CAPÍTULO 42
BUILDING A TRANSITION TO THE ENGINEERING FIELDWORK THROUGH PROJECT-BASED LEARNING

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1. INTRODUCTION

Higher education faces a challenging moment that presses to search for educational models to prepare students for the social and professional demands of the 21st century. The dynamic job market and the constant need for competitive knowledge personnel bring the need for universities to tie the learning process to the true business world. These changes require universities to rethink the way students are prepared for the changing and emerging job market. Traditional teaching methods are less effective in motivating students to learn (Freire, 2006). This represents an imperative call for a 180º change in the traditional learning and teaching dynamics in which the main actors, content, methodologies, activities and technology operate (Silva Quiroz & Maturana Castillo, 2017). Not only are core knowledge areas important in the professional world, but problem structuring, critical and strategic thinking, and understanding of the political and institutional contexts seem critical (Van Horen et ál., 2004). For these reasons, it makes sense that universities implement internships as a way to prepare students for professional work. However, the original purposes of internships have been replaced by a market in which the commonality is unpaid positions leading to fewer job offer positions after graduation and a fierce competition of well-qualified applicants willing to compete for free (Howe, 2014). It seems that companies are less concerned with the development of the interns and more about what they can get from them, deviating from the original purposes of internships.

2. BACKGROUND

In this study, the proposal is to describe the merged model between the undergraduate level course of Telecommunications Switching & Transmission and the university internship program in order to prepare higher education students for the engineering field.

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The model was a response to returning to the original goals of internships and achieving the development of real experiences for students. The model was based on internship intentions and a Project-Based Learning (PBL) methodology. The contribution of this study is to share the implemented model framework to inform decision-making faculty about the engineering curriculum design pedagogy.

2.1. Internships

Internships offer benefits such as learning experiences and preparation for the job market. Students gain first-hand experience in the work environment where they can apply theoretical and methodological knowledge learned at university to real business problems. Training "in" and "for" employment seems to be a fundamental pillar for the development of countries, productive organizations, and individuals (Garrido et ál., 2017). Organizations can obtain qualified knowledge workers after the internship program, which turns into a recruitment advantage. Host organizations receive assistance in completing specific tasks. Additionally, the host firms get in contact with the university education and research environments (Jawabri, 2017).

Internships also present challenges. Students seem to know the concepts; however, they lack knowledge of how to apply those concepts in real-life projects. Moreover, the employers in some cases do not have the time to establish and develop an internship model given that they are facing everyday business challenges. Research has shown that there is a lack of coordination between the business and an academic supervisor to coordinate internship programs (Anjum, 2020). From the side of the university, it becomes clear that there is a need for academic advisors to make this transition from classes to internships much smoother and reshape the internship model.

2.2. PBL

Some authors emphasize that teachers' pedagogical practices and the conceptions they have about education elucidate and justify transformations both in the practices that occur within the classroom and in initial training (Carrasco et al., 2016; Cortez Quevedo, 2013). These authors then would agree that the role of teachers is transformed to be facilitators of knowledge construction and lead to active learning pedagogies that are centered on students such as PBL.

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The PBL model allows engineering education to reflect the professional world. PBL demands a real-world perspective since learning is based on doing. As the Chinese proverb says: “Tell me and I will forget; show me and I may remember; involve me and I will understand.” PBL offers a student-centered learning framework that simulates workplace experiences and harnesses students' interest in giving practical meaning to education while developing key competencies for jobs in the corporate world (Habók & Nagy 2016; Miller & Krajcik, 2019). PBL also provides students with a learning framework for a modern workplace (Santos et ál., 2015).

The virtue of project-based learning is to provide a teaching strategy based on the work experience of the teacher, who has the task to develop problems that make it easier for students to act, not just rehearse (Santos, Sales, Fernandes, & Nichols, 2015). The learning process enriches when the teacher shares practical job experience, this is where project-based learning comes handy, given that this model is a pedagogical approach that has been incorporated into areas of study such as engineering and sciences, and demands a perspective from the business world because it suggests that learning involves a student acting on a subject of study (Jou, et ál., 2010).

Traditionally, the Telecommunications Switching & Transmission course has been taught with evaluation objectives pointing to conceptual understandings. However, the professor chose to implement the PBL model as an active learning education to foster innovation that addressed the higher education students' challenges to transition to the engineering field work. Table 1 describes the PBL model used for the class in which four projects were prepared with the collaboration of the university information technology (IT) department and companies linked to the professional internship program of the Telecommunications Engineering career.

Table 1

Project-based learning stages

Stage	**Description**
Project formulation	Academic advisors and class teachers managed project planning with firms linked to the internship program.
Activation	The curriculum content was worked with students through lectures.
Research	Students get in context to have a view of the project needs

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Development	Students develop solutions supported by the professor
Feedback	Teachers and industry experts give feedback on the development stage of projects to enable students to improve their projects.

3. THE COURSE

The study was developed in a university at the southern highland region of Ecuador in the Telecommunications Switching & Transmission course that was part of the Telecommunications Engineering program. This course focused on studying and applying telecom network elements to design, control and analyze Internet access networks. The course covered topics such as internal and external network design, IP network design, voice over IP (VoIP), traffic engineering, and the configuration of network and data center devices.

The participants were one professor, one academic advisor, 30 undergraduate students and 4 businesses. The professor had the technical knowledge and experience to teach the class, as well as a network of contacts in telecommunications firms. His professional network allowed him to get real hands-on projects that companies needed to develop. He worked with three different private firms and one public firm to develop the projects. The students were between 20 and 26 years old and in their seventh semester of the telecommunications career. They had a graduation requirement to have an internship.

4. COMBINING PBL AND THE INTERNSHIP PROGRAM

Figure 1 describes the merge between the project-based learning course with the internship program. In the projectship phase four projects were established by the professor, academic advisor and firms. The projects were: (1) Internal plant, (2) External plant, (3) Voice over IP services, and (4) Voice & data traffic. This was the foundation to plan the conceptual and technical knowledge as well as competencies students will need and also will get from an internship.

During the course the PBL method from table 1 was applied to each project. At the beginning of the semester, the students were given lectures on the generalities of the course and what was expected as a result of the resolution of the different projects. The teacher assigned groups of three students who had to complete all four projects. Each

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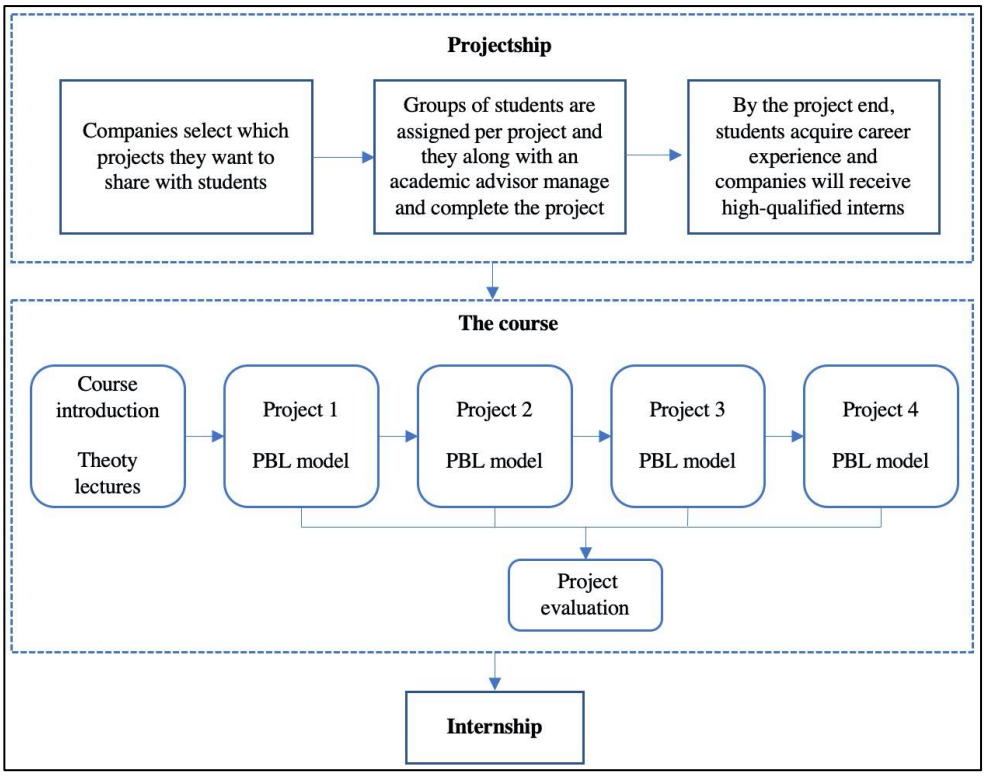
project had a duration of four weeks. During classes, the teacher guided students with project-applicable concepts, applying his experience to designing these networks. Planning, designs, and other materials and equipment were provided in class, and progress was received for feedback before each project ends. Students delivered progress reports to obtain constant feedback. For each project a final report and presentation to the teacher and industry experts were delivered.

At the end of the semester, students were assigned according to internships programs based on weighted decision of their performance on the project, firm needs and recommendations of the professor and academic advisor.

Figure 1

Combining project-based learning with the internship program.



5. EMPIRICAL STUDY

The proposed framework was validated through an empirical study that was applied in the 2018 fall semester. Data collection involved (1) semistructured interviews with the professor, firms, and students, (2) field notes, (3) documents provided by the firms such as the floor computer-aided designs (CADs) of and network designs and city CADs for optical fiber design and (4) final reports presented by students. Data was analyzed using Creswell & Poth (2016) Data Analysis Spiral. Informed knowledge, privacy,

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confidentiality and protection of the identity of the participants, authorship and intellectual property was done following Valenzuela and Flores (2013) procedures.

Table 2

Description of projects designed for the course

Project	**Description**
Internal plant	This project involved the design of voice and data network cabling for IP telephony and involves the connection of equipment according to structured cabling standards in such a way that each telecommunications outlet carries both voice over IP and data traffic.
External plant	The teacher and the academy advisor worked with the collaboration of "Corporación Nacional de Telecomunicaciones (CNT)", for the development of fiber optic designs that go from the internet services provider (ISP) to the home/office. Each team was responsible for designing fiber-optic access networks in different areas of the city.
VoIP services	This project was designed to configure networking devices and VoIP servers to provide telephony services for enterprises. Networking and server devices configuration were lectured by the teacher using Open Source Software. Students had to reapply those configurations to set VoIP services.
Voice & data traffic	Students learned how to estimate phone demand and meet such demands. This project also involved networking equipment setup. This type of project is important for phone networks, the Internet, the cellular backhaul network, and other networks where demand from multiple users is carried across shared channels.

6. RESULTS

The results are organized through four categories emerging from the study: competences, comparison with other courses and areas of opportunity.

At the end of the course, interviews revealed students' perception on what competences they had developed more with the project as shown in table 3. The table

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includes de percentage that students mentioned the competence and sample fragments of the comment related to the competence.

Table 3

Competenses

Competence	Mentioned	Comment by student
Collaboration	90 %	During the project, I had to collaborate with two other people to create projects that involve teamwork (Evelyn).
Communication	70 %	Not only I had to be aware of my communication with my classmates but with the firms. I had to use a more professional language to express myself (Bryan)
Project management	60 %	The most fascinating part was that since the internal plant we had to calculate the timing and costs for the project. I loved my role leading the project schedules (Camila).
Empathy	50 %	The projects developed helped me to consider others when carrying out a project, to know what the problem was, and to carefully design the most feasible solution taking in account others needs and wants (Cesar).

Students' discourse in the interviews also led them to contrast this course with others they previously had specially finding a difference in the methodology. Table 4 shows some fragments related to these results.

Table 4

Comparison with other courses

Difference	Comment by student
Practical	We had four hands on projects which we knew were real projects impacting the community. They were relevant for people and not just concepts in the air (Fabian).

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Dynamic	The teacher was in everything! He was dynamic and the class was dynamic. (Jenny).
Collaborative learning	He was always open to our ideas and shared his with us too. I felt that I was co constructing knowledge and not just absorbing and memorizing knowledge (Luisa).

Students' experience also led them to give some suggestions about the course that are reflected in table 5.

Table 5

Suggestions for the program

Suggestions	Comment by student
Conference	It was useful to meet with business managers, I think it would have been useful to have more of these conferences to hear more of their expertises (Paul).
Content	We work with one public business. It would have been useful to have a background on the public purchasing system that the government uses (Angel).
Software	The classes were practical but I think we needed more training on technologies such as CISCO, Mikrotik, Ubiquiti, etc. (Andrea).

7. DISCUSSION AND CONCLUSIONS

Results indicate that a learning process based on practical experience combined with project-based learning is an effective way to prepare undergraduate students to complete successfully their internship program and acquire the experience for the engineering job market. The students recognized the development of competences that seem to be relevant with 21st century skills.

The fact that students made relevant some characteristics of the course portrayed differences with other courses. This course based on PBL methodology was practical, dynamic and made special emphasis in collaborative learning which shows a Vygotskian perspective in the construction of knowledge and aligns with a dialogic pedagogy of Freire (2006) where there is a recognition of student’s voice and participation.

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In the eyes of students, the framework presents some suggestions on content, software and contact with more business managers. According to the teacher, the time limit was one of the restrictions for that, but he considers that these recommendations could lead to bringing to the model other classes which imply a curricular change.

A teaching and learning environment based on practical experience, combining the PBL framework with the internship program, was an effective model for undergraduate students to learn to solve engineering design problems in a short time. Moreover, this course was career-boosting experience to transition to the engineering fieldwork.

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