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EFFORT IN PROJECT MANAGEMENT APPLIED TO ARTIFICIAL INTELLIGENCE PROJECT

ESFUERZO EN LA GESTIÓN DE PROYECTOS APLICADA A PROYECTOS DE INTELIGENCIA ARTIFICIAL

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ABSTRACT

In the last five years, advancements in computing power have brought about a surge in artificial intelligence (AI). Directly or indirectly, a significant number of systems have started incorporating AI algorithms or implementations into their functionality to perform various tasks. These implementations range from machine learning models to natural language processing and image processing, among many others. The development of a computer program requires technical skills, and it also necessitates the application of a project management model capable of incorporating and adapting to the new technologies integrated into the development process. This study examines whether the inclusion of a new AI technology as a functional requirement in the development of a product impacts the project management effort by measuring the hours devoted to this task. The research aims to answer the following research question: i) ¿Is there any difference in the effort and hours dedicated to project management in software development projects that include some form of artificial intelligence technology as part of their functionality? To address this question, a non-experimental quantitative documentary research approach is employed, using descriptive statistics as a quantification tool. The study encompasses the entire analyzed population, and the results highlight that the effort in management tasks does not show significant differences.

Palabras clave:
gestión de proyectos, esfuerzo de gestión, inteligencia artificial, desarrollo de software, tecnología.

RESUMEN

En los últimos cinco años, el avance en el poder de cómputo trajo consigo un auge en la inteligencia artificial (IA). De forma directa o indirecta, una gran cantidad de sistemas comenzaron a incluir dentro de su funcionalidad, algoritmos o implementaciones de IA para realizar diversas tareas. Estas implementaciones van desde

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modelos de machine learning, procesamiento de lenguaje natural o de imágenes entre muchos otros. La construcción de un programa informático requiere de habilidades técnicas, así como también, es necesaria la aplicación de un modelo de gestión de proyectos que sea capaz de incorporar y adaptarse a las nuevas tecnologías que se incorporan dentro del proceso de desarrollo. En este trabajo, se analiza si la incorporación de una nueva tecnología de IA como requerimiento funcional de desarrollo de un producto, impacta en el esfuerzo de gestión de proyecto mediante la medición de las horas invertidas a dicha tarea. En esta investigación se responde la siguiente pregunta de investigación: i) ¿Existe alguna diferencia en el esfuerzo y dedicación de horas de gestión en los proyectos de desarrollo de software que incluyen como parte de su funcionalidad alguna tecnología de inteligencia artificial? Para ello, se efectúa una investigación documental con enfoque cuantitativo no experimental haciendo uso de la estadística descriptiva como herramienta de cuantificación. El estudio incluye el 100% de la población analizada y dentro de los resultados se destaca que el esfuerzo en tareas de gestión no presenta mayores diferencias.

Introduction

Throughout this research, we will analyze the degree projects (or Degree Thesis) for the university careers of Engineering and Bachelor in Computer Science of the Faculty of Engineering of Universidad de la Empresa (UDE), focusing the study on the effort dedicated by students in project management activities, measured in hours.

According to the Project Management Institute (PMI) a project is "A temporary effort undertaken to create a unique product, service or result. The temporal nature of projects indicates a beginning and an end to the project work or a phase of the project work. Projects can be stand-alone or part of a program or portfolio." (Project Management Institute, 2021, p.31).

The university degree theses analyzed in this research work strictly comply with the definition presented above, since there is a defined time frame whose start and end dates are established in the preliminary project that formally initiates the project and the product to be built is unique.

The students who carry out these university theses (from now on degree projects) must select and apply some project management methodology in a mandatory way, being this obligation a fundamental part of the project and a necessary condition to obtain the final approval. In this scenario, the student(s) officiating as project manager(s) must apply all possible and available tools in order to perform an efficient and correct project management during the entire project life time leading to the successful completion of the project.

From a theoretical point of view, project management is a discipline that integrates a great variety of concepts, which when applied in a coordinated manner and with a common objective, allows leading or managing a project to achieve the defined objectives. Students doing the degree project have received a wide variety of training courses and a wide variety of management tools and techniques throughout their college career. All this acquired knowledge must be applied throughout the project in order to maximize the probability of success and successfully conclude the project.

One of the major decisions that students must make is the choice of the management methodology to be applied throughout the project. Throughout their careers they have been confronted with different management methodologies and many of them have been analyzed in greater depth due to their inclusion in the study plan. However, they have the knowledge to learn and apply any existing methodology.

Among the management methodologies are those referred to as traditional methodologies, where we can highlight the project management methodology promoted by the Project Management Institute (PMI), the ISO 21502 for project management and direction promoted by the International Organization for Standardization (ISO) and the competency-based methodology proposed by the International Project Management Association (IPMA) called ICB Competence Baseline, among many others.

The body of knowledge of the PMBOK in its 7th edition, leaves aside the concept of knowledge areas and replaces them with performance domains. The performance domains consist of the set of activities fundamental to the achievement of the planned objectives; the domains as a whole represent the interactive, interrelated and interdependent capabilities to achieve the expected results. In addition, the seventh edition of the PMBOK shifts the focus from a process-based methodology to a principles-based methodology. The new approach defines 12 management principles that focus on and aim to guide the style of work and management of a project (Project Management Institute, 2021).

The ISO 21502 standard for project management specifies high-level guidelines that emerge from the good practices applied and results obtained in different projects. The proposed guidelines are composed of a set of processes and methods that must be executed in a coordinated manner and as part of a complete system, considering the project's own characteristics. According to the ISO organization, this standard can be applied to any public or private organization of any size (Organización Internacional de Normalización, 2022).

The competency-based project management (ICB Competence Baseline) proposed by IPMA proposes that project management should be performed by individuals with three specific competencies, each of which focuses on a specific dimension. The competencies proposed by IPMA are: Perspective, focused on evaluating the context where the project is carried out to determine the execution strategy, governance, processes, culture, management of powers and interests, among others; People, focused on the human part of the team to manage internal conflicts, promote teamwork and communication, self-criticism and reflection, leadership, negotiation, among others; and Practice, where all activities related to time management, activities, finances, quality, risks and opportunities, among others, are highlighted (International Project Management Association, 2018).

On the other hand, there is a set of methodologies called "agile methodologies" whose objective is to focus on the product over the process. There is a misconception that these methodologies avoid "heavy" processes such as documentation in favor of product-focused tasks. It is important to note that in these methodologies the effort of management tasks is reduced and resources are focused on the production of the product. Management activities or activities transversal to the product are minimized to what is necessary to support the product. Within these methodologies we can highlight SCRUM, Kanban Scrumban.

The SCRUM methodology was created by Ken Schwaber in 1995, whose main objective is the software development process in an agile and continuous way. It prioritizes short iterations, where each iteration concludes with a piece of functional software, which is quickly validated by the customer represented in the figure of the Product Owner. Short cycles favor the incorporation of changes that can be included in the development process quickly, minimizing the impact on the process. The methodology is described in the SKBOK (Satpathy, 2022).

The Kanban method was created in 2007 and its mission is to improve, manage and define services that deliver intangible work, such as software development. To achieve this, it uses a dashboard to visualize the intangible work where the right amount of work required and the delivery capacity is presented, thus limiting the amount of work in progress. As a general rule, it uses the concept of carry-over, where a new job can start if and only if another job is completed. This minimizes "waste" or, in other words, work started but not completed or partially completed (Carmichael & Anderson, 2016).

Scrumban is an agile methodology whose origin dates back to 2008 and as its name suggests, it is a hybrid composition between Scrum and Kanban (Ladas, 2008). According to him Salvay (2017), it is particularly useful for maintenance projects where the adoption of this methodology allows the use of Kanban concepts that cannot be used when applying the SCRUM methodology or vice versa.

Authors such as Pressman (2020) y Sommerville (2016)define software project management as an additional activity or discipline that is included within the activities of software engineering.

There is a constant evolution and adaptation in project management methodologies to accommodate the changes that projects face every day, where we can

name the contexts where projects are carried out, such as the place where they are implemented, the external forces that exert different pressures on the project, the human or technical resources, as well as the new and different technologies that emerge at an increasingly accelerated pace.

A very particular case of this evolution occurs with the inclusion of new technologies, software projects must not only adapt to technological changes such as new versions of programming languages, changes in security or in the base systems, but must also be able to incorporate and adapt to the disruptive technologies of the moment.

In the past, technologies such as Bluetooth or IoT marked an era where many companies of different types and sizes began to include these technologies as part of their development solutions, and therefore project management had to adapt quickly to manage projects with cutting-edge technologies where an additional factor of uncertainty and risk was added to the existing ones.

The progress in the development and evolution of the various branches of artificial intelligence in recent years has shaken all existing disciplines and professions. Some of the concerns raised by artificial intelligence include the disappearance of some professions, as well as the creation of others. Project management is no stranger to these advances and there are several studies that identify or relate how this technology can collaborate with this discipline, enhancing it and facilitating its performance.

In the bibliographic research carried out, a lack of research on the subject of this work was observed, thus limiting the understanding of how this new technology impacts the management effort in development projects that decide to implement and incorporate artificial intelligence technologies as part of the product, in any of its branches, either as part of the core of the software to be built or as an added value of it. It is in this context that this study presents a first approach to the subject.

Software development projects that include the development of some type of artificial intelligence must include new profiles such as: data engineer/scientist, data analyst, machine learning engineer, among others. Along with these new roles, new activities arise where the activities related to preparing the data to be processed by the artificial intelligence algorithms, the modeling and optimization of the machine learning algorithms and the infrastructure where these algorithms are to be executed are highlighted (Arias, 2023).

Different authors such as Pressman (2020) y Sommerville (2016) agree that project management consists of a series of activities that, according to Pressman, include: Human Resources Management, Measurement (Product and Process Metrics), Project Estimation, Planning (Scheduling), Risk Management, Maintenance and Evolution.

The inclusion of cutting-edge and innovative technology should not be taken lightly or underestimated, as it impacts every one of these activities and every one of the decisions a manager must make.

By analyzing each of these activities, we can understand to what degree and how each activity is affected by the new technology included in the development project.

Human resource management from the project manager's perspective consists of the manager's ability to select the right human resources for the specified task, as well as managing the interactions and supporting the people in whatever they require (Pressman, 2020).

In this scenario, the inclusion of a new technology will have an impact not only on the management of the project from the point of view of the choice of the most suitable human resources or collaborators to carry out the task, but also, the time required for training and the minimum necessary mastery of the technology in question must be considered. When using a new technology, it is important to manage the emotions and

mood resulting from possible setbacks or difficulties in the learning curve and adoption of these new technologies, which is why managing this type of situation will be critical when managing the project.

Project measurement consists of choosing the right metrics to be able to measure and act proactively in the different situations faced by the project manager. Project metrics are divided into process metrics and product metrics; while the former are likely to be maintained independently of the technology implemented, product metrics are closely linked to the technologies used and therefore monitoring these metrics may require additional effort in project management (Pressman, 2020).

Project estimation is one of the most complex tasks a project manager can face. This task is not carried out by the manager individually and must be supported by different people, with a mastery of the technology to be used, who are an integral part of the project team together with the use of different tools that allow the most accurate estimate possible (Pressman, 2020).

As can be seen, the use of new technologies adds several additional components to the project, including training and the time required to minimally master the new technologies. As a result of the above, and due to the fact that all projects exert different pressures on the teams assigned to them, new and different uncertainties associated with these technologies and new scenarios are generated, which have an impact on the lack of technical knowledge at the time of making the necessary estimates to carry out the project.

Planning is an activity that is strongly related to estimation, since estimation is a fundamental input for a project manager to plan the project. Additionally, planning requires the ability to divide complex tasks into smaller and simpler tasks, to achieve the interrelation between the different tasks, to include the amount of available resources and their allocation so that as a whole the time needed to complete the project can be determined, giving rise to the base schedule (Pressman, 2020).

The planning of a project is directly affected by a new technology, mainly in the ability to subdivide tasks, since working with a new technology can be more complex, and in the allocation of human resources to these tasks. It may also be indirectly affected by estimates, as these were influenced by new technologies and will therefore affect planning and timing, as well as the allocation of resources to tasks. It can be seen that, to a greater or lesser extent, new technologies affect the manager in terms of planning and, ultimately, how it should be managed.

Risk management, according to Pressman (2020), consists of identifying any event that may positively or negatively affect the development and objectives of the project. The project manager must not only be able to identify risks, but must also be able to classify them into general, technical and human risks, among others; plan the follow-up and actions to be implemented by designing mitigation and contingency plans; perform the analysis and subsequent writing of lessons learned and reporting (Pressman, 2020).

A project that includes the use of new technologies presents additional risks inherent to new technologies. In this scenario the manager faces new challenges, where there may be no similar projects that can be used as sources of inspiration, and the manager's abilities to anticipate, predict and identify new risks become critical in meeting objectives.

The main objective of the project manager is to administer and/or manage the project within the stipulated time, however, he/she must also be able to determine or provide additional information on the steps to be performed once the project is completed and the product delivered; this phase is referred to as "maintenance and evolution". Although this phase is subsequent to the completion of the project, it should be considered

and included as part of the activities that the project manager must plan and determine to ensure the continuity of the product delivered to the customer (Pressman, 2020).

In the degree projects, maintenance and evolution are outside the students' responsibilities, since they should only focus on the degree project within the stipulated timeframe. Any subsequent activities are outside the scope of the project and within the scope of an agreement between the student and the company sponsoring the project.

The theoretical concepts detailed above allow students to understand each of them from a general perspective, but sometimes the practice is very different from the theory. Students require concrete examples of how to apply or take these methodologies from a theoretical perspective to a practical and concrete example. That is why authors such as Lledó (2016) y Alaimo & Salías (2013) provide a realistic approach that allows students to visualize the implementation of these methodologies in concrete situations.

Throughout this research work, we will analyze the effort dedicated by students in their university degree project in those activities focused on project management in projects that include some artificial intelligence or machine learning technology, as part of its functionality and thus, compare the results obtained with software development projects without these technologies. Based on the data analyzed, the following two research questions are posed, which are highly interrelated.

- Is there a difference in the effort and dedication of management hours in software development projects that include artificial intelligence technology as part of their functionality?
- how much management effort do projects involving this type of technology require?

Method

Among the different types or strategies of research are the quantitative and qualitative approaches. The quantitative approach presents a set of characteristics that allow a clear and specific definition of a problem, the formulation of objectives and hypotheses, and the use of tools that allow the precise and objective measurement of the event to be investigated. On the other hand, the qualitative approach focuses on aspects that cannot be quantified, focusing on aspects of behavior, patterns, processes or meanings, such as, for example, feelings, thoughts, among others... (Lerma González, 2009). According to the above, the quantitative approach was used in this research work because it is the one that best suits the objectives set out.

The study population participating and evaluated in this work is made up of the total number of degree projects available, and it is because of this that we will not work with a statistical sample, but, as previously mentioned, with the population as a whole. Working with 100% of the set of projects is possible because the number of projects is limited and manageable. In accordance with the above, descriptive statistics is the ideal tool to be used throughout this research work. By using descriptive statistics, the behavior of a set of individuals can be described clearly and accurately. The use of descriptive statistics is chosen over inferential statistics because the set of total projects is reduced and manageable, thus avoiding the need to make inferences or validations through techniques such as the p-value or null hypothesis.

The first group consists of those development projects that implement some artificial intelligence technology, while the second group is composed of traditional software projects where no artificial intelligence functionality is implemented. The variable of relevance for this study consists of the effort in management activities without

any manipulation on it, thus the work will allow comparisons to be made in search of similarities or differences.

On the basis of the above, authors such as Sampieri Hernandez et al., (2014) y Ñaupas et al., (2018) classify this research work as a quantitative, descriptive, univariate and non-experimental study.

Data acquisition process

Data acquisition was performed following a sequential set of steps, which are listed below:

1. Data collection in the library.

The first step consisted of collecting all the degree projects, for the careers that make up this study, that are available in the university library, either in physical or digital format.

2. Initial data cleansing or debugging.

Based on the previous step, the bibliographic review of each project was preceded by an initial filtering and filtering based on the following criteria:

a. Period to be used
b. Discard projects that do not include development

3. Collection and recording of project management (PM) effort and activities.

With the information recorded by the students, we proceeded to record the effort in hours for the project management task and then calculate what percentage it represents in the total hours. This record was made using the total hours reported by the students, the sum of hours for each iteration or the percentage calculated by the students.

4. Review and adjustment of the GP value.

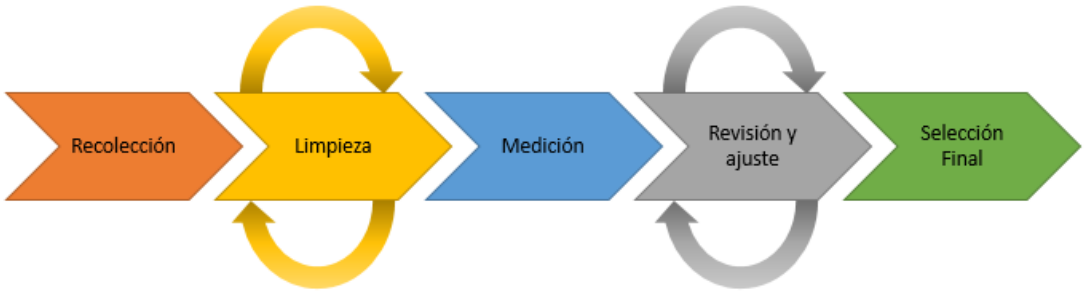
An analysis was made of the documents submitted by the students and in those cases where the project presented greater detail in the information provided by the students, the values recorded were verified and, if any inaccuracy was detected in the record, the necessary corrections were made.

5. Final selection of projects.

The last step consisted of discarding and consequently selecting those projects that will be part of this work. Projects were discarded if the documentation analyzed did not show evidence of registration and/or the variable of interest (GP effort) could not be reconstructed.

The process used for data acquisition is presented below.

Figure 1
Data acquisition process



Participants

The study covers the final academic degree projects of the Faculty of Engineering of the Universidad de la Empresa for the undergraduate degrees of Bachelor's Degree in Computer Science and Computer Engineering recognized by the Ministry of Education and Culture of Uruguay (MEC).

The initial number of projects within the selected study period and whose final product is either a software development or a software prototype consists of 113 projects.

The initial data set was fragmented into two sets, the first set contains the traditional software development or prototype projects, this set is composed of a total of 95 elements of which 77 of them have the study variable, while 18, lacking this variable, will not be considered throughout this work.

The second dataset contains 18 projects that directly or indirectly use some artificial intelligence technology; of these 18 projects, 13 contain the study variable, while 5 are discarded for lacking it.

Table 1 shows the details of the data presented above for each data set.

Table 1
Number of projects analyzed

Number of Projects	Methodology	Valid	No data
95	App development projects.	77	18
18	AI related projects	13	5
113		90	23

Data design and analysis

The projects that are part of this work are in the period from 2012 to 2022. The minimum duration of the undergraduate projects is a total of 6 months with an automatic extension of up to 50% of the initial duration, giving a maximum total duration of 9 calendar months without penalty in the grade obtained. After this deadline, students may apply for an additional extension of up to 5 months, where the tutor authorizes this extension based on different criteria or situations that have arisen throughout the project. In this scenario, students are penalized in the final grade by the tribunal, since the project has a total duration of 14 months.

The University has a mechanism that enables and authorizes the continuation of the project if the term is extended and exceeds 14 months. This mechanism allows the University to contemplate extreme and serious cases where there is a health problem or a very particular situation and a formal process must be fulfilled with evidence that supports the problem occurred and it is the University's responsibility to authorize the

continuation of the project outside these deadlines, up to a maximum of 4 months, however, none of the 113 projects analyzed have been in this situation.

The data analysis was performed using the bibliographic information provided as part of the project and accessible through the university library. As mentioned above, the review process included a detailed and in-depth analysis of the documents submitted and the verification of the time records for each of the projects. In case of discrepancies between the data reported by the students and the verification performed, the pertinent correction and adjustment is made.

Results

Tasks performed as part of project management

For the students, the undergraduate projects proposed by the Faculty of Engineering of the Universidad de la Empresa are simulations of projects that they will face in their professional activity, which is why all projects are sponsored by a real client. All projects must comply and be managed as a real project, so all the activities of a software project must be performed, including those management activities that must be executed by the Project Manager.

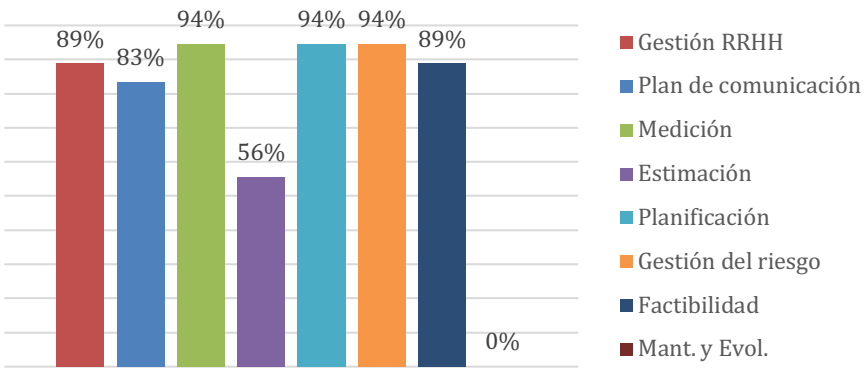
Pressman (2020) describes project management, or project administration, as a discipline within software engineering, and groups management activities into the following six categories: Human Resources Management, Measurement (Product and Process Metrics), Project Estimation, Planning (Scheduling), Risk Management, Maintenance and Evolution.

Project management requires that activities be carried out in a recurrent and planned manner, although no activity is considered more important than another, since all of them are focused on achieving the project's objectives, in what refers to a project in the context analyzed, we can say that some of these activities can be carried out in a cursory or very limited manner, such is the case of "Human Resources Management".

Figure 2 shows the percentage of projects that carry out each of the activities. According to the values observed, it can be seen that with the exception of the "Estimation" and "Maintenance and Evolution" activities, the rest of the activities are carried out by more than 80% of the projects analyzed.

Figure 2

Project management activities in AI projects



Regarding "Estimation", it is important to note that students make an initial estimate prior to the formal start of the project, in what is called the delivery of the

preliminary project. The pre-project is an official document that stipulates in writing the scope of the project, the start date, the tasks to be performed, the functional and non-functional requirements and the methodology to be used.

With regard to the refinement of estimates during project development, it is observed that only half of the projects make new estimates or adjustments to the initial estimates, whether these are estimates of scope and effort required to successfully complete the project, using and taking advantage of the information gathered and obtained throughout the execution of the project.

It is difficult to explain or understand the reason for this low percentage, because from the information analyzed, there is no information that can explain it, however, some possible explanations may be in the direction of the absence of similar projects, lack of knowledge to estimate projects that include artificial intelligence or that the project should be carried out regardless of the estimate made, so it can be seen, erroneously, as an activity that will not produce a positive/negative impact on the project.

University degree projects have a finite scope with an established end date, where within the scope, no maintenance or any linkage after the end date is included. This is reflected in the percentages shown in Figure 2, where it can be seen that no project performs Maintenance and Evolution tasks. Having said this, it is important to note that the projects do include a section where they must clearly express the future work that can be carried out and in some way delimit where the systems can evolve.

In analyzing the recording of project management effort we came across two errors that are commonly made by students when accounting for hours on this particular type of task. Both errors consist of confusing or counting project and/or documentation management hours as if they were the same activity. It is very difficult to understand the causes of this confusion using only the documentation presented by the students, so when analyzing these hours, we must be cautious and, as far as possible, review and compare the spreadsheets (if they exist) to validate the correct allocation of hours.

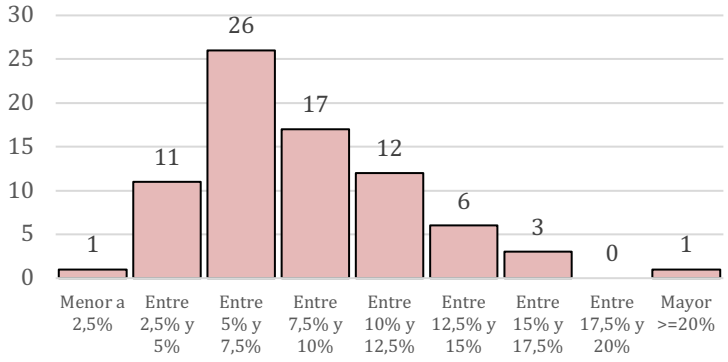
According to the above mentioned, and based on my experience as a tutor and corrector of undergraduate projects, in projects where the project management effort is less than 5% generally many management hours are counted as documentation and when the management hours are very high the opposite happens. While this is not true in all cases, and there may be exceptions or nuances, it is a common mistake that has been seen in some projects.

Project management hours effort survey

The management of software development projects that do not include any type of artificial intelligence or machine learning technology presents a Gaussian curve with a slight slope to the left (See Figure 3).

Figure 3

Histogram of the effort in software development projects (Without AI)



As can be seen from the data analyzed and presented in Figure 3, 93.4% of the university degree projects for the Bachelor's and Computer Engineering degrees at the Universidad de la Empresa are in the range of 2.5% to 15%, and within this range, 56% correspond to projects whose management is between 5% and 10%. As stated above, projects with values below 5% may contain an under-recording of hours and an incorrect allocation, so that, in principle, it can be discarded as part of the range of valid effort.

Jones (2005) indicates that project management in development projects is around 10% of total project hours. A specific study of the effort registered in undergraduate projects for computer science majors carried out by Rojas Sánchez & Uc Ríos (2022)confirm what was presented by Jones (2005)and state that the mean value of effort in project management activities in the context of the academic degree projects evaluated is 9.1%. In addition, they claim that the effort in management tasks is in a range between 5% and 15% with an average of 9.8%.

When contrasting the results obtained in this research work, we can see that although the values reported by the students are not centered on the 10%, they are very close to it.

The project management effort that includes some type of artificial intelligence or machine learning technology presents a behavior with some observable differences, mainly in that the curve drawn in the graph does not present the shape of a Gaussian curve. However, in general terms, it respects the ranges presented above and, as can be seen in Figure 4, 92.3% that applied some degree of IA within the project dedicated a management effort in the range of 5% to 15% (there are no projects with an effort of less than 5%) and within this range 53% are in the range of between 5% and 10%.

Figure 4

Histogram of the effort in software development projects (With AI)

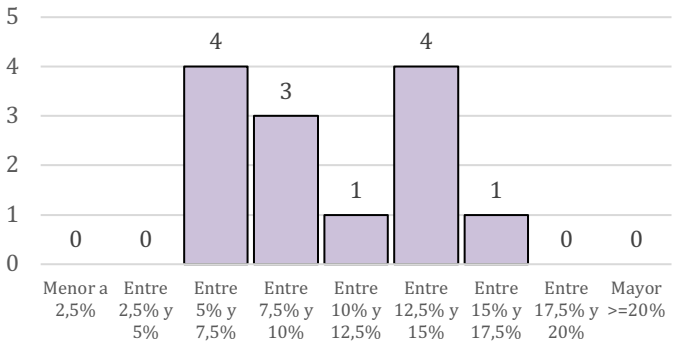


Table 2 shows the summary of the statistical values obtained throughout this research work as opposed to those presented in the research conducted by Rojas Sánchez, M. & Uc Ríos, C. (2022). As can be seen, the IA/ML projects do not present major differences with the values obtained for conventional development projects or with the values presented by Ríos, C. and Rojas, M. (2022). With regard to statistical values such as average, mean and bounded mean, they show a difference of around 2% with respect to traditional projects and around 1% for the values presented by Ríos and Rojas, while the standard deviation and variance indicate that there is little dispersion in the IA projects.

Table 2

Management hours statistics by type of software project

	Software Traditional	**Software IA/ML**	**Rojas and Rios (2022)**
Range	5%-12,5%	5%-15%	5%-15%
Average	8,3%	10,3%	9,8%
Average (10%)	7,5%	10,0%	9,1%
Median	8,1%	10,3%	8,5%
Minimum	1,0%	5,9%	1,0%
Maximum	21,1%	17,1%	45,7%
Standard deviation (o^2)	3,6%	3,7%	5,9%
Variance (o)	0,1%	0,1%	0,4%

Note. Source: Own elaboration with data from Ríos and Rojas (2022)

Discussion and conclusions

The origins and triggers that initiate this research work arise with the objective of answering the following two questions:

- Is there a difference in the effort and dedication of management hours in software development projects that include artificial intelligence technology as part of their functionality?
- How much management effort do projects involving this type of technology require?

These questions are generated by the massive implementation and development of information systems that use or implement, to a greater or lesser extent, artificial intelligence or machine learning algorithms.

Artificial intelligence technologies have opened up new opportunities and have been widely disseminated due to the benefits and advantages they provide to users and the potential improvements they offer when used in everyday problems.

Throughout this research work, we have measured the impact of including these technologies in software development projects and in particular, how the inclusion of these technologies can affect the effort dedicated to project management tasks.

The students who carry out the academic degree project are faced with new activities and tasks that resemble real projects, where they must make decisions as project managers that impact positively or negatively on the development of the project.

As could be observed, all the project management activities proposed by Pressman (2020) were performed in almost all the projects, with the exception of the estimation activity, which was only performed by half of the IA projects studied. That said, there is no difference between the tasks performed by students in traditional development projects compared to projects that include artificial intelligence in some of its variants.

It is difficult to discern and explain why traditional development projects and projects implementing artificial intelligence technologies perform exactly the same project management tasks (presented above), however, we can venture a hypothesis that should be tested with a specific study to verify its validity. The undergraduate projects in the academic context analyzed are framed within an inflexible context where the tasks that must be performed and evidenced in order to approve the project are to a greater or lesser extent pre-established. Although there is a margin for adaptation, this margin is not very large and tends to be small. In addition, students take projects from previous years as examples, so they base their documentation and tasks on projects that have already been evaluated and approved, because aligning themselves with successful projects maximizes their chances of success.

However, this leads to a lack of innovation in terms of process adaptation and, consequently, a lack of risk-taking to bring about improvements or to create new implementations and/or adaptations that are better suited to the projects they develop.

From the measurement and analysis carried out, it can be seen that IA projects do not behave differently from traditional projects. All statistical measures, as well as the ranges found, are very close to or equal to the rest of the types of projects studied.

In response to the questions posed, based on the data analyzed and presented, there is no evidence indicating the existence of any considerable or detectable impact that positively or negatively influences the effort and dedication of hours dedicated to project management tasks for the projects under study.

The hours dedicated to project management tasks for these projects were in the range between 5% and 15%, with minimal differences with respect to the hours and effort dedicated to similar tasks in traditional development projects, in line with the results proposed by Rojas Sánchez & Uc Ríos (2022) and, to a greater and lesser extent, very close to those presented by Jones (2005).

Based on the foregoing and in conclusion, the answers to the research questions posed at the beginning of this paper are presented below. The initial question originating this paper was: is there any impact on the effort and dedication of hours in project management, in the projects that include as part of its functionality some artificial intelligence technology, has the answer that there is NO impact in terms of effort and dedication of management hours.

Regarding the second silver question: How much management effort is required for projects that include this type of technology, the answer to this question is that the project management effort is in the range of 5% and 15% with a median of 10% and an average of 10.3%.

Reflections and limitations

Among the limitations detected in this research work, those directly related to the available data stand out. The following is a list of the present and future limitations detected:

1. One of the most important limitations that was present from the beginning of this work was the number of projects. This research has a number of projects of less than 120 elements and the number of projects that can be categorized within the projects subject to study turns out to be in the order of 15%. Although this favors the use of descriptive statistics and makes it possible to describe the behavior of this type of project as opposed to traditional projects, the total number of projects is small. For this reason, it is important to emphasize that this work is exploratory and a starting point to lay the foundations and direction for further work that may include a larger number of projects from other universities and other countries.
2. The recording of effort measured in hours was performed exclusively by the students. It is important to note that there are always small errors in effort recording, but experienced project managers are able to minimize or even detect and minimize these errors. The students, lacking experience in project management and in view of the imperative need to carry out and complete the project, do not apply any methodology to minimize possible errors in the registry, so a certain margin of error in this registry is to be expected. In order to minimize these errors, in cases where there was additional information regarding the recording of effort, the values recorded were validated, verified and adjusted if inconsistencies and/or anomalies were detected.
3. The diversity by type of project is a minor limitation that, although it did not have a direct impact on the object of study of this work, it does present challenges and challenges for the future in possible lines of research that may derive or originate from this work.

Continuity proposals

Research work in academic contexts is a research opportunity that is seldom taken advantage of. Having the information of the entire process executed throughout the project presents endless possibilities and lines of research that can be the starting point for different lines or future work.

This paper analyzes the impact of a new technology, such as artificial intelligence, from a development point of view and whether this inclusion impacts project management.

Among the possible proposals for continuity, it is proposed to evaluate the impact of this new technology on specific project management activities, such as risk management. When including a new technology, it is expected that specific risks will arise, as well as mitigation and contingency plans associated with these new technologies. Students are trained and will be able to cope with these new scenarios, is a question that seems to be interesting to answer.

Another possible line of research is a direct extension of this work, which consists of measuring the hours spent on software development tasks, as well as the hours spent

on documentation tasks. While development hours may indicate that this type of activity may be more or less from a technical expertise standpoint, development hours are a critical component of providing quality and compliance to the end user. While the manager is not the role that performs these activities, it is something that is under his control and therefore he is partly responsible for these activities.

Finally, the information obtained in this work is intended to be the starting point for future specific research work, which will investigate the impact of new technologies on academic degree projects, and how they affect the dynamics and activities that are performed by students when faced with new or disruptive technologies.

Companies that within their processes perform measurements similar to those performed in this project will be able to compare their results with those obtained in the academic field and thus evaluate and have a reference value as a point of comparison.

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