

INDUSTRY POSTGRADUATE STUDIES: TECHNOLOGICAL PROJECT ENGINEERING MASTER'S OF THE UNIVERSITY OF GUADALAJARA

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The present paper will expose the Technology Project Engineering Master's of the University of Guadalajara that is being offered since February 2014; the master's is based on project engineering, emerging discipline that is barely being attended in Mexico through postgraduate studies, despite its importance in industrial development for its cross-disciplinary content. The description of its relevance will be shown by exposing its curricula and the necessary general infrastructure it will have to operate. In addition, an approach to a new modality "Industry postgraduate studies" is made; promoted by the National Board of Science and Technology, that given its structure and the interest shown by the Board it could be linked to it. This paper will also present 6 cases of 6 different companies already working under this modality to attend its requirements.

Keywords: *Education; Project Engineering; Industry*

POSGRADOS CON LA INDUSTRIA: MAESTRÍA EN INGENIERÍA DE PROYECTOS TECNOLÓGICOS DE LA UNIVERSIDAD DE GUADALAJARA

El presente trabajo aborda la Maestría en Proyectos Tecnológicos que la Universidad de Guadalajara ofrece a partir de febrero de 2014; la maestría está basada en la ingeniería de proyectos, disciplina que en México se atiende apenas de manera incipiente como posgrado, a pesar de la gran importancia que tiene en el desarrollo industrial por su contenido interdisciplinar que conlleva. Se hace una descripción de la pertinencia del posgrado, mostrando su estructura curricular y la infraestructura general con que se contará para operar. Se hace también un acercamiento a la modalidad "posgrados con la industria" que está impulsando el Consejo Nacional de Ciencia y Tecnología, encontrándose que la Maestría en Proyectos Tecnológicos podría acoplarse a esta, dada su propia estructura y la vocación de vinculación que tiene la sede del mismo. Se muestra que ya existen seis empresas con las que se coordina la impartición de la maestría para atender sus requerimientos.

Palabras clave: *Educación; Ingeniería de Proyectos; Industria*

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1. Introduction

Technological projects are developed in different universities around the world and so within the technology industry. They are oriented to project management on different fields. These projects are characterized for being cross-disciplinary and with a great vision; focus that can fulfill different economical sectors, and where engineering firms and consultant's firms play an important role on their development.

The projects in the Mexican industrial environment have been characterized by having an evolution immersed in conditions of pragmatic development and especially in a difficult economy.

The projects have gone from being a reliable and firm resource to the specific needs of the industrial infrastructure projects in Mexico, to be wrapped in an unfavorable economic environment that has resulted in medium- and long-term loss of qualified personnel in the discipline and technological upgrade necessary for the Mexican industry. It is important to strengthen the vision of the academy and industry toward the project engineering as an important link to the industrial and economic development of Mexico.

The National Council of Science and Technology is pushing for the creation of graduate programs in the form called "Graduate Programs with the industry", to train personnel with the capacity of generation and application of knowledge, as well as the incorporation of scientific and technological advances in the companies in which they are working; with the purpose of increasing productivity and competitiveness (Consejo Nacional de Ciencia y Tecnología, 2012).

The University of Guadalajara offers, since the school calendar 2014A the Master's degree in Projects Technology that, while it was not prepared to meet the call of the National Council of Science and Technology, it is structured to comply with the trend of Graduate Programs with the industry, because the field seeks to include the process and manufacturing industry, project management and administration, as well as leadership and management of engineering and consulting companies favoring technological modernization and innovation. In addition, the headquarters of the postgraduate program will be the Project Engineering Department, with a wide-ranging career in the discipline and with a clear vocation in the relationship with the industrial sector; in effect, the Department first emerged as an Institute for the Development of Capital Goods, constituting itself, then in the direction of linking and Transfer of Technology before being the current one.

2. Objectives

This paper has the fundamental purpose of making the Master's Degree in Projects Technology at the University of Guadalajara public, highlighting its background, the curriculum, the relevance, its scope and expectations within the industry; it also shows the possibility of becoming a "postgraduate study with the industry" according to the guidelines of the National Council of Science and Technology.

3. Methodology

The methodology used for the design of the curriculum of the Master's Degree in Technological Projects considers four stages described below.

a) Foundation of the postgraduate study

To outline the environment of the general engineering in Mexico it is necessary to explain it within the global economic system, since the positive and negative impacts that the economy has on the scientific and technological development impacts the engineering of projects as well. In 2009, the Academy of Engineering, A. C. hosted the First Symposium of Project Engineering, involving entities that define the market, as well as institutions and companies that make up the supply of domestic engineering. They also had the participation of companies providing specialized applications for engineering and some higher education institutions. Problems and focus areas were analyzed, proposals for a solution were considered, aimed at finding innovative mechanisms to provide feasibility for success in its scope for the project engineering. The Academy of Engineering, A. C. also supported the study entitled "Analysis of the project engineering of industrial facilities in Mexico" prepared by the engineer A. Ricardo Rosales G., in May of 2010. The main objective of this study is to propose a series of actions to support the restoration of the supply of engineering projects in the national level. Through a careful analysis of the situation of the engineering in Mexico, the author manages to establish the current status of the project engineering, its particular problem and the perspective in the industrial sector; it also covers the challenges to overcome to reverse the effect of the economic problems of the country. Some topics of interest can be rescued to support the creation of the Master's in technological projects, and which are described below (Rosales, 2010):

- a.1.) In the mid 1970s the company Petroleos Mexicanos had nearly twenty million man-hours per year in engineering projects. These hours were divided between internal groups of the public and private engineering firms that accounted for almost half of the needs.
- a.2.) In the 1980s the economic environment in Mexico changed. The demand in engineering had a substantial decline by the economic crisis. The entry of Mexico to the General Agreement on Tariffs and Trade and the new criteria of global competition forced many engineering projects were tendered at the international level.
- a.3.) The construction of industrial plants with the so-called "green package" was reactivated in the 1990s but began a competition between national and foreign engineering firms.
- a.4.) The *North American Free Trade Agreement (NAFTA)* has exacerbated the problems of engineering as it forced Mexican companies to compete in conditions of great disadvantage, not only economically, but by a lack of qualified personnel in the areas related to the projects to bid. Many engineering firms disappeared in this crisis.
- a.5.) The work field of the projects engineering has been affected by the historical behavior described above.

The market of project engineering is composed on the demand or requirement of engineering to develop infrastructure in the public and private sector, and the ability to develop competitive engineering for the national and international companies. So the working area of the project engineer extends in a comprehensive way in public and private sector in industries as diverse as: infrastructure of railways, roads, ports, airports, telecommunications, water and sanitation, hydro-agriculture, electricity, production of oil, gas and petrochemical derivatives, metal mechanics, mines,

chemistry in all its disciplines, energy, automotive industry, and construction industry among others.

There are no specific statistics in Mexico related to the demand for engineering of industrial projects. To get an idea of this index, it is necessary to quantify the magnitude of the investment in the design and development of engineering for the industrial infrastructure. The analysis done by Rosales involves a method to quantify several parameters required to estimate and compare the demand and supply of engineering projects, and with which he concludes that (Rosales, 2010):

"... the capacity of the national supply cannot meet the volume of engineering required by the demand, meaning that it covers only 50% of the it and that, the remaining segment, must necessarily be covered by companies with national presence and committees that include international tenders...It also tells us that the installed capacity of the supply of project engineering of industrial facilities ought to be fully occupied, however it is well known that the national companies have expressed in various forums, the lack of projects, the appropriate size and type, that will allow them to maintain and develop their productive plants...and on the other hand, it is necessary to say that in the information analyzed and available, there are no plans at the national or local level, to meet the growing demand for project engineering"

From the picture that the engineering has been facing in Mexico, and therefore the industrial projects engineering, it is possible to deduce from the above analysis a series of specific obstacles facing the Mexican industry, among others:

- Difficulty to find qualified market staff in specific areas of engineering, especially projects, and by the migration of staff with experience in other economic activities very different and that it therefore cannot be re-recruited.
- Lack of training for staff with a focus on engineering projects for universities and linked with the needs of industry.

Small and medium-sized enterprises in engineering do not have the capacity to compete directly in the large industrial projects, thus they are involved only through outsourcing.

b) Professional profile

The Master's Degree in technological projects will provide students with the necessary skills to develop an engineering project, which includes the following areas: conceptual engineering, basic and detail for a new plant or an expansion of an existing one, the basic principles of project management, as well as to foster the development of various skills necessary for implementation of projects in general. As the foregoing implies the integration of the various knowledge acquired during the race and the ability to interact with other engineering disciplines such as civil engineering, electrical, electronic and mechanical, piping and instrumentation, industrial engineering, environmental engineering and after disciplines, in addition to some economic-administrative areas, it is necessary to create an atmosphere of teaching-learning for the acquisition of knowledge and skills that will help the student master the discipline of the projects engineering. The profile of a Master in Technological Projects must cover knowledge that is the base of the discipline. Therefore the postgraduate student will:

- Formulate and evaluate investment or engineering projects, plan, organize, direct and control the activities concerning the development of project.
- Design and evaluate profiles of important positions for the integration of the project team.

- Perform market research, determine the size of an industrial plant, and determine the best location for a project.
- Develop conceptual engineering, basic and detailed for a project.
- Develop process engineering.
- Design and interpret engineering drawings for industrial plants
- Operate specialized computer systems in the different project areas.
- Design, calculate and select equipment.
- Generate and interpret information in the areas of mechanical engineering, civil engineering, instrumentation and piping, electrical engineering, architectural group.
- Apply the foundations and practices of the project management approach
- Design and develop the necessary process engineering for an industrial project.
- Calculate, specify and select processing equipment: pumps, heat transfer equipment, compressors, tanks of storage, equipment for mixing, vacuum equipment, reactors, columns of process, etc.
- Design and develop the engineering services for the integration of the engineering core of the project: water, steam and condensate, fuels, compressed air, inert gases, ice water and brines, vacuum, waste management.
- Learn about the different methods for the procurement of materials and equipment.
- Understand and apply the different types of contracts that apply to industrial projects.
- Understand and apply the regulations of construction, bonds/insurance, deposits and other legal aspects of the work in a project.
- Review and evaluate plans and memories of calculation prior to the implementation of the project.
- Build, start and operate industrial plants according to plans and engineering programs.

To this basic profile, knowledge and skills that students will acquire with the optional training areas open are added, either in environmental engineering, manufacturing engineering and control engineering, with an approach in project engineering.

c) Organization and curriculum structure

The curriculum structure is understood as a set of organizing components in connection with the education objectives, content, learning experiences, resources and valuations, from which plans of study are designed. The curricular structure of the program is in some ways, the backbone of the formative processes, because it depends on the guidance, selection, organization and the distribution of knowledge and the practices that contribute to the vocational training. The students of the Master's in project engineering will be trained to:

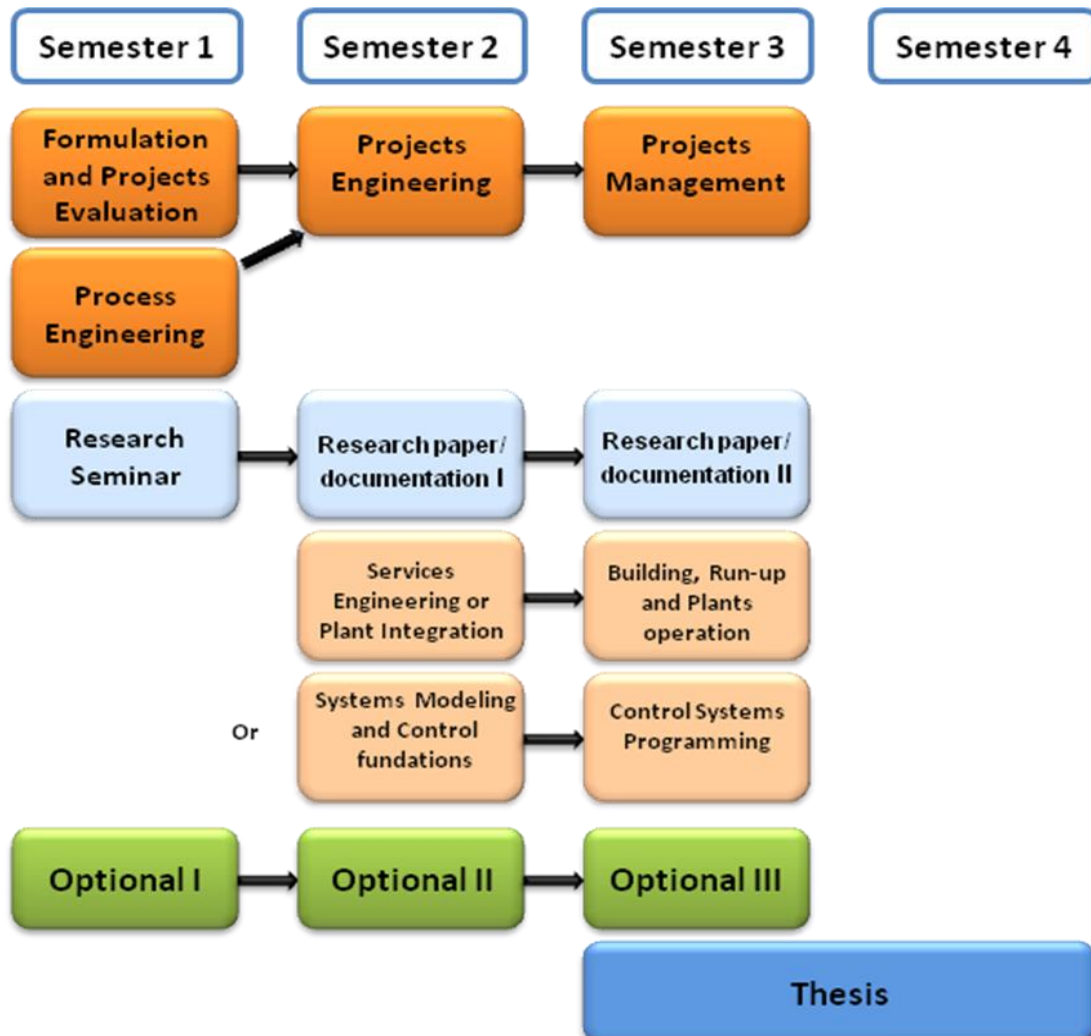
- Formulate, develop and evaluate industrial projects, research and technological application.

- Develop the ability to evaluate and select technology for industrial projects.
- Organize, coordinate, and execute research and development projects, aimed at the generation of technology for obtaining products, improvement of processes and equipment design
- Develop and coordinate projects of assimilation, technological innovation and development

From the above, and according to the General rules of graduate of our University, knowledge is organized in relation to the following thematic nuclei:

- Mandatory common basic training
- Basic Training Area Particular compulsory
- Selective specializing area
- Compulsory specializing area
- Open elective training area

Figura 1. Curriculum map



4. Results

The Master's Degree in technological projects' background is the Master's of Engineering Projects, established in 1989 in the Direction of Linking and Transfer of Technology from the University of Guadalajara. From that year and until the year 2004 was canceled. Around 250 students, of local origin, national and international, involved primarily in the private industrial sector but also from public and private universities studied this postgraduate study.

The potential market for the Master's degree is very broad; in fact in the Centro Universitario de Ciencias Exactas e Ingenierías (CUCEI); Faculty of Mathematics and engineering; during 2012 over 12, 148 students were enrolled in pregraduate studies.

According to the National Association of Universities and Institutions of Higher Education (ANUIES), in the period 2008-2009 there were in Jalisco 154,559 bachelor students enrolled, of which 43,600 were in the area of Engineering and Technology (28.2 % of the total); also, it is estimated that in our institution during the period 2007-2008 from 4,100 pupils in this area around 2,500 graduated. At the national level, also with data from ANUIES, 774,597 students were enrolled in Engineering and Technology, representing 33.7 % of the national total, being the second in importance after the area of Social Sciences and Administrative that was 45.6 %. In the case of master's degrees at the national level, the number of students enrolled in the area of Engineering and Technology in the period 2008-2009 was of 14,410 students (11.3 %), occupying the third place, after Social Sciences and administrative and Education and Humanities.

During the second National Congress on engineering in the development of Mexico, sponsored by the Academy of engineering, which took place in the Palacio de Minería in November 2005, Mr. Gonzalo López de Haro, in his lecture "The education of engineers for global competitiveness", says that only 4 out of 1,000 pupils entering elementary school conclude the graduate.

It also points out that the engineering and technology ranks second in the national registration, after the administrative disciplines and that there are more than 300 institutions that teach engineering careers, and a total of 1,251 programs of engineering, which had a total enrollment of 315,525 students and a graduate of 32,923; with a degree of 21,540 students (Lopez, 2005), whom are candidates for the postgraduate study throughout the Mexican Republic.

To meet the students and the local and regional industry needs, The Master's degree on Project Engineering has sufficient infrastructure in classrooms, equipment of projection, library and laboratories for environmental engineering, manufacturing and control, access to information and general services for students. Something important is that mastery Headquarters also houses a business incubator of technology-based where students can develop synergies or establish their own businesses. The academic plant meets all requirements established by the University of Guadalajara and the National Council of science and technology to enter the national program's quality postgraduates; there will be 10 doctors and 5 Masters, with experience in the business field. The other requirements of the national program's quality postgraduates have been analyzed and the graduate will be able to fulfill them, so soon it will be prompted to be incorporated as a recently created program.

Recently the graduate programs with industry workshop was held (Guanajuato, June 2013) and organized by the Council Mexican of studies of postgraduate A.C., which discussed the nature of these graduate programs emphasizing the participation of industry, the implications on the institutions headquarters, the evaluation criteria and the origin of the financing. The Foundation and structure that has been given to the master in technological projects allows adjusting to the type promoted by the National Council of science and technology as a

postgraduate course with the industry, having also the flexibility to adapt the Organization and schedules to assist students working in the industry.

As an example, it is already working with the company *Automatyco*, based in the city of Zapopan specialized in technological development for manufacturing companies; a graduate of the Master's degree in engineering projects created it in the University's incubator of companies and has grown to the degree of opening a second headquarters in Aguascalientes to meet the needs of the company Nissan Mexicana. The company has pledged to send 12 of its engineers to master technological projects, covering tuition for all of them; it has been preparing a schedule that fits its needs. An important detail is that attendees must sign a promissory note that forces them to complete the postgraduate, degree included.

5. Conclusion

There is a need for an approach between the universities and the industrial sector to strengthen engineering Projects in Mexico. Train specialists with the knowledge, skills, and abilities required for the development of engineering projects. Establish a mechanism to complement the training and development of professionals in engineering graduates to confront the design and implementation of projects. The Master's Degree in technological projects, which aims to meet the needs raised and analyzed in this work, is founded. It should be noted that, after an intensive search on the academic programs related to the engineering projects in Mexico, it was found that only the National Autonomous University of Mexico, includes this discipline as area of vocational training as graduate and as complementary training in the career of Chemical Engineering.

In response to the guidelines which establishes the National Council for science and technology for the graduate programs with the industry, expertise in technology projects could be adjusted given that there is already an option with an specific company, in addition to the flexibility to adjust schedules and the vocation of link with the industry-based; However, the University as well as the companies have to do an analysis of the implications of to determine the viability.

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