of the engineering students perceiving it as helpful and suitable for their learning.

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Keywords: Value-added engineering education; theory-practice connection; competence.

1. Introduction

Nowadays, the new global economy fueled by the openness and interdependence of the markets as well as the constant development of the increasingly accessible information technology and communication, has established new areas and paradigms (models) related to economic, cultural level and social exchange. This dynamism and constant evolution challenges the classical models of success and challenges them to reinvent themselves to respond assertively and ethically being this response flexible, agile and accordingly to the needs of the local and global community form.

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The training in engineering and technology has unique importance in addressing global challenges (Kumar and Parashar, 2012) and are essential for the economic development of our society areas (Palma et al., 2012). In this context Peruvian engineering education must include a strategy to develop educational models, taking into account its status as an emerging country inserted in the global economy respecting their culture and values, training professionals to provide adequate responses to the environment, effective in relation to the value of their contribution to Peruvian society and economy as well as sustainable and efficient in terms of resource use.

The Engineering School at University of Piura (UDEP) focuses the education given in the holistic formation of the person as required by the UDEP vision and recognizes the need to restore the missing links between engineering graduate attributes and employers’ expectations (Nair et al., 2009) through skills training.

In the last two decades there have been various studies defining skills (Garcia, 2008) and selected those with a holistic approach as the most appropriate (Palma et al., 2012) that produce a qualitative impact on the formation of engineering (Crawley, 2007). Recent analyzes indicate that the skills required by employers continue to be a failure in the learning outcomes of graduates (Nair et al., 2009). This requirement is already covered in the syllabus (Sale, 2014) but is in the application where the difficulty is seen either by the lack of experience of teachers or the passivity of students (Rugarcia et al., 2000).

Many universities are making efforts to create areas for the acquisition of skills in students either involving them in research projects (Daniels et al., 2010) (Jenkins et al., 2007), promoting global collaboration with other institutions and encouraging mobility of students, an example of this is the Global mobility Program Purdue University Engineering Alliance for Research and Education (GEARE) focused on educating global citizens (Warnick, 2010) who work in multidisciplinary and transnational environments (Jesiek, et al. 2013) (Stromquist, 2007).

In the Latin American region the proposals from Development University of Chile are remarkable to promote the acquisition of interdisciplinary skills with the creation of the Institute for Interdisciplinary Innovation (Contreras and Broitman, 2013), from the University of La Sabana the proposal to identify the basis for the internationalization (De Zan, et al., 2011); from the Inter-University Centre for Development (CINDA), consisting of universities in Chile, the proposal is to perform an implementation job and graduate skills assessment (Larrain and Gonzalez, 2005). All these efforts are taken as basis the competences defined in the Tuning Project (Tuning Project, 2003). All these actions are aimed at enabling engineers to lead and guide the sustainable human development (Barreto, 2012) and maximize their success in complex and cross-cultural situations.

To implement a competency-based educational model is to constitute an indicator of educational quality for it has already been raised for the training of engineers in Peru by Palma et al. (2012).

2. Justification of the project

Competency-based training requires a comprehensive and integrated approach to all aspects that make the university work and involves the active participation and interaction of agents in the process of learning (Palma et al., 2012).

Traditional instructional methods will probably not be adequate to equip engineering graduates with the knowledge, skills, and attitudes they will need to meet the demands likely to be placed on them in the coming decades, while alternative methods that have been extensively tested offer good prospects of doing so. (Rugarcia et al., 2000).

On the other hand, according to the newspaper Gestion, Peru has emerged as the third most globalized country in Latin America (41st of 60 countries) falling below Mexico (36) and Chile (25) according to the globalization index prepared by Ernst & Young in 2012, data presented at the business and Investment Guide in Peru from 2013 to 2014 (Ernst & Young, 2012). The factors measured were openness to trade, capital flows, exchange of technology and ideas, international movement of workers and cultural integration. (Rosado, 2014).

Among these factors Peru obtained its lowest score in the exchange of technology and ideas, even lower than those achieved by other countries in the region with lower rates of globalization, this factor being the top driver of globalization. (Ernst & Young, 2012).

In an unstable global environment, dependent on world trade, without a strong local market, risks are created and affect production and investment in the country, said Jorge Medina, Country Managing Partner of Ernst & Young.
Young. (Rosado, 2014)

A frequent complaint from stakeholders about undergraduate training of Peruvian universities is that it is considered very theoretical. Industrial engineering is no exception in that perception, despite the concern of most of the universities to include in the career curriculum of the semesters lab sessions that simulate the actual conditions of the industry.

This, together with the deficiencies found in the levels of exchange of technology and ideas at national level shows gaps in the acquisition of skills involving the transfer and combination of concepts, procedures and attitudes to practical situations to be solved efficiently in the middle globalization imposes complex (information, interconnectedness, dependency, complexity).

This situation leads us to think that to narrow the gap between theory and practice and to provide future engineers with the necessary skills to develop and add value in the complex and changing environment faced also requires –apart from -laboratories and visits to plants or companies, a synergistic educational curriculum project (materials and learning strategies covered in the curriculum) to generate added value to the acquisition of skills, contribute to meaningful learning of the subjects of the curriculum of engineering students and facilitate the linkage between it with fields and areas of engineering work.

This reflection has led to the called Experiential Engineering Project.

3. Design of the Experiential Engineering Project (EEP)

The EEP is an educational project of the Industrial Engineering School at UDEP Lima Campus whose goal is to bring value to the education through skills, to contribute to significant learning of the subjects of the curriculum and to help link it with fields and areas work of industrial engineering.

The concept is a set of extracurricular nature, high-impact, fun, participatory and interactive activities on and off campus, with measurable results based on compromise between teachers and students, between academia and industry, university-state.

Its format is composed of participatory workshops and interactive workshops closely linked to visits to factories or companies and opportunities for interaction with professionals in public or private activity, these workshops are designed taking into account the knowledge, skills and elements that promote student learning, the national issues, global trends and reinforcing the characteristic values UDEP.

The EEP has a phase structure, and it is for all students of the five years of industrial engineering career to be carried out simultaneously and is managed under the focus of the Project Management Institute (PMI).

The specific objectives of each phase must be aligned to the goal of EEP that is to contribute to the job competition of the future engineer providing value to their future employability and self-employment generation based on ethical and responsible action with their community and the environment.

The particular focus of the first phase was to link the curriculum courses with fields and work areas of industrial engineering.

4. Development of the EEP - First Phase (EEP-FP)

This first phase considered in this work consists of following items: context, objective, deliverables of the EEP-FP, stages of the project, design of the activities and surveys.

4.1. Context

The EEP-FP was carried out as a Project subject to be assesses in order to measure the efficacy of its value regarding the industrial engineering students’ levels of competence and from those results check the viability of others phases as a pedagogical project for the University so as to get funding, logistics and staff. It was financed by of the academic program of Industrial Engineering Lima Campus own resources to cover mobility costs and materials and sponsoring companies for internal diffusion and lower expenses. The team had a project manager and consisted of full-time students from the School of Engineering and student support program.
They organized themselves according to responsibilities of part or all of the time designated for projects in their respective personal plan.

The running of the EEP-FP was planned and carried out during the first semester (March-July) of 2012 immediately after midterms at times that were distributed over five days between the hours of availability of the students. The attendance was voluntary and the registration was according to the activity to be performed and the year/semesters the students were in.

4.2. Objective

To increase the significance of the of Industrial and Systems Engineering students learning, generating opportunities for contact between the work of the engineering and academic content known by the students, considering at least three of the following skills:

a. To relate the knowledge gained through the career practice
b. To work assertively in teams to anticipate and solve problems considering the optimization of resources and quality
c. To anticipate key concepts that serve as benchmarks in the following career courses
d. To harmonize technical, environmental and management aspects of the career
e. To identify operational models sensitive to changing
f. To reply in a creative and an innovative way to the challenges offered by the implementation of the career—especially those sensitive to change.
g. To reflect on the opportunities that can self-generate or be identified in the labor market of industrial engineering based on ethics and social responsibility.

Objectives derived from the implementation, development and results of the project EEP-FP:

1. To achieve the necessary skills for teamwork of teachers and students in charge of the project management team.
2. To learn and to put into practice the basics of project management by students and faculty members of the project management team

4.3. Deliverables of the EEP - First Phase (EEP-FP)

1. Experiential Engineering Project-EEP
   These are activities designed for all industrial engineering students in which students, teachers, engineers, entrepreneurs and/or coaches can share and interact with each other on a day of high impact and recall, preferably under a ludic approach that facilitates the accomplishment of the main objective. Students are divided in group according to the level of schooling. In Appendix A groups, theme activities, checking if any and design competitions are presented are shown.

2. Statistics of the EEP
   They are the results of the surveys designed to evaluate the assessment of students on the achievement of the objective of each activity and the degree of satisfaction with the EEP as a whole.

3. Report of the registration and analysis of data
   It is a documented report, delivered in writing to the sponsor of the project where it is included the following:
   - The qualitative evaluation of the project regarding the achievement of the main objective.
   - Quality metrics: teachers’ participation percentage, student participation percentage, percentage of perception of achievement of the objective (surveys), degree of student satisfaction (surveys).
   - Metrics quality of project management: relationship between the number of unforeseen tasks on the
number of scheduled tasks; relationship between the number of unforeseen problems on the number of identified risks; percentage deviation of planned budget, percentage deviation from the project schedule.

- Identification of the improvements and best practices.
- Conclusions

4.4. Stages of the Project

I. Preliminary tasks before the EEP

Step 1: Raising awareness and motivating students. To get the students to know the purpose and scope of the EEP and to get them to participate freely in the day. Its aim was to prepare the student in relation to what and how you learn. It was to aimed at influencing in the activation or the generation of relevant prior knowledge and experiences, and to place it in the appropriate context to generate expectations.

Step 2: Promoting EEP among all teachers of the career, aiming at getting teachers to know the purpose and scope of EEP and to make them commit to participate in at least one of the activities designed by each group leader.

Step 3: Designing of each of the activities EEP.

Step 4: Developing a work breakdown structure (WBS) with pre-implementation tasks, implementation and post-implementation of each activity EEP.

Step 5: Costing and budgeting of activities EEP.

Step 6: Approval of the final budget EEP.

Step 7: Preparation of surveys.

II. Tasks of execution of the EEP

Step 8: Checking for visitors: contact company re-visit, re-contact transport company, registration list with corresponding identity document. Collecting qualitative assessment of the visit.

Step 9: Checking in-campus activities: classroom organization classrooms with enough material; checking with teachers, coaches and speakers who lead the session. Check list of students attending list against list of registered participants.

Step 10: Filling Surveys

III. Carrying out of tasks after the EEP

Step 11: Identifying of good practices and improvements

Step 12: Administrative closure

Step 13: Handing in results report

4.5. Design of the activities

Taken into account that the EEP was aimed at all students in the career addressed, students were divided into five groups according to the academic semester completed by the first half of 2012. The proposal was that the day was made up of two or more activities linked by group being the workshop-visit to model plant or company the preferred one.

Guidelines for the selection and design of workshop activities:

- They should have relationship with the visit to do.
- They should pursue at least three of the proposed competencies
- They should be written taking into account learning strategies (Diaz Barriga et al. 2002)
- If prior knowledge of the contents of past activity or the activity is required, they should be delivered in writing and posted on the intranet
4.6. Surveys

The surveys were developed for activities, workshops and visits, both based on the four questions regarding:
- The student's perception in relation to the objective pursued in the activity (specified in each survey)
- The student's perception about the increase in their learning
- The student’s opinion regarding the dynamics of the activity (was not fun, if it was entertaining)
- The student’s opinion regarding whether it would recommend further workshops (or visits) in the EEP.

The questions had two alternatives, being NO the first option prior to that of YES option. The question regarding learning, students were asked to, if the answer was YES, indicate the reason for the increasing in their learning. The idea was to make them take a little more time and therefore not be limited to just answer YES.

Table 1. Results of degree of satisfaction for Workshop

<table>
<thead>
<tr>
<th>Group</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% satisfaction</td>
<td>% satisfaction</td>
<td>% satisfaction</td>
<td>% satisfaction</td>
<td>% satisfaction</td>
</tr>
<tr>
<td>Achievement of objective</td>
<td>100</td>
<td>100</td>
<td>Not applicable</td>
<td>100</td>
<td>100</td>
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<tr>
<td>Learning</td>
<td>94,45</td>
<td>100</td>
<td>Not applicable</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Fun</td>
<td>100</td>
<td>96,15</td>
<td>Not applicable</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Recomend</td>
<td>100</td>
<td>100</td>
<td>Not applicable</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

5. Results

- Attendance to the EEP: More than 85% of the registered students per group attended. An approximate of 94% of the total of students registered.
- Results of the surveys of the activity: Workshop (see Table 1) and visits (See Table 2)

5.1. Analysis of results

a. Taking into account that the activities were not mandatory and that the EEP schedule (see Appendix B) extended the activities in days with consequent difficulties for recalling, this assistance can be considered very satisfactory and the students' interest in such initiatives can be supposed.

b. The result of the surveys show that the participants to the EEP considered it, mostly as beneficial to their learning and well recommended.
Table 2. Results of degree of satisfaction of the visits to factories

<table>
<thead>
<tr>
<th>Group</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>% satisfaction</td>
<td>% satisfaction</td>
<td>% satisfaction</td>
<td>% satisfaction</td>
<td>% satisfaction</td>
<td>% satisfaction</td>
</tr>
<tr>
<td>Achievement of objective</td>
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<td>100</td>
<td>100</td>
<td>94.74</td>
<td>Not applicable</td>
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<tr>
<td>Learning</td>
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<td>100</td>
<td>96.16</td>
<td>100</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Fun</td>
<td>Not applicable</td>
<td>100</td>
<td>96.16</td>
<td>94.74</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Recomend</td>
<td>Not applicable</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

c. The result of the surveys show that the pursued objective and the statement for each activity was perceived by most students as reached implying that the design of each of the activities followed a process that could be taken as a good working practice.

d. The management of the EEP as a project carried out under the focus of PMI facilitated the identification of contextual constraints and its scope helped to identify and to sequence tasks and those responsible for them, allowing to design simple plans for the management of communication, of the risk and the time as well as the identification of best working practices and lessons learned to consider in the following phases of EEP.

e. Lessons learned

- The commitment of the team in terms of time to the conference planning and to the execution of the preliminary tasks influenced the number of activities per group. The team's work was part-time and with different availabilities, which demanded greater effort in communication management at the expense of the number of activities per group. It is advisable that the team should devote full time to the managing of EEP.

- The EEP schedule - five days spread over two weeks - generated more work for the recall of the activities between students and teachers, difficulties in contact with students responsible for each group and difficulties for teachers responsible who also had their teaching duties to do. Difficulties to reconcile the availability of student schedules, tour schedules and schedule of workshops were found. It is considered that the project must be carried out in three days without classes to focus student interest, to keep them motivated by learning, and to reduce management of efforts that do not add value to the EEP.

- The budget did not limit the scope of the project but restricted the number of activities that took place off the campus. It is considered that the positive results of EEP favor the decision to give it a bigger budget in the following phases.

f. Best practices:

- Development of a design process of the workshop-visit activities: analysis and definition of knowledge, skills and motivating persons in the group of students at each group, definition of competencies for group taking into account at least three of the ones posted for EEP-FP, design of workshop with a fun format, experiential format with great impact and recalling, choosing of a visit closely linked with the workshop, survey design.

- Documentation of all aspects related to the management and design of the EEP-FP.
6. Conclusions

- The EEP model can be considered as a pedagogical Project to link subjects from the curriculum with the different areas and fields of the industrial engineering practice contributing to the meaningful learning of the student.
- The design of the workshop-visit activities is critical to the success of the EEP: activities designed to achieve more than one specific skill over the EEP, should take into account the student's knowledge up to the previous year of studies, so as to identify concepts and the lines of engineering that can not be experienced in class.

7. Recommendations

- An EEP should be considered within the academic calendar giving it its own schedule that allows to focus its activities in three days without classes and assessments.
- A special budget item should be considered in the annual budget of the career so as to increase the EEP scope and impact.
- A full-time EEP working team should be hired.
- The project approach should be taken into account to facilitate the management of the EEP to provide useful documentation (best practices, lessons learned) for the following EEP.

Appendix A. Summary of the Activities: Content, Topic and General Objective EEP-FP attended.

<table>
<thead>
<tr>
<th>Cycle</th>
<th>Activities</th>
<th>Topics of the activity</th>
<th>Visit</th>
<th>Prior Knowledge</th>
<th>Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introductory</td>
<td>Workshop Group A</td>
<td>1. Optimal design: Approach to the concept of engineering design</td>
<td></td>
<td>Basic Mathematics</td>
<td>a, b, c y d</td>
</tr>
<tr>
<td>And First</td>
<td>Workshop Group B</td>
<td>1. Recycling: Engineering Approach to environmental issues</td>
<td></td>
<td>GLORIA</td>
<td>a, b, c y d</td>
</tr>
<tr>
<td>Second</td>
<td>Workshop Group C</td>
<td>1. Strengths and Weaknesses</td>
<td></td>
<td>Resistencia de materiales</td>
<td>a, b, c y d</td>
</tr>
<tr>
<td>And Third</td>
<td>Workshop Group D</td>
<td>2. Distribution nets</td>
<td></td>
<td>Introduction to Logistics</td>
<td>a, b, c y d</td>
</tr>
<tr>
<td>Fourth</td>
<td>Workshop Group E</td>
<td>1. Talk with Pension management company</td>
<td></td>
<td>JOSFEL</td>
<td>a, c, f y g</td>
</tr>
<tr>
<td>And Fifth</td>
<td></td>
<td>2. Productive processes</td>
<td></td>
<td>Finance</td>
<td>a, c, f y g</td>
</tr>
<tr>
<td>Sixth</td>
<td>Workshop Group F</td>
<td>1. Quality control using statistics methods</td>
<td></td>
<td>SEMAN</td>
<td>a, d, f y g</td>
</tr>
<tr>
<td>And Seventh</td>
<td></td>
<td>2. Talk with Financial company</td>
<td></td>
<td>Finance</td>
<td>a, d, f y g</td>
</tr>
<tr>
<td>Eighth,</td>
<td>Workshop Group G</td>
<td>1. Talk with enterprises</td>
<td></td>
<td>Labor Market of the industrial engineer</td>
<td>a, d, e, f y g</td>
</tr>
<tr>
<td>Ninth</td>
<td></td>
<td>Visit: SIEMENS - COGA – RANSA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>And Tenth</td>
<td></td>
<td>2. Productive processes</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Appendix B. EEP-FP Schedule

<table>
<thead>
<tr>
<th>SCHEDULE EEP-FP</th>
<th>Date</th>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Thursday 3</td>
<td>8am -1pm</td>
<td>Visit to SEMAN Group D</td>
</tr>
<tr>
<td></td>
<td>Monday 7</td>
<td>2pm - 5 pm</td>
<td>Workshop Group D Laboratory of Physics</td>
</tr>
<tr>
<td></td>
<td>Tuesday 8</td>
<td>7pm -9pm</td>
<td>Workshop group E B-32 Conference: Pro-Futuro Group C,D y E A-22</td>
</tr>
<tr>
<td></td>
<td>Wednesday 9</td>
<td>8am -1pm</td>
<td>Visit to JOSFEL Group C</td>
</tr>
<tr>
<td></td>
<td>Friday 11</td>
<td>2pm - 5 pm</td>
<td>Workshop Group B Laboratory of Physics or B-32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7pm -9pm</td>
<td>Workshop group A Laboratory of Chemistry</td>
</tr>
</tbody>
</table>

References


