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Methodological proposal for the management of academic projects requirements in research calls

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***Abstract*– In this research work, a methodology for a requirement organizing system based on requirements engineering techniques and project management standards is proposed, which allows monitoring and supporting the planning and management of the requirements of projects participating in different academic calls for proposals issued by sponsoring organization for academic projects. As a case study, the research calls of the PRODEP program for the Teacher Professional Development of the SEP (Secretaría de Educación Pública), of México was selected. This system will allow to understand and satisfy customer needs, the designers, to monitor and control their projects, from the beginning to the end. The methodology of a requirements organization system allows the assimilation of good practices in the areas of requirements engineering, information quality, among others.**

***Keywords*– Project methodologies, Requirements organizer, Requirements engineering, Project management.**

I. Introduction

Projects have existed throughout history; however, project management started only a few decades ago, when companies and other organizations began to see the need to organize work in the form of projects and the advantages to be gained from doing it this way. The synchronized work of various disciplines required the construction of more complex systems, leading to the creation of new organizational methods.

This project-centered organizational landscape evolved further as organizations began to understand the fundamental need for their employees to communicate and collaborate with each other while integrating their work across departments, professions and, in some cases, entire industries [1].

On several occasions, once a project has been completed and when it is believed that everything that needs to be done has been done, according to experience and the requirements of the client who requested it, users are often confronted with the fact that the result achieved is not what they expected. History shows a variety of failed projects for multiple reasons: unclear objectives, missed deadlines and budgets, functionalities that do not meet the needs of users and ineffective communication, with the consequent impact on organizations and businesses. [29].

A. Background

Other main problems in the development of a project are insufficient requirements management, problems affecting communication, undetected inconsistencies between requirements, design and programming, late validations of requirements, facing risks and uncontrolled change propagation. As a result of these problems, requirements are not met, delivery times are exceeded or costs are repeatedly increased. However, the main problem or error is the lack of agreement and formalization of the customer's request, which refers to the detection, definition and formalization of the so-called user requirements [7], [17], [29], [35].

Among the various measures implemented to improve quality in higher education, the programs for institutional strengthening, professionalization of academic staff, training and strengthening of academic bodies and the integration of research networks stand out. [8]. An example of these program is PRODEP, which is the Program for the Professional Development of Teachers (PRODEP, formerly PROMEP), and is an initiative of the Ministry of Public Education, whose purpose is to help teaching staff, technical teaching staff and staff with management, supervision, technical-pedagogical consultancy and academic bodies to access and/or complete training programs, academic updating, training and/or research projects that enable them to strengthen their profile for the performance of their duties. The program's support is activated on the basis of specific calls for applications. Currently, the program's coverage extends to 730 public higher education institutions (HEIs) in the country [27], [28].

Some shortcomings that can be found in the PRODEP program for secondary and higher education are given in [27], [28].

Design. Weak theoretical and empirical justification of the intervention. The diagnosis is based on non-recent research and similar experiences, which, however, are not critical.

Operation. It is detected that not all the URS (Especificación de Requisitos de Usuario) of the program are updated and do not publish in their electronic portals the main results of the program; as well as other deficiencies in the set of indicators to monitor the operation of each of the URS.

Population Served. The program consists of systematizing the information compiled through available surveys and making it public knowledge, which does not consolidate the operational processes of the program.

Measurement and results. The program has a Logical Framework Matrix (LFM) that contains the designation of indicators for all levels, but there are no technical sheets for all the indicators of "components" and "activities".

For this reason, several countries have developed programs and incentives for the professional development of teachers and professors. Like the PRODEP Program, implemented by SEP in Mexico, there are certain financial support programs for academics in some countries.

On the other hand, referring to projects, they can produce products, components or a final component, perform services, or documents. There is a great variety and diversity of projects. Figure 1 shows the generic phases of the project development life cycle. In project management,

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there are two important management models that are being implemented:

B. Predictive or Classical Project Management

Predictive or classical project management is a formal management discipline, based on planning, execution and monitoring through systematic and repeatable processes [1], [12], [14], [23], [24].

C. Agile or Adaptive Project Management

Agile project management is not a management of anticipation (requirements, design, planning and monitoring) but of adaptation (vision, exploration and adaptation), [13], [18].

D. Requirements

A requirement is a description of a condition or capability that a project or system must meet, either coming from an identified user/customer need, or stipulated in a contract, standard, or other document formally imposed at the beginning of the process. When developing a project, one of the first phases is the definition of the project requirements. Requirements Engineering (RE) facilitates the understanding of what the customer wants by analyzing the needs, confirming their feasibility, negotiating a reasonable solution without ambiguity, validating the specification and managing the requirements so that they are transformed into an operational system. Identifying competencies for general project requirements covers [3], [7], [17]:

- Identify the Requirement of the project in question;
- Analyze and negotiate the project Requirements with the users;
- Specify the Requirements identified;
- Specify and model the System Requirements of the project to be represented;
- Validate the aforementioned Requirements;
- Manage the visualized Requirements.

E. Scrum

A Scrum project involves collaborative work to produce a new product, service or other result. Projects are handicapped by constraints of time, cost, scope, quality, resources, organizational capabilities, among others, that make it difficult for them to plan, execute, manage and ultimately succeed. An important strength of Scrum lies in the use of cross-functional, self-organized and empowered teams that divide their work into short, concentrated work cycles called Sprints [11], [13], [18], [21], [26].

F. Canvas Model

The Canvas model is a very useful tool for project management during the project initiation and definition stage. This model seeks to manage projects as business units and emphasizes the entrepreneurial potential in project management. The Canvas model is simplified into four broad areas: customers, supply, infrastructure and economic viability in a box divided into nine modules; some companies that use this model are: IBM, Ericsson, [8], [9].

G. Project management under international standards

The way of organizing the efforts and experience of project management has been carried out through the power of the project manager. These reasons have meant that today there are several institutions dedicated to the study of projects such as: IPMA (International Project Management Association), PMI (Project Management Institute), ISO (International Organization for Standardization), OGC. (Office of Government Commerce). [15], [16], [20].

II. STATE OF THE ART OF REQUIREMENTS MANAGEMENT SYSTEMS

In general, all Requirements Management tools are based on centralized database management systems to store the information corresponding to the requirements, which usually consist of free text paragraphs with a series of predefined attributes and to which most tools allow new types of attributes to be associated by the user. All tools assume that the structure of the requirements is hierarchical, so that a requirement can be formed by or have other lower-level requirements associated with it [13].

Within CASE (Computer Aided Software Engineering) tools are those specialized in requirements management. These tools focus on capturing requirements, managing them and producing a requirements specification, but almost all of them are focused exclusively on software development projects [14], [17].

As an example of those mentioned, four of the tools that fulfil most of the functions are selected: IBM Rational RequisitePro, IRqA 3.0, CaliberRM, DOORS ERS, although these tools are oriented only to software projects.

The requirements management tool ORMEX provides tracking and control of requirements for various types of projects, such as those already mentioned and is among the first of its kind in Mexico and abroad [29], [30], [31], [32], [33], [34], [35], [36].

For now, we have not found any tool for the organization of requirements that is exclusively dedicated to the management and evaluation of requirements for academic projects, nor in PRODEP programs and calls [28]; but we have found some tools for the management of requirements with an academic focus: Proyecto Educación en línea [4]; Manual para el diseño de proyectos de gestión educacional [6]; Proyectos Educativos y sociales [5].

Planning, Management, Monitoring and Evaluation [5]; Educational Management Projects [3]; Design of a management system based on the Balanced Scorecard methodology for the Faculty of Chemical Engineering of the University of Guayaquil [19]; Design of educational projects mediated by ICT [22]; The Logical Framework as an instrument for planning, monitoring and evaluation of educational projects, among others [2], [8].

In this proposal, a different treatment is given to the projects, in order to manage them, following up on the requirements and evaluating their quality in use, once they are completed. A methodology of a project organizer system based on Requirements Engineering techniques and Project Management standards is proposed, which allows to be a support guide for the administration and structuring of projects, especially academic projects, participants in the program for the Professional Development of Teachers (PRODEP) [28]. This methodology will allow the advanced description of different kinds of requirements and their traceability between all documents related to Software Requirements Engineering (RI); it has as a case study, the projects participating in programs and calls of the PRODEP for the Higher Level, of the SEP in Mexico. Most of the tools are aimed at software development projects; very few, such as those mentioned above, are aimed at other types of projects. The proposal for a Methodology of a Requirements Organizing System for the Management of Academic Projects in PRODEP Programs, which is proposed for this research, has a different focus, as it seeks the management and monitoring of academic projects for their approval in PRODEP programs and calls for proposals [28].

III. Methodology to be developed

This research is based on a mixed type of study and applies ad-hoc information gathering instruments, documentation and registration that allow the analysis and confirmation of the hypothesis, since the characteristics of the requirements engineering techniques are identified and evaluated, as well as the standards of project management mentioned above, which serve as a basis for developing and implementing a requirement organizer, in which the established assumption can be tested.

The variables identified and which will be used in this research are the following (independent variable: vi = identifier of each project; dependent variable: vd = are the other variables that will make up the various partial ratings of each item or factor of the project subject to evaluation, so that processed as a whole, they provide the final rating of the project in question).

An ad-hoc instrument was constructed, with which data was obtained for this doctoral research work. For the validation of this instrument, it was applied to a specific interest group of 15 experts, who are full-time ITCM (Instituto Tecnológico de Ciudad Madero) professors who have participated in PRODEP programs and calls for proposals. The invitation and background consultation was done by means of a Google Drive questionnaire sent to their emails.

According to the number of respondents obtained, by stratified sampling; a survey was conducted to 168 ITCM academics, through the application of Google forms. The survey consisted of 20 questions, but it should be noted that in this section we will only analyze the key questions of the survey, because they are related to the study variables, where the following results are obtained.

With the analysis of the 168 surveys carried out by ITCM academics, it is determined that 48% (80) of the respondents confirm that they have participated in PRODEP calls and programs, while 53% (88) of the respondents have not participated in such calls.

As a result of the analysis of the various questions in the different surveys, it can be concluded that, of the 80 academics interviewed, who have participated in PRODEP calls and programs, the following can be determined: 81% of the respondents confirm that they agree that they would be willing to try a requirements organizer tool to support the development and monitoring of their projects in this type of calls; 10% of the respondents state that they totally agree with this question; while 9% state that they neither disagree nor disagree with the question.

For the selection of the standards and methodologies mentioned above, a study of different research works on project management was carried out, among the research works can be found from the following authors [9], [10], [11], [13], [18], [19], [20], [21], [25], [36].

This research provided the basis for defining the following criteria for the evaluation of methodologies:

A. *Standard Criteria:*

Certifications.

- Maturity of the model.
- Number of versions.
- Year of last version. -Working Team.
- Learning Curve.
- Relevance and appropriateness.
- Concern for project stakeholders.
- Change Management.
- Risk Management.
- Alignment to Business Strategy.
- Customer Satisfaction

Knowledge Criteria:
Certifications.

- Knowledge
- / Competence Project Leader.
- - Knowledge
- / Competence Team.
- -Specialized Consultants.
- -Training.
- Information available.
- Tools and techniques.
- Software tools.

B. *Criterion Organization:*

Resistance to change - Customer involvement According to this evaluation, it can be concluded that the best standards and methodologies for the development of the research are: the SCRUM methodology and the PMBOK standard (ISO 21500) [15]. Both methodologies are not mutually exclusive, they can be combined to form a more robust hybrid methodology.

The selection of these standards and methodologies is due to the fact that they are the most widely used approaches in project management and many of the new methodologies are derived from them due to their main characteristics, tools, projections, etc.

The objective of this stage is to determine which processes, practices and tools from the PMBOK and ISO 21500 will fit into the SCRUM framework. [23], [24], [25], [26].

In order to select the processes that will generate value within the framework of the new methodology, an evaluation of the phases and processes of the PMBOK, ISO 21500, Requirements Engineering and SCRUM methodologies was proposed. As a conclusion of this review and analysis, Table 5 shows how the framework was integrated by groups of processes or phases for the new academic project management methodology.

C. *Life Cycle of an Academic Project*

The life cycle proposed for the development of an academic project is divided into five phases. In the proposed model, it will have the phases of Initiation, Planning, Execution, Monitoring and Control and Closure, as structured in the standards of project management, being a management process with sequential characteristics, but at the same time iterative during the development of projects.

The proposed methodology aims to provide a group of procedures organized by phases, which are implemented in the projects, allowing to simplify its management and generate added value to users and / or customers in less time as its development is simpler. Therefore, a better alignment will be obtained with the agile development teams according to the needs of users and sponsors and therefore to the organizational strategy of the companies. In this research, a diagram with the interaction of processes of an academic project is presented.

The proposed methodology aims to provide a set of procedures organized by phases, which are implemented in projects, thus simplifying their management and generating added value for users and/or clients in a shorter period of time, as their development is simpler. Additionally, it seeks to reduce or avoid the informality of agile methodologies by complementing them with project management standards.

Therefore, a better alignment with agile development teams will be obtained according to the needs of users and sponsors and therefore to the organizational strategy of the companies. In this research, a process interaction diagram of an academic project is presented. A proposed methodology

is presented, where the methodology is based on a five-phase life cycle where 36 fundamental processes are distributed (Table 1).

D. *Validation of the Methodology*

The process and results of the validation of the Methodology of a Requirements Organizing System for the Management of Academic Projects in PRODEP programs by the expert judgement validation method are described.

The expert judgement validation method consists of verifying the reliability of a research that is established as "an informed opinion of people with experience in the subject, who are recognized by others as qualified experts in the subject, and who can provide information, evidence, judgements and evaluations" [8].

The validation process of the ad hoc instrument to evaluate the proposed methodology was carried out with a group of twenty (20) experts who are full time professors at the ITCM, who have previous experience on the subject, having participated in PRODEP programs and calls for proposals.

The next stage of the process consists of a questionnaire of 24 closed questions, following a Likert scale (with options from 1 to 5), which you select according to your degree of agreement with the questions, where: 1 = Strongly disagree; 2 = Disagree; 3 = Neither agree nor disagree; 4= Agree; 5 = Strongly agree).

TABLE 1.
PROPOSED MODEL OF ACADEMIC PROJECT MANAGEMENT

Phase	Processes
Project conception	1. Develop the project charter 2. Identify stakeholders 3. Establish the project team*
Project planning	4. Create user stories*. 5. Define the scope 6. Create the work breakdown structure 7. Define activities and tasks*. 8. Establish the sequence and duration of activities and tasks. 9. Create the time block* 7. 10. Develop the timeline 11. Estimate resources 12. Estimate costs 13. Determine budgets 14. Quality planning 15. Communications planning 16. Procurement planning 17. Identify and assess risks
Project implementation	18. Daily Stand up 19. Refine the product backlog*. 20. Lead and manage project work 21. Develop the team 22. Manage quality 23. Procurement management
Monitoring and control	24. Control and monitoring of project work. 25. Change control 26. Scope control 27. Schedule control 28. Communication control 29. Quality control 30. Cost control 31. Resource control 32. Monitoring and risk management 33. Procurement control 34. Demonstrating and validating the time block* 17.
Project closure	35. Close the project or phase 36. Lessons learned *

Source: Own Elaboration with information from PMBOK (2017), SBOK (2017), ISO 21500 (21500)

For the construction of the methodology evaluation questionnaire, the fundamental bases of the proposed methodology were examined, and a question was elaborated for each of them.

The main aspects, which were retained in the evaluation of the methodology, were the following:

- Relevance of the methodology: this is related to the design of the methodology, i.e. the design of the methodology responds to the needs of the users.
- Effectiveness of the methodology: this refers to the extent to which the methodology obtains the expected result and therefore achieves the specific objective.
- Efficiency of the methodology: refers to the analysis in which the planned activities and tasks are managed and carried out optimizing the means, resources and time available to produce the expected results.
- Impact of the methodology: it is related to the effects that may be produced on the project or on the beneficiary participants of the project, as well as the indirect effects that may be produced in a specific sector or geographical area.
- Sustainability of the methodology: this refers to the extent to which the impacts of the methodology intervention are likely to continue after the end of the project.

E. *Interpretation of Data from the Evaluation of the Requirements Organize Methodology*

For the evaluation of the proposed requirements organizer methodology, twenty experts, who are full-time professors at the ITCM, and have previous experience in having participated in PRODEP programs and calls, were sent [27], [28].

The instrument consists of three stages, which are as follows:

- In the first stage, general information about the Expert such as background and professional experience is questioned.
- In the second stage, the level of expertise on the topic is asked to be evaluated.
- In the third stage, the evaluation of a form with 24 closed questions, following the Likert scale, is carried out in order to evaluate the methodology proposed in the doctoral research work.

IV. RESULTS

The evaluation criteria with the most discrepant answers are those corresponding to the impact criteria with the questions: Does the proposed methodology support the evaluation of the effects and follow-up of the project, together with the beneficiaries, does the proposed methodology propose socio-economic valuation models for the projects, and the sustainability criteria with the question: Does the proposed methodology have evaluations of the capacity to maintain the positive impacts of the project over a long period of time? Considering that these criteria can be perceptible issues in project management and PRODEP programs and calls, it was decided to dispel doubts by giving more detail and a better approach to the proposed methodology (functioning, mechanisms) to the experts, in view of the second round. For the second round, once the doubts had been clarified and greater detail and function of the methodology had been provided, more positive results

were generated than in the previous round. In this evaluation questionnaire, four experts used the space for notes and comments to clarify and complement their views.

Through the use of the evaluation instrument and the results obtained from it, the validation of the criteria of the designed methodology is achieved, which allow to follow up and support the planning and management of the requirements of the projects participating in the program for the Professional Development of Teachers (PRODEP), in order to understand and satisfy the needs of the clients (PRODEP).

Figure 1 shows the interaction of the academic project management process, from the application of this proposed methodology. This figure shows the interaction of the participating projects with the guidelines of the calls for proposals in which they participate, as well as the clients and suppliers (organizations) that determine the requirements to be met.

A. *Adjustment Mechanisms*

Once the methodology of a project requirements organizer has been validated by the group of experts and after examining the results obtained in the two rounds of evaluation where the validation instrument was applied based on the main criteria of the proposed methodology, the following adjustment mechanisms are proposed to be applied when starting the implementation process:

- The proposed methodology can be implemented as a technological application, which can be very user-friendly, concrete and fast, distributed in small sections, between which it is easy to move, so that it can really be used as a support tool to carry out monitoring, efficient resource management and finally the achievement of the objectives of each project.
- The requirements organizer should allow direct communication between PRODEP and the user.
- That the requirements organizer can allow the user access to its evaluation in PRODEP calls for proposals.

V. CONCLUSIONS

The present research work starts with the problem that project managers face when developing a project, which is the lack of information provided by the project participants, and the fact that they do not obtain an exact definition between what they want and what they need to do, resulting in a misinterpretation of the requirements. This results in a misinterpretation of the requirements and a failure to follow up the project objectives in detail.

The methodology of a project requirements organizing system, as a model of innovation, arises from the combination of several methodologies such as: PMBOK, ISO 21500, SCRUM and the chosen Methodologies stand out for having great worldwide coverage and diffusion, they are also distinguished for being the most used approaches given their main characteristics, tools, projections, bodies of knowledge, instruments.

The proposal of a methodology for a requirement organizing system is presented, which is the result of the combination of project management methodologies that stand out for their worldwide coverage, and its phases and processes are detailed. It was also demonstrated how this methodology favors project management as it allows to follow up and support the planning and administration of the requirements of a participating project, in this case of study, for the Program for the Professional Development of Teachers (PRODEP) in order to understand and satisfy the needs of the users.

In accordance with the research work carried out and for the fulfilment of the objectives, a mixed approach was selected, as this is an exploratory study that seeks to address the phenomenon of project management in PRODEP programs and calls for proposals for the creation of a methodology for a requirement organizing system that supports participants in the creation, organization and monitoring of the project, from their role as project administrators.

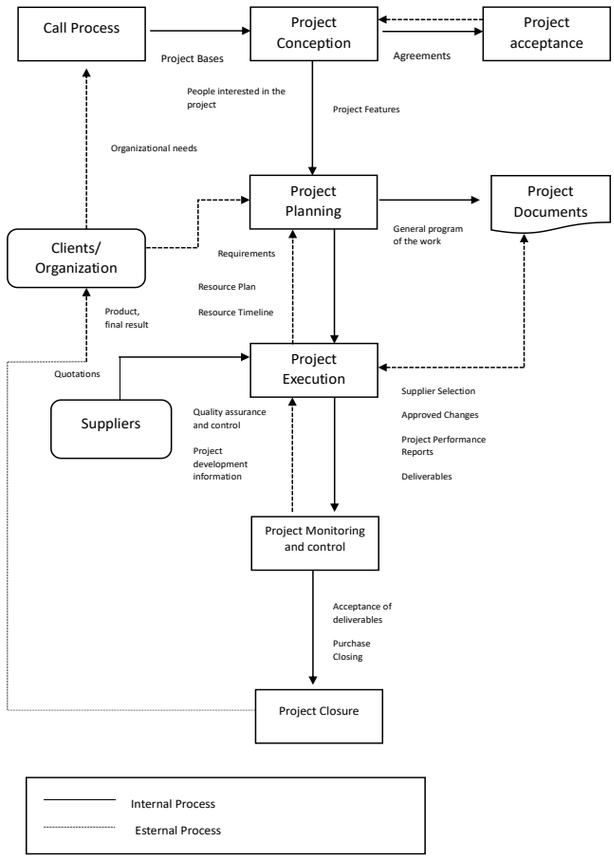

Fig. 1 Interaction of the academic project management process
Source: Own Elaboration

The various variables present in the case study were determined, which make up the PRODEP calls for proposals, which can be configured according to the academic levels, categories and priorities of the calls; as well as Standardized Indicators and Metrics, for the construction of the evaluation model. This objective is fulfilled with the proposal and development of the evaluation model of a requirement organizer methodology based on requirements engineering techniques and project management standards.

This proposed methodology will serve as a guide for the structuring of a project in a clear and effective way, which allows the detection of errors found, related to the requirements, increasing the satisfaction of the client and the leader in charge of the project, fulfilling the requirements that were agreed, respecting the standards and regulations to deliver the projects on time and budget, taking control of their specifications. The methodology of the requirements organizer system was validated by a group of experts through an ad hoc instrument, in which the different aspects that are part of the designed methodology were analyzed and evaluated.

The fulfilment of the general objective defined for this research is corroborated: to design a methodology for organizing academic project requirements, with its own

methodology based on requirements engineering and project management techniques and standards. In Results, it is explained how the proposed methodologies complement each other to constitute a methodology for a requirement organizing system: the points in common between both are detailed, as well as the contribution areas that make up the proposed methodology.

It also refers to the documentation and records for the development of the methodology, as well as the breakdown of phases, activities and process of the proposed model (Fig. 2).

The methodology presented in this article is focused on supporting academic projects participating in PRODEP calls for proposals and programs; however, it is projected that this model, based on its criteria, can be adopted to other similar types of educational calls for proposals; as well as the methodological part of this requirements organizer is designed to monitor and control the requirements of the academic projects, so it is intended that, for future work, this methodology can be transposed to any type of project to make it more complete.

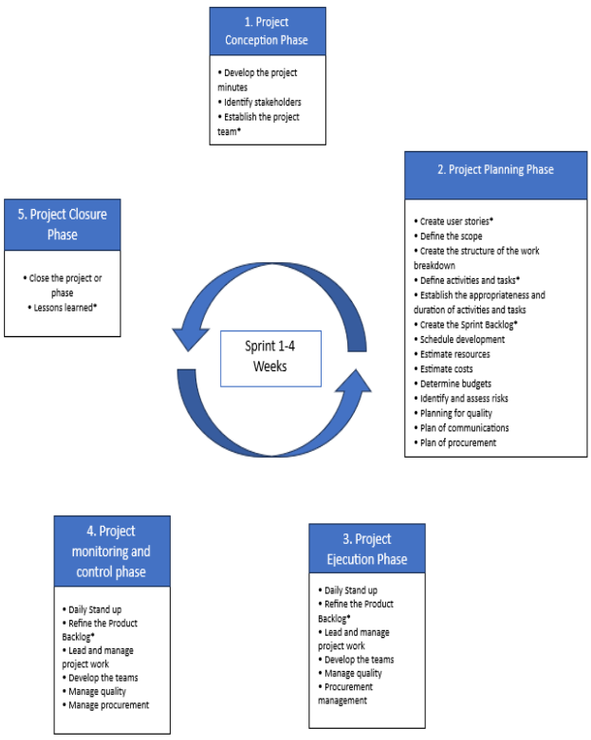

Fig.2 Model of the proposed methodology for academic projects
Source: Own Elaboration

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