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PROJECT MANAGEMENT IN UNIVERSITY CAPSTONE PROJECTS

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Abstract. Project management is a discipline that directly influences the success or failure of any project, and the software industry is no exception. The university's academic curriculums focus on providing students the required knowledge to obtain technical and methodological skills that are necessary to achieve correct project execution. However, the emphasis on project management subjects, as well as their practice in real projects presents an additional difficulty and therefore a lower dedication than the rest of the knowledge areas. This article answers the following research questions: (i) How many hours do students devote to project management? and (ii) Are the project management hours related to the methodology applied? In this research work, descriptive statistics were used with a quantitative approach of a non-experimental nature, where data from 349 university capstone projects of computer science careers from two different universities were analyzed. The projects analyzed focus on 3 management methodologies: the one proposed by the Project Management Institute (PMI), one specific to software projects, and the SCRUM framework. Finally, depending on the results obtained, it is shown that in the academic context there are no considerable differences that relate the effort to the methodology applied and that the effort in management tasks is located in the range between 5% to 15 %, being consistent with the literature presented.

Keywords: project management, degree thesis, software development, comparison of effort between management methodologies

GESTIÓN DE PROYECTOS EN TESIS DE TITULACIÓN UNIVERSITARIA

Resumen. La gestión de proyectos es una disciplina que influye en forma directa en el éxito o fracaso de cualquier proyecto y la industria del software no es la excepción. La curricula académica de las universidades se centra en brindar los conocimientos necesarios para que los estudiantes adquieran las competencias técnicas y metodológicas necesarias para lograr la correcta ejecución de un proyecto. Sin embargo, el énfasis en materias de gestión, así como la práctica en proyectos reales presenta una dificultad adicional y por consiguiente una dedicación menor que el resto de las áreas de conocimiento. En este artículo se responde las siguientes preguntas de investigación: i) ¿Cuántas horas se dedican los estudiantes

a la gestión de proyectos? y ii) ¿Las horas de gestión de proyectos se relacionan con la metodología aplicada? Este trabajo de investigación utiliza la estadística descriptiva con un enfoque cuantitativo de carácter no experimental, donde se analizaron los datos provenientes de 349 proyectos de tesis de titulación universitaria de carreras de ciencias de la computación provenientes de dos universidades. Los proyectos analizados se centran en 3 metodologías de gestión: la propuesta por el Project Management Institute (PMI), una específica para proyectos de software y el framework SCRUM. Finalmente, en función de los resultados obtenidos se demuestra que en el contexto académico no existen diferencias considerables que relacionen el esfuerzo con la metodología aplicada y que el esfuerzo en tareas de gestión se ubica en el intervalo de entre 5% y 15% siendo consistente con la literatura presentada.

Palabras clave: gestión de proyectos**,** tesis de grado, desarrollo de software, comparación de esfuerzo entre metodologías de gestión

Introduction

According to the Project Management Institute (2017), a project is "a temporary effort that is carried out to create a product, service, or unique result" (Project Management Institute, 2017, p.4) due to the fact that a project requires the investment of material, economic, human, and time resources, among others, a previous step must be carried out to determine its feasibility.

Once the feasibility of a project has been determined, the next logical step is to carry out its planning. For Campo Arranz et al. (2014), the planning of a project consists of determining and estimating the activities, assigning the resources that will carry them forward and defining how the management and administration will be carried out.

The planning of a project is the initial step in the construction of a software system and it is in this planning where the different phases that compose it are defined, where in each phase different tasks are performed. However, there is a process that must be executed transversally and throughout the whole project, which is called project management. Project management is the activity in charge of verifying that the development of the project is carried out within the agreed deadlines, with the agreed quality and at the stipulated cost. The success of a project depends to a large extent on the correct execution of project management. (Sommerville, 2011).

In the industry, there is a large amount of information generated by companies, product of years of work, and accumulated experience. The collection of metrics on the effort dedicated to different types of tasks, hours invested, technologies used, as well as other types of information is a very valuable asset and is one of the innate activities of companies seeking to improve the execution of current projects and the planning of new projects.

Unfortunately, this information is held by companies and is hardly shared with academia. Cooperation between industry and academia through the exchange of information would make it possible to align academic plans with what industry needs. Sharing this information with academia is only possible if companies visualize the benefit or gain, not necessarily economic, that they can obtain either in the short or long term; in other words, a win-win investment in the future. The existing disconnection between academia and industry means that students do not have reliable information on real projects, and access to metrics or statistics of this kind of projects (real and current) is very difficult.

In the academic degree theses analyzed in this paper, students must perform the complete cycle of building an information system. This means that they must not only

demonstrate that they are able to build a system, but also that they are able to perform the project management activities. Within these activities, they must be able to perform estimation, collect metrics that feed back into the project, monitoring, risk management, and many other activities that will lead the project to a successful conclusion.

As expressed by Ramos Cerdas (2015), the role of the university does not consist exclusively in disseminating knowledge, nor in preserving acquired knowledge, since both actions can also be achieved by using a book. The role of universities is to keep knowledge alive, the conjunction between those who know and those who want to learn.

For Morales Vallejo (2013), academic goals are related to the students' learning process and the final grades they obtain. To help students meet academic goals, universities need to measure the degree and quality in which their students achieve their academic objectives as well as their learning. It is of vital importance for universities to detect those points that can and should be improved, allowing them to design academic strategies that allow them to reinforce those skills that do not present the expected quality or those skills that are not applied, and, thus, act upon them. Through these strategies, universities seek to train better professionals and citizens, which is the main and most important objective of a university.

The Association for Computing Machinery (ACM) publishes since 1960 recommendations for academic curricula in different computer science majors, where project management is included as a discipline that students must master. (Association for Computing Machinery, 2021).

For Fioravanti et al. (2018), software project management is one of the most relevant topics within software engineering, and it is for this reason that it should not be missing in the academic curriculum of computer science. The main argument put forward by this author is the relationship between project management and project success or failure. In this same line, he states that there are difficulties in linking theory with practice, and that teachers are not able to demonstrate the importance and relate these two realities. In the development of his article, he introduces and presents evidence of his experience applying project-based learning where students can apply their knowledge in real projects.

Authors, such as Pressman (2010) or Sommerville (2011), deepen and apply project management to software projects. These authors include project management as another existing discipline within the field of software engineering. It is in this scenario where the project management described by these authors is only applicable to software projects, and this is because they describe in great detail the way in which each of its activities should be performed, providing specific tools and guidelines for these types of projects.

The project management methodology specified and described by the PMI (Project Management Institute, 2017) and the agile methodology of SCRUM (Satpathy, 2016) determine, in general terms, everything that a project manager must perform to achieve exercise effective project management, but these disciplines do not go into detail on how project management should be performed for a particular activity. Because of this, these methodologies can be applied to any type of project, and it is up to the project manager to define how to implement the activities described in these methodologies, as well as the tools to be used.

The project management methodology proposed by the Project Management Institute[1] (PMI) is a management methodology that can be applied to any type of project and for this reason, it is one of the most widespread. It stands out for being flexible and

[1] https://www.pmi.org/

adaptable to any type of project; however, from the methodological point of view, it is considered by some as a very bureaucratic and heavy methodology in terms of procedures and requirements.

The body of knowledge that describes for this methodology how project management should be performed, correctly and efficiently, is developed in its completeness by the Project Management Institute (Project Management Institute, 2017) through what is known as the PMBOK[2] . This document is under a constant process of revision and updating by this institution. Authors, such as Lledó & Rivarola (2007), complement these documents by providing practical, concrete, and applied examples for each of the procedures defined in the PMBOK, in order to bring theory and practice closer together.

As the years have progressed, agile methodologies have become very popular, and it is increasingly common to use these methodologies to manage software projects (Appelo, 2011). This adoption is based on the fact that agile methodologies allow building small units of functional software, which is delivered quickly to the customer to correct any problems in the misinterpretation or implementation of requirements, functional failures, or customer dissatisfaction as quickly as possible.

SCRUM is one of these agile methodologies, where agility and continuous delivery are prioritized over processes. Through the definition of short iterations and strictly defined processes, the human is favored to achieve the objectives set in the required times, making the right corrections at the time they are detected. Like PMI, SCRUM has a manual, also called body of knowledge, where the methodology is fully described. (Satpathy, 2016).

According to Alaimo & Salías (2013)the SCRUM methodology is based on 3 fundamental foundations: Inspection, adaptation and transparency, for which team roles, events and artifacts are defined respectively. The complete description and specification of this methodology can be found in the official site of SCRUM, founded by Ken Schwaber, one of the creators[3] of this methodology.

In academia, the use of the main project management methodologies is encouraged, but no research conducted by universities has been found that describes and focuses on measuring specific aspects of how the project management activity is carried out, or how many hours a student dedicates to this type of task.

There are few research papers that focus on investigating the effort devoted to management tasks in software projects in the academic context. One of these works is conducted by Saini & Chomal (2020). In this project, they analyze how effort is distributed in the development of software projects, focusing on Master's degree work. According to the results presented by these authors, the effort in the planning and requirements phase or activities was located in the range between 2% and 15%, with an average of 7%.

When we focus our attention on the industry, many companies are jealous to provide information on the real effort invested in the different tasks performed in their projects since in many cases it is information for internal use, and they do not want the competition to have this knowledge.

In the article presented by Jones (2005), this issue is studied for the software industry, classifying projects according to their size or objective. As revealed in this article, Capers Jones indicates that the effort dedicated to management tasks in software projects, according to the data analyzed, is between 10% and 13%, with 10% being the type of project that most resembles academic degree projects.

[2] https://www.pmi.org/pmbok-guide-standards/foundational/pmbok
[3] https://www.scrum.org/

The point-by-use-case technique used to measure effort in project management is analyzed by Primandari & Sholiq (2015). In their work, they conclude that the effort in management activities reaches 3.8% of the total hours invested. The results obtained and presented by Kassen Shaleh, where he relates management effort to the rate of payment for such tasks, indicate that according to the rate of payment of effort for management tasks in medium or large software projects is 8.34% (as cited in Primandari & Sholiq, 2015, p.83).

A study of similar characteristics is conducted and presented by Mukherjee, Gupta, & Thirugnanam (2016) obtaining other results, which were that the effort on project management tasks stood at an average of 16.14% of the total hours input, with a minimum observed value of 1.82% and a maximum value of 35%.

According to the Project Management Institute (2017) in its body of knowledge, project management is a fundamental competence for any professional who wishes to manage projects and for this reason future professionals must acquire the necessary practical experience. The rest of the authors mentioned above express themselves along the same lines, highlighting the importance of project management and its relationship with the success or failure of projects.

According to Pressman (2010), the effort in project management does not depend exclusively on the characteristics of the project, but it is also important to consider the type of project and the context where it is executed or implemented. It is for this reason that recording measurements in project management tasks in academic degree projects is relevant since these measurements can be contrasted with the industry and the existing literature.

With what has been said above, there seems to be a gap in terms of research work that focuses on measuring the effort of project management tasks in the academic environment and, in particular, in university degree projects. Studies of these characteristics can provide very valuable information to understand how future professionals apply and carry out project management, providing very important inputs not only for academia and universities but also for companies that are in a position to hire the best technical and human talent.

In this research work, a detailed study is conducted on the effort dedicated by students in project management activities, in order to answer the questions: i) Are the hours of project management related to the methodology applied? and ii) How many hours do students dedicate to project management?

In order to answer these questions, the final works of academic degree whose objective is the construction of a software system, where any of the project management methodologies object of this study have been used, will be analyzed. The analysis of the data will be carried out through the use of descriptive statistics according to the concepts presented and proposed by Ross & Valdés Sánchez (2014), paying special attention to the basic statistics used within this branch of statistics (descriptive), such as tendency, dispersion, centralization, median, among others.

Method

According to the authors, Sampieri Hernández et al. (2014), there are 2 research approaches: quantitative and qualitative, but if we combine both research approaches, it results in a third approach called mixed approach. The approach used for this research work was the quantitative approach since, in the development of this approach, the recording and measurement of the effort (in hours) of the tasks and/or activities of project management in university degree theses is performed.

The absence of intervention by the subject of the study, as well as the non-manipulation of the variables collected, determines that the type of research conducted is non-experimental in nature. This work being categorized as descriptive since its purpose is to determine the effort of students in the tasks of project management in the academic context and, likewise, to validate the relationship of effort with the methodology used in university work.

According to Martínez, (2020) and Ross & Valdés Sánchez (2014), descriptive statistics is used when working with the entire population under study, allowing to organize, describe, analyze, interpret, and present the characteristics of the data analyzed through the use of basic statistics, such as median, minimum, maximum average, bounded mean, variance, standard deviation, among others.

In this work, the access to information and the volume of data analyzed allows for an investigation that includes 100% of the population under study, which is why descriptive statistics (and not inferential statistics) will be used during this research work.

Participants

The projects participating in this study come from two private universities in Uruguay: Universidad de la Empresa (UDE) and Universidad ORT Uruguay (ORT). The selection of these universities is mainly due to the fact that the undergraduate projects for the university degree, in most of their projects, consist of the creation of a software system; while in the rest of the universities, the undergraduate thesis consists of a research work or the creation of a prototype product of research, or the access to the undergraduate projects was not possible.

For this research work, information was collected from 250 projects from Universidad ORT Uruguay and 99 projects from Universidad de la Empresa. A total of 349 projects carried out as part of the university degree thesis of undergraduate students in Bachelor's degree and/or Systems Engineering were analyzed. The minimum duration of the projects is 6 months, with a planned extension of 3 additional months. There are very few projects whose duration exceeded the time stipulated by the universities, reaching a maximum of 14 months. The documentation analyzed was collected from the universities' libraries.

The projects analyzed cover the academic periods from 2012 to 2020 inclusive. The analysis of the projects included the review and validation of the information provided by the students in the documentation submitted as degree thesis. For this purpose, the record was analyzed in detail to determine the correctness of the information recorded by the students; in those cases, in which an error was detected in the record, such as in the sum of hours or in the assignment of hours in an incorrect task, as in the case of documentation hours accounted as management hours, the corresponding adjustment was made.

Data design and analysis

This study is focused on the analysis of the documentation submitted by the students of the project carried out as a requirement for obtaining the university degree. The first step was to identify and quantify the projects that recorded the effort (in hours) of tasks and/or activities dedicated to project management and the management methodology used. From the analysis, 3 methodologies were identified as being used in more than 96% of the projects: the methodology proposed by the Project Management Institute (PMI), project management specific to software projects (PMS), and the SCRUM framework. The rest of the methodologies that were used, such as Kanban, OpenUp, etc., were discarded from this work since there were not enough projects. The total number of theses for each methodology is presented in Table 1.

Table 1
Number of projects analyzed according to the applied methodology

Number of Projects	Methodology	Universidad ORT Uruguay	Universidad de la Empresa
115	Specific software management	42	73
35	PMI Methodology	17	18
199	SCRUM	191	8
3	OpenUp, Kanban, etc.	0	36
352		250	99

Note: Source: Own elaboration

A dataset was created and organized with the information obtained in the previous step, so that each project to be included had to satisfy two conditions: 1) to have recorded the methodology used and 2) to have recorded the number of hours. Stacked bar charts and histograms and tables with the relevant statistical information were used to facilitate the interpretation and comparison of the data.

This dataset was subjected to various analyses including: analysis of the percentage of project execution as a function of the management methodology applied per university and another histogram with the complete set of data, effort dedicated to project management tasks in 5% intervals per university and with the complete set as well as histograms of the effort measured in hours for each methodology and for all projects as a whole.

Results

Project management hours effort survey

The documentation submitted for a total of 250 ORT Universidad ORT Uruguay projects covering the periods 2012-2020 was analyzed, as presented in Table 1. In 33.6% of these projects analyzed (84 projects), no evidence was found in the written documentation on recording or measuring hours in project management tasks, while the remaining 66.4% of the projects (166 projects) had provided evidence of the recording of activities related to project management. According to these percentages, there are a total of 166 valid projects to measure project management effort as shown in Table 2.

Table 2
Valid projects according to methodology applied and university of origin

Number of Projects	Methodology	Universidad ORT Uruguay	Universidad de la Empresa
		Valid	
81	Specific software management	23	58
30	PMI Methodology	13	17
134	SCRUM	130	4
245		166	79

Note: Source: Own elaboration

With regard to the company's university and out of a total of 99 projects analyzed (see Table 1), the percentages obtained, as shown in Figure 1, do not present major

variations. 20.2% (20 of the projects) did not present evidence of having recorded project management hours, while 79.8% did present written evidence of having done so, for a total of 79 valid projects (see Table 2).

From a general point of view, in the academic field and for the projects analyzed from both universities, 29.8% (104 projects) of a total of 349 projects did not provide written evidence of the recording of hours spent on project management tasks, while the remaining 70.2% (245 projects) provided evidence of having done so.

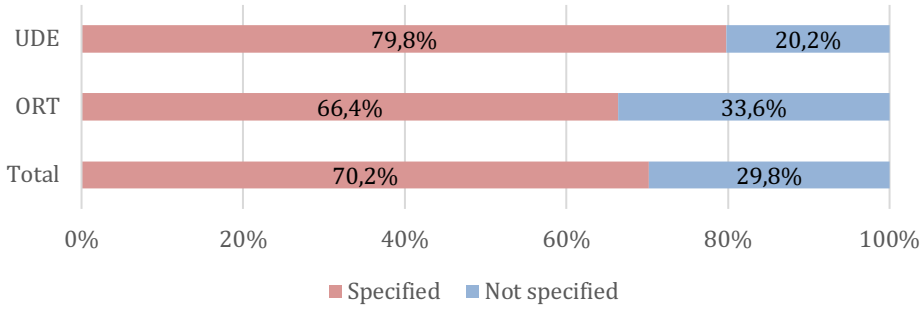

Figure 1. Percentage of projects with specified management hours.
Note: Source: Own elaboration

The Universidad ORT Uruguay projects show a strong tendency to use scrum as a methodology or framework for project management, thus relegating the PMI methodology or software-specific project management. The detail of the percentages obtained for each university and each methodology is shown in Figure 2.

On the other hand, unlike the ORT university, the company's university presents a strong tendency towards traditional methodologies, being software-specific project management with 73.4% the most used methodology, in second place, with 21.5% the PMI methodology, and lastly scrum with only 5.1% of the projects.

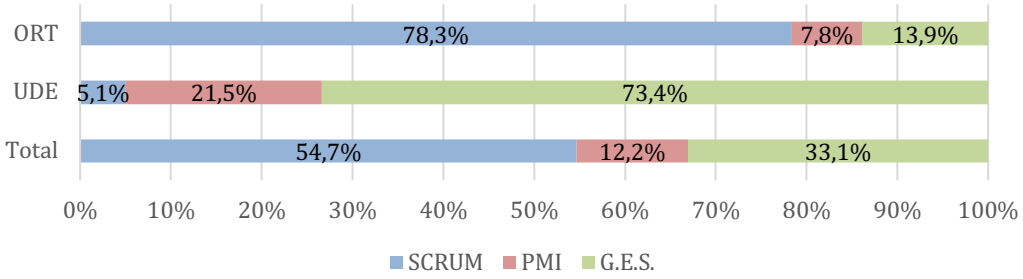

Figure 2. Projects discriminated according to the methodology applied
Note: Source: Own elaboration

From the previous figure, it can be deduced that both universities present different preferences in terms of the management methodology used by students to carry out project management in undergraduate theses. This difference may be due to the characteristics of the undergraduate projects, the focus of the academic curriculum, or some other factor that should be further analyzed.

When totaling the projects from both universities, and taking into account that ORT contributes more than twice as many projects as UDE, it can be seen that almost half of the projects are based on traditional methodologies for project management (12.2% PMI + 33.1% G.E.S.), while the other half (54.7%) uses scrum (see Figure 2).

The quantification of the projects according to methodology and university of origin were presented in Table 2.

The effort dedicated to tasks related to project management shows small differences when comparing the data obtained in both universities. In most of the projects analyzed, the number of hours dedicated to these tasks was between 5% and 15%, and to a lesser extent, with a dedication of more than 15% or less than 5%.

As can be seen in Table 3, both universities present a very similar percentage of projects, with a difference of only 3% for the number of projects whose management hour record is less than 5%, being this percentage 15.7% and 12.7% for ORT and UDE, respectively.

This behavior is not observed in the interval between 5% and 10%. According to the results obtained, the difference between the number of ORT and UDE projects is 18.5%, where 59.5% of the total number of UDE projects analyzed are in this interval, in contrast to ORT, where only 41% of the projects analyzed are in this interval.

The range between 10% and 15% does not show significant differences and both universities have almost the same percentage of projects in this range with 24.7% and 24.1% for ORT and UDE, respectively, a difference of only 0.6%.

Finally, the number of projects in which the number of management hours exceeded 15% shows a difference of 18.5% between the two universities. While 18.7% of the ORT projects analyzed had a record higher than 15%; at the UDE, this behavior was only observed in 3.8% of the projects analyzed. The details of the results obtained are presented in the following table.

Table 3
Breakdown of projects by percentage of hours dedicated to project management

	Universidad ORT Uruguay (ORT)		**Universidad de la Empresa (UDE)**		**Total**	
	#	%	#	%	#	%
Less than 5%.	26	15.7%	10	12.7%	36	14.7%
Between 5% and 10%.	68	41.0%	47	59.5%	115	46.9%
Between 10% and 15%.	41	24.7%	19	24.1%	60	24.5%
Greater than 15%.	31	18.7%	3	3.8%	34	13.9%

Note: Source: Own elaboration

When considering all the projects analyzed, it can be observed that 71.4% of the projects are located in the 5% to 15% range. According to Jones (2005), software development projects present an effort in management tasks in the range of 10% of the total project hours. If it is considered that the projects analyzed are in an academic context and are executed by future professionals, it can be considered that the range of 5% to 15% is a range that, to a greater or lesser extent, is very close to the industry.

The statistical data calculated for both universities are shown in Table 4. As can be seen, there are no considerable or relevant differences between the projects of both universities, with the exception of the minimum or maximum that deviate from the median. It is important to note that the mean, when excluding the 10% of the lower segment and the upper segment, returns a value very close to the average and the median, which means that the extremes do not affect the dataset.

Table 4
Statistics on management hours by university of origin

	UDE Hours Management %	ORT Hours Management %
Average	8,3%	10,5%
Trimmed Median (10%)	8,2%	9,8%
Median	7,8%	9,0%
Minimum	2,8%	1,0%
Maximum	16,7%	45,7%
Standard deviation (o^2)	3,1%	6,8%
Variance (o)	0,1%	0,05%

Note: Source: Own elaboration

Effort according to applied methodology

A total of 134 projects were used to analyze the effort dedicated to the management of projects that were managed using the SCRUM methodology. This dataset was used to construct the histogram presented in Figure 3. The shape of the histogram (drawn curve) resembles a bell or normal distribution, with a slight increase for projects whose effort is greater than 20%. These results are not surprising because these are projects carried out by students and, due to the academic nature of these projects, particular situations or behaviors may arise. In real projects there may also be particular situations that may cause some projects to escape from the typical values.

The histogram in Figure 3 shows that 93 projects (69.4%) are between 5% and 15%, 20 projects (14.9%,) with an effort below 5%, and 21 projects (15.7%), with an effort above 15%.

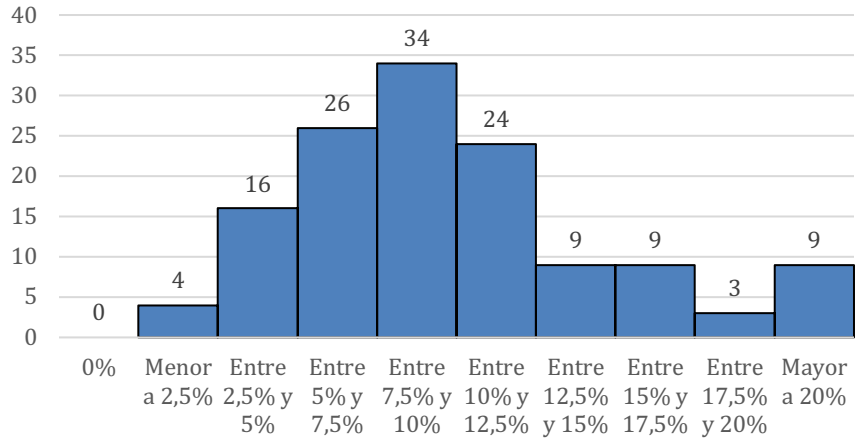

Figure 3. Project management effort in projects managed with SCRUM
Note: Source: Own elaboration

In the histogram obtained for the 30 projects, whose execution was managed using the PMI methodology and which is presented in Figure 4, it can be seen that the curve drawn in this graph has an irregular shape as in a bimodal classification. This means that there is a possibility that there are 2 groups of projects, where the peaks are presented, with distinctive characteristics, the analysis of these projects and their characteristics is beyond the scope of this work. Of the total number of projects analyzed, 24 projects,

which is equivalent to 80% of the projects, provided evidence that places the effort spent on project management tasks between 5% and 15% of the total hours executed in the project. Only 2 projects (6.7%) had an effort lower than 5%, and 4 projects (13.3%) had an effort higher than 15%.

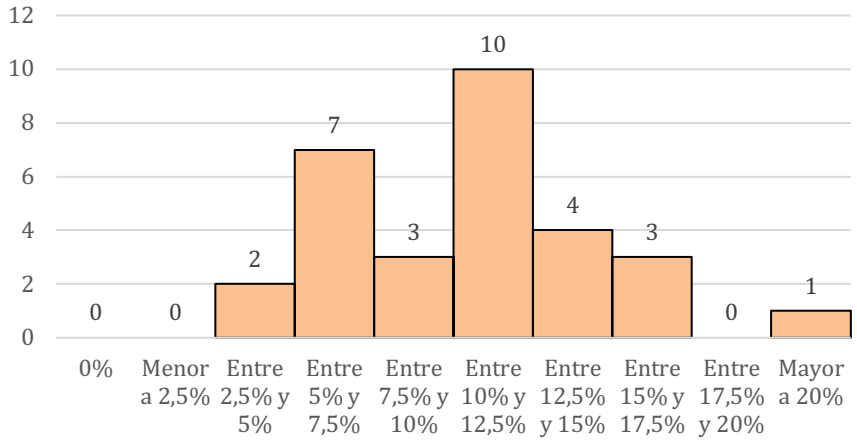

Figure 4. Project management effort in projects managed with PMI methodology
Note: Source: Own elaboration

The histogram presented in Figure 5 was constructed with the data obtained from the 81 university degree projects that carried out the project management using the specific software management methodology.

Figure 6 reveals that 58 projects of those analyzed (71.6% of the total) state that the effort expended for project management activities or tasks is between 5% and 15%, while 14 projects (17.3%) devote less than 5% effort and 9 projects (11.1%) devote more than 15% effort.

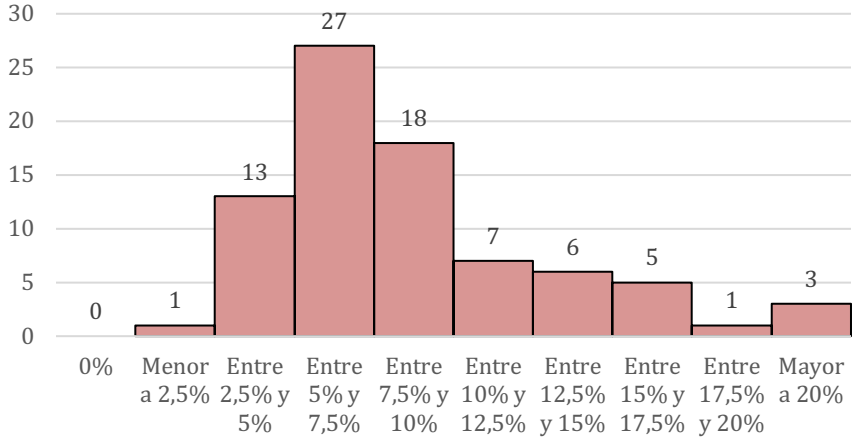

Figure 5. Project management effort in projects with specific software management
Note: Source: Own elaboration

The analysis of the data for each methodology allows an objective comparison of the values obtained and the drawing of appropriate conclusions. However, it is also possible to analyze the data from the academic point of view for all the degree projects, regardless of the methodology applied. As shown in Figure 6, 175 projects (71.4% of the 245 projects included in this work) show evidence that the effort invested in project management tasks is between 5% and 15%.

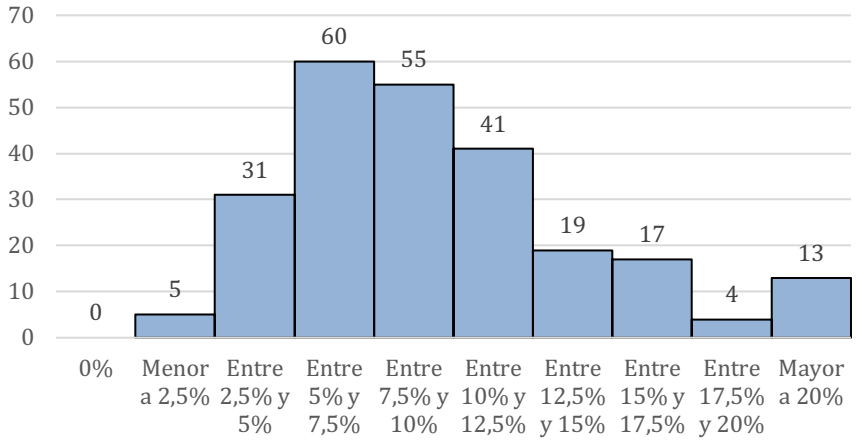

Figure 6. Project management effort regardless of the methodology used
Note: Source: Own elaboration

From the statistical data presented in Table 5 and Figure 7, it can be seen that there are no significant differences between the management methodologies applied by the students. The distribution of projects, according to the methodology applied, indicates that the methodology most used by the students in the 245 projects analyzed is SCRUM, followed by specific software management (SSM) and, finally, the PMI methodology with 134, 81, and 30, respectively. The total number of hours of the projects (based on averages) show little variation among the different methodologies: SCRUM, PMI, and software-specific project management with 1737, 1646, and 1561, respectively. The average duration of the undergraduate projects analyzed when not discriminated, according to the management methodology applied, is an average of 1666 hours.

Table 5
Statistical data broken down by methodology applied

	SCRUM	PMI	Specific software management (SSM)	Total (General)
Number of projects	134	30	81	245
Average (Total hours)	1737	1646	1561	1666
Average (Project Management)	10,2%	10,5%	8,7%	9,8%
Trimmed Median (10%)	9,5%	10,2%	8,3%	9,1%
Median	8,7%	10,2%	7,3%	8,5%
Minimum	1,0%	3,0%	2,0%	1,0%
Maximum	45,7%	25,3%	24,9%	45,7%
Standard deviation (o^2)	6,8%	4,5%	4,5%	5,9%
Variance (o)	0,5%	0,2%	0,2%	0,4%

Note: Source: Own elaboration

The effort dedicated to management tasks declared and recorded by the students in the university degree theses does not show significant differences according to the methodology applied. The application of PMI and SCRUM methodology are at 10.2% and 10.5%, respectively, while the specific management of software projects is a little lower with an average of 8.7%. As expected, the average (at 10%) maintains the relationship and allows us to discard the extremes (outsiders) that may affect the

calculated value. The values obtained 9.5%, 10.2%, and 8.3% do not differ significantly when contrasted with the averages presented above. There are also no considerable differences in terms of variance and standard deviation.

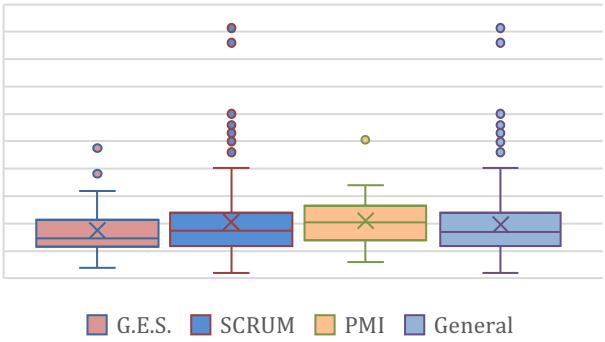

Figure 7. Box plot for the methodologies applied.
Note: Source: Own elaboration

With the results obtained, it can be observed that the different methodologies applied show very similar values among them, with few outliers and with a median value that does not show very dissimilar values among the methodologies analyzed. Regarding the minimum and maximum values observed, it can be seen that, in the case of the minimums, there are no relevant differences between the different methodologies, although the minimum value recorded seems to be the result of a project whose measurement was not correctly carried out. Regarding the maximum, SCRUM is the methodology where the maximum is four times higher than the average; this being one of the edge cases. For the rest of the methodologies, the maximum was around 25%.

Discussion and conclusions

At the beginning of this research work, the objective was to answer the following two research questions:

i) Are the project management hours related to the methodology applied?
ii) How many hours do students spend on project management?

To answer these questions, 245 undergraduate projects were analyzed from two private universities in the country, the Universidad ORT Uruguay and the Universidad de la Empresa.

Based on the results obtained and the percentages calculated, Universidad ORT Uruguay is the university with the highest number of projects where no project management hours were recorded with a percentage of 33.6%, compared to the 20.2% recorded in the company's university. If we analyze the percentage of projects that did not record management hours for the total number of projects (without discriminating by university), the percentage obtained is approximately one third of the total number of projects (29.8%).

Since this is a critical task, which is directly related to the success or failure of projects, 29.8% seems to be a very high percentage and should not be taken lightly. This means that there is no evidence, or it is not presented, indicating that students perform fundamental tasks, such as measurement, recording of work performed, follow-up, and control; basic activities of a project manager. Based on the percentage of projects that do not provide evidence of this work or that these activities were not performed, it is evident that universities should focus on stressing the relevance of performing this task, and that

students understand the importance, its impact, how to perform it, and the need to record this information.

With respect to the projects that did register the effort in management tasks, a set of observations and conclusions can be made, which are detailed below.

According to the results obtained, there is no evidence to indicate that the methodology applied is related to the effort students devote to project management tasks. The difference between the calculated bounded mean for the 3 methodologies analyzed did not exceed 1.9%; these results being 8.3%, 9.5%, and 10.2% for SCRUM, PMI, and GES, respectively. This means that regardless of the methodology used, the percentage of hours spent on these tasks does not differ significantly.

It is interesting to note that the PMI methodology, being a traditional methodology that focuses on the documentation and application of clearly defined processes, does not demonstrate an overload in the effort dedicated to management tasks over the other methodologies. Before conducting this research work, it could have been hypothesized that PMI methodology or software-specific project management require more management efforts than agile methodologies and in particular SCRUM; however, in this work, this hypothesis is discarded.

In this paper, sufficient evidence is presented to answer negatively the first research question: Are the hours of project management related to the methodology applied? According to the results obtained and presented throughout this article, we can rule out the existence of a relationship that indicates that the methodology applied throughout a project is related to the effort that students must make in project management tasks, at least in the academic context. However, having said that, it is important to highlight that there are 2 areas of knowledge that were not applied during the projects, these being supplier management and cost management. It is quite possible that, in real projects, by including these areas of knowledge, the management hours using PMI would be slightly higher than those used in this research work.

Answering the following question: How many hours do students dedicate to project management? It was the second objective of this research work. Obtaining an answer to this question based on the analysis of academic projects allows us to compare whether projects in the academic environment have the same level of dedication as real projects.

Based on the results obtained, it can be affirmed that in an academic context the effort dedicated by students to project management tasks is between 5% and 15% of the total hours dedicated to the project. As expected, there were some projects that deviated from the defined interval, in order to determine the causes, it is necessary to perform specific analyses; however, with the analyzed documentation, it was not possible to make any conclusion. It is advisable that in these cases the correctors perform this analysis and document in the projects the reasons for the deviations in order to have the necessary information available when required.

The results obtained and the defined range of 5% and 15% of the total project hours in management effort seem to be more consistent with the results expressed by other authors, as presented in the literature analyzed, as well as with the industry. Remember that Jones (2005) placed the effort in 10%, in the academic context and, being the students in charge of project management, a deviation of ±5% seems to be within the acceptable range, being these values very close to those obtained in real projects.

In conclusion, through this work and with regard to the academic context, it is evident that there is no relationship between the percentage of hours dedicated to project management tasks and the methodology used. According to the results presented,

between 70% and 80% of the projects analyzed showed evidence that the total hours spent on management tasks were between 5% and 15%, regardless of the methodology used.

Reflections and limitations

Universities are a fundamental element in the training of professionals, but even more important in the training of people who, through their skills, contribute to the society in which they are immersed. It is in this context where it is increasingly necessary to train better professionals, not only in terms of technical skills but also in social skills.

The academic plans of universities must be constantly changing, adapting to the demands of industry and society, and it is for this reason that measuring the correlation between what is taught and what industry demands is a necessity. However, in this work we measure some parameters that allow us to contrast the results obtained in the academy, for project management, with those presented in the industry. The purpose of this contrast of results is to verify whether the academic content and the university's demands on students are in line with what the industry needs or demands, or if, on the contrary, there is a gap between the academy and the industry.

This work focused on analyzing, quantifying, and presenting the results obtained from measuring the effort dedicated to one of the tasks that is closely linked to the success or failure of projects, such as project management.

During the course of this work, various difficulties have arisen that had to be overcome and that limited the number of projects, such as the existence of projects where adequate measurements, documentation or records were not made. For this reason, it is advisable for universities to emphasize the importance of measuring the effort of the tasks carried out throughout the project, giving clear and precise guidelines on how it should be done and what should be measured.

Continuity proposals

This work presents the opportunity to provide a look at project management from the point of view of academia and students, laying the groundwork for similar future work for the rest of the activities involved in a university degree thesis. In particular, it seems interesting to carry out research that focuses on the effort in development, testing, and documentation individually, as well as work that combines and presents this information in a unified way. With the results obtained, it can be investigated whether any of these tasks are directly related to the methodology used, as has been done throughout this work.

Another interesting avenue to explore is to measure project management effort in other disciplines and contrast it with the results presented in this paper in order to verify and compare the similarities and discrepancies in the effort devoted to project management tasks between software projects and projects in other industries.

Finally, this work aims to collaborate with universities by providing more information on the nature and execution of undergraduate projects, focusing on project management in the academic context. The ultimate goal of this research is to provide universities with real data from their students' own projects. Universities should not forget that they work by and for students; continuous improvement is not an option but an obligation.

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