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Project Management in Higher Education Institutions in Mexico: A Case Study*

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Project management (PM) is considered a determining factor in the success of collaborative innovation and technological development projects carried out by universities and private companies. This work presents the findings of a study carried out in the Faculty of Engineering of the Autonomous University of Querétaro (FIUAQ) that aimed to determine the level of maturity in project management of the faculty members. Their level of maturity is also linked with the perception of success (in terms of satisfaction level) of the companies that collaborated with the FIUAQ in research and innovation projects. Knowing the level of maturity in project management of its members is important for the FIUAQ, since it aims to incorporate a Project-Based Learning Model (PBL) in the curriculum of undergraduate and graduate students, encouraging their participation in collaborative projects between academia and industry. The conclusions section describes some factors that may hinder an organization such as the FIUAQ in its aim to increase the level of maturity in project management of its members.

Keywords: project management; level of maturity; academia-industry relationships; research and innovation projects

1. Introduction

The Governments of developing countries are increasingly concerned with fostering interactions between science and private industry and developing high-technology sectors. Mexico has not been the exception and the National Innovation Plan for 2013–2018 (PIDE 2013–2018) [1], published by the federal government, recognizes that Mexico lags behind in the development of an economy based on knowledge, innovation and skills. This has several causes: low spending on Science, Technology and Innovation (CTI), a weak innovative culture and weak links between the academic and productive sectors. It should be emphasized that even though technological infrastructure and human capital resources are scattered throughout the country, they have not established adequate links with the needs of private industry, which reduces the effectiveness of the public resources allocated for these purposes [2–4].

The federal government of Mexico has promoted several strategies that aim to develop a policy of industrial promotion and innovation to foster balanced economic growth among economic sectors, regions and companies; these strategies include: (1) encouraging the development of suppliers to integrate and consolidate value chains that contribute to the creation of technological clusters; (2) promoting innovation in different sectors under collaboration schemes between academia, private sector and government (the so-called triple-helix). [5, 6].

To promote innovation in the academic, private and government sectors, the National Science and Technology Council (CONACYT) have several programs to foster the growth, strength and connectivity of the scientific, technological and innovation sectors, these programs are supported by federal budget. One of these programs is the Innovation Stimulus Program (PEI, Programa de Estímulos a la Innovación). The main objective of PEI is to encourage, throughout the country, investment by private companies in activities and projects related to research, technological development and innovation, by providing complementary stimuli. Through this program, private companies can submit investment proposals, either individually or in alliance with at least one or two Higher Education Institutions (HEIs) or Research Centers (CIs) [7].

However, it is not easy to establish, maintain and strengthen research collaborations between academia and industry; each party must overcome cultural and communication gaps that hinder these relationships and tend to undermine their potential. The literature on the subject provides some guidelines for increasing the probability of success of collaborative research and innovation projects between academia and industry. Some authors argue that the most important factors influencing the success of these type of projects include: establishing clear objectives shared by all parties; applying project management methods; having available resources; and establishing an adequate communication between the parties, among others [8–11]. In addition, it is necessary to consider that the char-

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acteristics of the collaboration of private companies with universities can vary depending on whether the companies are emerging or mature. [12, 13]

Collaborative research projects between universities and industry present several challenges related to project management, since they are often associated with a high degree of uncertainty and risks. Work teams tend to work individually and have a heterogeneous composition; their members often reside in distant geographical locations and are also subject to a lot of pressure to carry out creative and innovative projects [14].The increase in the number of collaborative projects between academia and industry has motivated experts on the subject to develop and propose new project management methods to face the challenges presented by them [15], and to focus their studies on the factors and components that influence the success of these projects, as well as on the benefits generated by them [16–18].

Not only is it of interest to researchers to understand what factors influence the success of research projects done in collaboration with industry but also to know how to measure the success or failure of such projects. Some authors argue that the success of a project can be measured through the classic golden triangle (budget, time, functionality) or through the value of the innovation and learning that it generates [19, 20]. Other authors argue that the changes in the organization or in the organizational strategies implemented to carry out a project are reliable measures of its success [21, 22]. There are even those who affirm that the measure of success of a project depends on the perception of all those involved in it [23–25].

This raises a question of no small importance: What are the results of the public policies adopted by the governments of several countries to support and encourage collaborative projects between academia and industry that aim to promote economic growth in terms of knowledge, innovation and skills? To answer this question, we decided to study the case of the Universidad Autónoma de Querétaro (UAQ), a Mexican public higher education institution that in 2015 participated in 123 of the 155 collaborative projects between academia and industry sponsored by the PEI of CONACYT in the state of Querétaro.

Querétaro is located in the centre of the country, with an area of 11,668 km^2 and a population of approximately 1.9 million people (2011). According to the National Institute of Statistics and Geography (INEGI), in the year 2011 Querétaro had the fastest growing state economy [26]. Queretaro is the fifth state in terms of federal resources allocated to science, technology and innovation, taking advantage of sponsorship programs such as the PEI, which, as mentioned above, is supported by CONACYT [27].

The structure that lies behind the State System of Science and Technology of Querétaro is formed by 57 Higher Education Institutions (HEI) offering 80 postgraduate programs registered in the National Program of Postgraduate Quality (PNPC); of these, 64 programs belong to the UAQ. Likewise, the UAQ concentrates the largest number of researchers belonging to the National System of Researchers (SNI) in the state. Most SNI researchers in the state are concentrated in Academic Area VII (Engineering), Area II (Biology and Chemistry) and Area I (Physics-Mathematics and Earth Sciences) [27].

The Faculty of Engineering of the Autonomous University of Querétaro (FIUAQ) is, within the institution, the academic unit with the largest number of external projects funded by PEI. This is mainly due to the fact that since 2012, a series of models and strategies have been implemented to promote and strengthen the links between the academic activity carried out in the FIUAQ and the demands and social needs of private companies and public institutions. This has been done through the establishment of agreements and schemes that promote the collaboration between academia and industry on research and innovation projects.

Through these actions, the FIUAQ seeks to establish the conditions needed to incorporate the Project-Based Learning model (PBL) in the training of undergraduate and graduate students, encouraging their participation in collaborative projects between academia and industry so that they acquire skills and competences in project management, increase their technical knowledge and obtain work experience in multidisciplinary teams. In this way, students can participate in work teams that are led by professors-researchers (project leaders) attached to the FIUAQ [28, 29]

The present work shows the level of maturity in project management of the work teams and the project leaders that participate in collaborative research projects carried out by the FIUAQ. It also shows the perception about the projects' success of the project leaders belonging to the private companies with which the FIUAQ collaborated. Considering the context in which the UAQ operates, and the fact that we were able to perform direct observations of the processes and the people involved in them, we used an exploratory study as a research strategy [30].

2. Research and data methods

In order to know the level of maturity in project management of the work teams and the project leaders that participate in collaborative research projects established by the FIUAQ, as well as the perception about the projects' success of the project leaders belonging to the private companies that collaborated in those projects, it was necessary first to define the units of analysis and the research objectives.

2.1 Unit of analysis

The FIUAQ was selected as the unit for analysis for the following reasons:

- It is the academic unit with the largest number of research and innovation projects linked to industry needs, not only within the University but also in the state of Queretaro.
- The project leaders and members of their work teams are attached to this faculty.

It is worth noting that the FIUAQ has a team of technical accounting assistants who assist the project leaders in the management of the human and material resources that are required for each particular project, as well as in carrying out all processes that need to be coordinated and supervised by the Purchasing, Finance and Comptroller departments of the Autonomous University of Querétaro. Moreover, the Autonomous University of Querétaro has a Research and Postgraduate Studies Department and a Liaison Department that assist project leaders in the legal management and liaison processes required to formalize and established collaborative projects between academia and industry sponsored by the PEI of CONACYT.

In addition to the above, each of the project managers of the FIUAQ, works individually using the project management methods, techniques and tools that they consider best suited for their work team and their specific projects. It is important to note that 50% of the project managers interviewed took a 56-hour preparation course for obtaining a project management certification (PMP) given by a company certified by the PMI (Project Management Institute). However, none of them has presented the certification exam. It is also important to note that not all members of the work teams took this course.

The data collected covers the period from November 2014 to January 2017.

2.2 Research objective

The research objective is defined as follows: to determine the level of maturity in project management of the project managers and work teams of the FIUAQ who participated in collaborative research and innovation projects between the FIUAQ and private companies, and to study the perceptions of success of the project leaders belonging to the associated companies. The resulting research questions were:

1. What is the level of maturity in project management that university project managers and their work teams showed while participating in collaborative research and innovation projects?
2. What is the perception of the success of these collaborative projects, in terms of satisfaction levels, of the project managers working for the private companies that participated in them?

2.3 Methods

2.3.1 Data collection

The main source of evidence was primary documentation directly available from the FIUAQ, mainly internal technical reports, technical reports presented to CONACYT, articles and theses.

2.3.2 Interviews

The second main source of information were two sets of interviews that aimed to gather information about ten (10) research and innovation projects carried out by the FIUAQ in collaboration with private companies. These projects were supported by CONACYT under the PEI and were carried out during the years 2014–2016. We interviewed a total of ten (10) project managers from FIUAQ to find out the maturity level in project management of their work teams. This group of respondents are known as Group I. We also interviewed the project managers working for the private companies that collaborated with the FIUAQ on the same specific projects; this was done to find out their perception of the success of each project (in terms of satisfaction) and to compare it with the perception of FIUAQ's project managers about their own level of maturity. Only seven (7) private project managers answered the interview; this group of respondents is known as Group II.

The interviews of Group I were carried out using a voluntary self-evaluation method, with the interviewer providing assistance to resolve doubts about the interview itself.

The interviews included the definition provided by the Project Management Body of Knowledge (PMBOK) [31] for the following terms:

1. Project management is "the application of knowledge, skills and techniques to execute projects effectively and efficiently through processes like planning, executing, monitoring/controlling, and closing of a project".
2. Process: is "a series of systematic activities aimed at producing a final result so that one or more inputs will be acted upon to create one or more outputs".

The definition of the level of maturity in project management was based on the standards ISO/IEC

Table 1. Levels of maturity in project management

Level	Description
Level 1—"Performed"	The organization implements and achieves the processes objectives.
Level 2—"Managed"	Standards, processes, methods, procedures and project management personnel exist in the organization, but are not considered an organizational standard. There is basic documentation. The resulting products are established, controlled and maintained.
Level 3—"Established"	All project management standards, processes, methods, procedures and personnel form part of an organizational standard. There is formal documentation and consistent management support.
Level 4—"Predictable"	There are more sophisticated project management standards, processes, methods, procedures and personnel. All projects can rely on very detailed documentation, consistent management support, and a consistent and efficient execution. Performance data for each project are collected and analyzed using different metrics.
Level 5—"Optimized"	Lessons learned and best practices are used to continuously improve existing standards, processes, methods, procedures and personnel. Metrics are collected and applied at project, portfolio and organizational levels. The organization is able to evaluate future decisions based on past performance and maximize its competitive advantage.

15504-2 [32], Organizational Project Management Maturity Model (OPM3[M]) [33] (See Table 1).

The interviews of Group I had a semi-structured format organized by categories (each category corresponded to a phase of the project life cycle) that was characterized according to the expected results (the products of the processes performed) for each category. The project managers were asked to evaluate the activities and tasks (processes) that were performed to obtain a specific product, according to the levels described in Table 1. The respondents were allowed to comment on each of the definitions. Table 2 shows the categories that were included in the surveys and the expected products for each category.

The survey applied to Group II was organized in two parts. The first part was semi-structured and was designed to obtain information about the collaboration itself and the satisfaction of the respondents with it. The second part had a structured format, organized into categories that correspond to each phase of the project life cycle, similar to the interviews conducted with Group I. Each category was related to a product or deliverable obtained as a result of the processes associated with each phase of the project life cycle (Table 3). The questions were structured as statements with which the respondent could agree or disagree using a 5-point Likert scale; except for the collaboration activities in the first part of the survey, which asked for specific information about the collaborative project.

Table 2. Categories and the expected products for each category included in the surveys applied to Group I

Categories	Expected products for each category
Category 1. Planning	Contract or Agreement Project Plan (Objectives, Scope, Limitations, Expected Deliverables, etc.) Communications Plan Delivery protocol
Category 2. Design	Requirements Specification Work Breakdown Structure (WBS) Project schedule Risk management plan Procurement plan Analysis and Design Document Prototype design Schematic diagram List of parts Test requirements
Category 3. Construction	Prototype configuration Follow-up reports Operation manual
Category 4 Integration and Testing	Subsystem test plan Integration test plan Subsystem test reports Integration test reports Delivery report Acceptance document

Table 3. Questions, categories and products for each category included in the surveys applied to Group II

Part 1. Collaboration	
Collaboration Activities (Information about the collaboration itself)	Economic support from CONACYT Amount of support Name of the project Project manager with whom the outreach project was carried out Date of collaboration Duration of collaboration
General opinion about the collaboration	Satisfaction obtained from the collaboration Satisfaction with the management of the project by the technical leader of the Faculty Communication with the project manager and the work team Satisfaction with the management of administrative processes related to the procurement of material resources. Intention to continue collaborating with the engineering faculty Recommendation to other companies to collaborate with the engineering faculty
Part 2. Project management process and deliverables	
Category 1. Planning	Contract or Agreement Project Plan (Objectives, Scope, Limitations, Expected Deliverables, etc.) Delivery protocol
Category 2. Design	Requirements Specification Analysis and Design Document Prototype Design Test Requirements
Category 3. Construction	Prototype Configuration Follow-up Reports Operation Manual
Category 4. Integration and Testing	Subsystem Test Plan Integration test plan Subsystem Test Reports Integration Test Reports Delivery Report Acceptance document

The results obtained from the interviews conducted in Groups I and II are presented below.

3. Presentation and discussion

3.1 Views and positions

3.1.1 Group I: Project leaders/project managers from the faculty of engineering

Project leaders self-evaluated the level of project management maturity of their work teams in a specific project. Tables 4–7 show how each leader rated the processes carried out by their work teams to obtain the products or deliverables associated with each phase of the project.

Table 4 shows that most project leaders characterized their work teams as having a maturity level ranging from Managed (level 2) to Established (level 3). It can also be observed that the leaders and their teams have a lower level of maturity for the processes associated with certain products, as in the case of the Communications Plan and Test Plan products.

It is important to note that, when interviewed, some of the project leaders said that it is difficult to develop a Test Plan during the planning phase of the project life cycle, since most of the projects have as final product an innovative prototype whose design and research frequently involves adjustments in the requirements and scope of the project. Furthermore, most of the companies that collaborated with the Engineering Faculty did not establish the scope and boundaries of the projects from the beginning.

For category 2 (see Table 5), which corresponds to the design phase of the project life cycle, the results were similar to those observed in category 1: most of the project leaders characterized their work teams as having a level of maturity corresponding to level 2 (Managed) for the processes required to obtain the following products: Requirements Document, Project Schedule, Work Breakdown Structure (WBS), Procurement Plan, and Analysis and Design Document. However, project leaders also characterized their work teams as having a level of maturity corresponding to level 3 (Established) for the processes associated with the following deliverables: Prototype Design, Schematic Diagram and Parts List.

In the processes related to the Risk Management Plan and the Test Requirements Document, most of the project leaders rated themselves at Level 1 of maturity (Performed). In this respect, some project leaders said they had difficulty visualizing the risks

Table 4. Level of project management maturity in the Planning phase

Category 1.—Planning Phase				
Leader/Products	**Contract**	**Project plan, Delivery protocol**	**Communications plan**	**Test plan**
Leader 1	3	2	1	1
Leader 2	3	2	1	1
Leader 3	4	3	3	1
Leader 4	3	3	3	2
Leader 5	3	2	2	2
Leader 6	3	2	2	2
Leader 7	3	2	2	1
Leader 8	3	2	1	1
Leader 9	3	2	1	1
Leader 10	3	2	1	1

Level 1 = Performed; Level 2 = Managed; Level 3 = Established; Level 4 = Predictable.

Table 5. Level of project management maturity in the Design phase

Category 2.—Design				
Leader/Obtained Products	**Requirements Document, Project Schedule**	**Work Breakdown Structure, Procurement Plan, Analysis and Design Document**	**Risk management, Test requirements**	**Prototype Design, Schematic Diagram, Parts List**
Leader 1	2	2	1	2
Leader 2	2	2	1	3
Leader 3	3	3	3	3
Leader 4	3	3	3	3
Leader 5	3	2	1	3
Leader 6	3	2	1	3
Leader 7	2	2	1	3
Leader 8	2	2	1	2
Leader 9	2	2	1	2
Leader 10	2	2	1	2

Level 1 = Performed; Level 2 = Managed; Level 3 = Established; Level 4 = Predictable.

of innovation projects, and the same thing occurred when elaborating the Test Requirements Documents with the clients, since there was often the need to modify, readjust and change the design parameters of a prototype for various reasons, such as changes in the materials, changes in the customer requirements, etc. All this made it difficult to define the test requirements according to the needs of the customers. However, the project leaders recognized the need to define and develop these documents in order to obtain a prototype that could satisfy the customers.

In the Construction phase (category 3), regarding the processes whose products are the Verification of the Prototype according to the Customer Requirements, five project leaders rated the level of maturity of their teams at level 1 (Performed), three leaders rated their teams at level 2 (Managed) and two at level 3 (Established). Regarding the Follow-up Reports and Operation Manual, eight project leaders rated their teams at level 2 (Managed) and two leaders at level 3 (Established) (Table 6).

In Category 4, which corresponds to the Integration and Testing phase (Table 7), project leaders reported difficulties in obtaining the Test Requirements from the customer, but they still presented evidence of tests (proposed and performed by the project leaders of the FIUAQ and their work teams) performed on the subsystems that comprised the

Table 6. Level of project management maturity in the Construction Phase

Category 3.—Construction		
Leader/Obtained Products	**Verification of the Prototype according to the customer requirements**	**Follow-up Reports, Operation Manual**
Leader 1	1	2
Leader 2	1	2
Leader 3	3	3
Leader 4	3	3
Leader 5	2	2
Leader 6	2	2
Leader 7	2	2
Leader 8	1	2
Leader 9	1	2
Leader 10	1	2

Level 1 = Performed; Level 2 = Managed; Level 3 = Established; Level 4 = Predictable.

Table 7. Level of project management maturity in the Integration and Testing phase

Category 4.—Integration and Testing			
Leader/Obtained Products	**Integration and test plan**	**Integration Tests Reports, Subsystem Tests Report**	**Delivery reports, Acceptance document**
Leader 1	1	1	2
Leader 2	1	1	2
Leader 3	2	3	4
Leader 4	2	2	3
Leader 5	2	2	3
Leader 6	1	1	2
Leader 7	1	1	2
Leader 8	1	1	2
Leader 9	1	1	2
Leader 10	1	1	2

Level 1 = Performed; Level 2 = Managed; Level 3 = Established; Level 4 = Predictable.

prototype, as well as integration tests. In processes whose products are the Integration Test Plan, Subsystem Test Reports and Integration Test Reports, the project leaders rated the level of maturity of their teams at level 1 (Performed). Project leaders 4 and 5 rated their team at level 2 (Managed), and leader 3 rated their team at level 3 (Established). In processes whose products are Delivery Reports and Acceptance Document, the majority of the project leaders rated their teams at level 2 of process capability (Managed), but leaders 4 and 5 rated their work team at level 3 (Established), and leader 3 rated his team at level 4 (Predictable).

Tables 4 to 7 show that most project leaders rated their work teams with a similar level of project management maturity. This has several potential causes:

1. Project leaders 3, 4, 5, 6 y 7 from the FIUAQ had taken the preparation course for obtaining a certification in project management, which involved the use of formal contracts, rescission, commitment and delivery clauses, requirements gathering and risk management planning, among other project management techniques.
2. The calls for applications issued by CONACYT to stimulate innovation and collaboration between academia and industry specify several products as indispensable requirements. This acts as an incentive for project leaders and their work teams, who take care to perform the processes whose products are requested by CONACYT (Contract, Project Schedule, Follow-up Reports, Delivery Reports, Acceptance Document).

3.1.2 Group II: Project leaders/project managers from the companies collaborating with the FIUAQ

The second group of respondents (Group II) was composed of leaders or project managers working for the companies that collaborated with the FIUAQ in the same specific outreach projects. The first part of the survey gathered general data of each company (these data are confidential and are not presented in this work), as well as the level of satisfaction obtained from collaborating with the FIUAQ.

Regarding the level of satisfaction (Table 8), most of the leaders or project managers working for the private companies were satisfied with the collaboration experience. However, leaders 1 and 7 gave an ambiguous rating to the collaboration experience (were neither satisfied nor dissatisfied with it); we will consider it as an unsatisfactory rating because we could not clearly determine if the respondents had a successful experience or not.

Regarding the administrative management of other UAQ departments, the level of satisfaction of the company leaders was even lower. The lowest rating was given by project leader 7, who rated the procurement process of the Procurement Department and the Finance Department of UAQ as very unsatisfactory.

However, there is interest in continuing the collaboration with the Faculty of Engineering in other research and technological innovation projects. Four companies are very interested in participating in other outreach projects, one company is interested in doing so and two companies expressed a lack of willingness to collaborate in other outreach projects. The latter two cases include leader 7, who worked for a company that collaborated with the Faculty of Engineering during a period of 5 years.

For the second part of the survey applied to Group II, the respondents were asked to rate some of the products of each of the processes that made up the life cycle of a specific project. CONACYT's PEI requires companies and HEIs that collaborate together in outreach projects, to produce deliverables or basic products such as: project plan, follow-up reports, delivery reports (which must contain specific information on deviations from the general

Table 8. Satisfaction of company project leaders with the collaboration experience

Part I: Collaboration established

Leader/Obtained Products	Company leader 1	Company leader 2	Company leader 3	Company leader 4	Company leader 5	Company leader 6	Company leader 7
The management of the project leader was very satisfactory.	3	4	5	4	5	4	5
The communication established between the project leader of the HEI and the company team was very satisfactory.	3	4	4	4	5	4	5
The administrative management (other HEI departments) was very satisfactory.	2	4	3	3	2	3	1
The administrative management of the DIPFI was very satisfactory.	3	4	4	4	4	4	3
The collaboration experience fulfilled my expectations.	3	4	4	5	5	5	3
I intend to continue collaborating with the HEI.	2	4	5	5	5	5	1
I would recommend other companies to collaborate with the Faculty of Engineering.	3	4	5	5	5	5	3

1—Strongly Disagree; 2—Disagree; 3—Neither Agree nor Disagree; 4—Agree; 5—Strongly Agree.

and particular objectives, schedule changes, work teams, etc.), prototype or system proposed by the HEI, and other products such as thesis, student training, published articles, etc. However, company project leaders (depending on their own process capability) often require other products. The survey applied to Group II included the products and deliverables that are most frequently requested by project leaders (Tables 9–11).

Table 9 shows the satisfaction reported by company project leaders with respect to the products corresponding to the planning phase. The products that had a greater degree of acceptance were: Agreement or Contract, Project Charter, Project Plan,

Table 9. Satisfaction reported for the products corresponding to the Planning phase

Part II: Category 1 Planning

Leader/Obtained Products	Company leader 1	Company leader 2	Company leader 3	Company leader 4	Company leader 5	Company leader 6	Company leader 7
The formal agreement or contract signed with the FI, specified terms of reference, penalties, etc. (Agreement or Contract).	5	4	5	5	5	5	5
Received or had access to a description of the project, which included start date, end date, purpose, objectives, scope, products, restrictions. (Project charter).	4	4	5	5	5	5	5
Received or had access to a schedule that specified the following: delivery protocol, activity cycles, estimated time for each activity, work team, estimated cost, schedule (Project Plan).	4	4	4	4	5	4	4
There was evidence that the project leader from the FI prepared a procurement plan that specified the required resources, including technological resources (Procurement Plan).	3	3	4	4	5	4	3
There was evidence that the project leader from the FI prepared and applied a risk management plan (Risk Management Plan).	3	3	4	4	4	4	3
Received or had access to a log of the progress made, efforts made, implemented changes classified by type, real time invested, duplicate work (Follow-up reports).	3	4	5	4	5	4	4

1—Strongly Disagree; 2—Disagree; 3—Neither Agree nor Disagree; 4—Agree; 5—Strongly Agree.

Table 10. Satisfaction reported for the products corresponding to the Design phase

Part II. Category 2 Design

Leader/Obtained Products	Company leader 1	Company leader 2	Company leader 3	Company leader 4	Company leader 5	Company leader 6	Company leader 7
Received or had access to a document specifying the requirements and scope of the project, functional requirements, HW/SW interfaces, design constraints, standards, etc. (Requirements document).	4	4	5	5	5	3	4
Received or had access to a document describing the structures and components of the prototype, system, subsystems, interaction relations (Analysis and Design Document).	4	4	5	5	5	5	4
Received or had access to a document specifying the required assembly tests, functionality tests, initialization tests, system or prototype test points (Test Requirement Document).	3	5	5	4	4	3	4

1—Strongly Disagree; 2—Disagree; 3—Neither Agree nor Disagree; 4—Agree; 5—Strongly Agree.

Follow-up Reports. The products with a medium degree of acceptance or that did not meet the expectations of the company project leaders were: Procurement Plan and Risk Management Plan.

This may be due to the fact that the project leaders from both the FIUAQ and the companies focused more on the products requested by CONACYT in order to avoid penalties to the company or the HEI. This dynamic repeated itself in the case of the products corresponding to the remaining phases of the project.

Table 10 shows the products corresponding to the processes of the design phase. These products are not specifically required by CONACYT, but no project could be managed without them; however, it is worth noting that not all of these products were requested by the company project leaders. The Tests Requirement Document was the product with which company project leaders were least satisfied.

Tables 11 and 12 show the products corresponding to the processes of the construction and integration phases and tests. It can be observed that the company project leaders were satisfied with the following products: Prototype or System, Operation Manual and Delivery and Acceptance Document. However, it is important to note that company leader 1 stated that he was not very satisfied with the Test Requirement Document, the Test Report and the Prototype or System received. Leader 6 stated that he was not satisfied with the Test Requirement Document but that he was satisfied with the prototype or system received.

Most company project leaders were satisfied with the collaboration experience. Even though, for some processes, FIUAQ leaders reported a level of maturity of 2 (Managed), the company leaders reported acceptable levels of satisfaction with those processes and the products derived from them. It is worth noting that the processes and products with which company leaders were least satisfied were those for which the FIUAQ project leaders rated their teams as having a low process capability.

Table 11. Satisfaction reported for the products corresponding to the Construction phase

Part II: Category 3 Construction

Leader/Obtained Products	Company leader 1	Company leader 2	Company leader 3	Company leader 4	Company leader 5	Company leader 6	Company leader 7
Received a prototype or system that complies with: Requirements Document, Analysis and Design Document, Test Requirement Document.	3	4	5	5	5	4	4
Received a document containing the information required for the installation, administration and operation of the prototype or system, HW/SW requirements. (Operation manual)	4	4	5	4	4	4	4

1—Strongly Disagree; 2—Disagree; 3—Neither Agree nor Disagree; 4—Agree; 5—Strongly Agree.

Table 12. Satisfaction reported for the products of the Integration and Testing phase

Part II. Category 4 Integration and Testing							
Leader/Obtained Products	**Company leader 1**	**Company leader 2**	**Company leader 3**	**Company leader 4**	**Company leader 5**	**Company leader 6**	**Company leader 7**
Received a test document that explained in detail the results of the tests performed (Test report).	3	4	5	4	4	4	4
The prototype or system was delivered according to the delivery protocol specified in the agreement. Delivery and acceptance document.	5	5	5	5	5	5	4

1—Strongly Disagree; 2—Disagree; 3—Neither Agree nor Disagree; 4—Agree; 5—Strongly Agree.

Company project leader 1 (Tables 9–12) stated that he had no interest in further collaborating with the HEI in other outreach projects. The company to which the interviewee belongs has not internal administrative processes fully defined, which gave rise to some problems related to the internal management of its economic resources. This, together with the fact that the project had an innovation component that involved constant changes in the prototype requirements, made it difficult to build the prototype and to check if it met all previously defined requirements. This lowered the perception of success about the project.

It is also important to note that academic project leaders and their work teams use institutional formats to document and record the start of a project through UAQ's Research and Postgraduate Department, which is responsible for documenting the start, advances and delivery of projects for CONACYT. However, each project leader applies his/her own criteria and experience to perform project management tasks (i.e., they make their own adaptations to the PMBOK).

4. Conclusions

Using an exploratory study as a research method allowed us to determine the level of maturity in project management that the project leaders of the FIUAQ assign to their work teams and themselves. It is worth remembering that the Autonomous University of Querétaro is the HEI with the largest number of collaborative projects between academia and industry in the state of Queretaro. This method also allowed us to determine the level of satisfaction of the leaders or project managers of the companies that collaborated with the FIUAQ in research and innovation projects sponsored by the PEI of CONACYT.

The greater the preparation in project management of the project leaders of the FIUAQ, the greater the level of maturity in project management that they perceive they and their work teams have. This perception coincides with the level of satisfaction expressed by the project leaders of the companies with which the collaborative association was established. This indicates a relationship between the level of maturity in project management perceived by the project leaders of the FIUAQ and the level of satisfaction (perception of project success) reported by the project leaders of the associated companies.

Some project leaders of the FIUAQ rated their work teams with a level of maturity 3 (Established), and up to 4 (Predictable), for some of the processes performed by them. This result is debatable since these levels of maturity require that project management techniques are part of an organizational standard and are integrated with other organizational processes, which is not the case of the UAQ. The latter is evident in the level of dissatisfaction that the company leaders reported regarding the administrative processes performed by the purchasing, finance and comptroller departments of the UAQ.

Project management represents a problematic effort in the development of technological or scientific innovation projects, due to the high degree of uncertainty that usually exists in this type of projects. Indeed, as stated by some of the project leaders interviewed here, it is often difficult to define and establish the requirements of the expected products or deliverables and to define a risk management or project test plan. In addition, the requirements often change due to the constant changes and adaptations made to the project objectives.

The work teams and project leaders of the FIUAQ work independently, which is why there is no possibility of developing programs that group related projects and that allow a coordinated management of those projects. The absence of coordinated project management prevents the FIUAQ from:

- adopting project management practices at the organizational level;

- identifying common and repeatable processes for the development of deliverables, tools, etc.;
- documenting and standardizing its own tools and techniques so that they can be used by the rest of the organization;
- identifying and eliminating common causes of problems in projects;
- increasing the level of maturity in project management of the FIUAQ.

We conclude that: the FIUAQ has been successful in establishing collaborative associations between the university and industry through joint research and innovation projects. Most FIUAQ project leaders and their work teams use project management tools and techniques to a greater or lesser extent and are trying to establish the foundations that will allow them to standardize project management processes. Until now, this has been enough to participate in outreach projects financed by CONACYT. The companies that participated in these collaborative projects were mostly satisfied with them and are willing to collaborate further in this type of projects.

Given the economic reality of Mexico and other countries, FIUAQ's future work should focus on establishing the conditions that allow it: to propose its own approach to project and program management, especially regarding the management of outreach research and innovation projects, in order to increase the level of maturity of the FIUAQ (of both academics and students), its competitiveness and its ability to attract collaboration partners not only through CONACYT's PEI but also through direct links with the industry. This will allow the University to consolidate a Project-Based Learning model (PBL) that teaches students the necessary skills and competencies in project management, and allows them to apply and increase their technical knowledge, as well as to acquire experience working with multidisciplinary teams.

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