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Applying an adaptation of the Prado Project Management Maturity Model in an academic context

Dissertação de Mestrado

Mestrado Integrado em Engenharia e Gestão de Sistemas de Informação

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STATEMENT OF INTEGRITY

I hereby declare having conducted my dissertation with integrity. I confirm that I have not used plagiarism or any form of falsification of results in the process of the dissertation elaboration.

I further declare that I have fully acknowledged the Code of Ethical Conduct of the University of Minho.

ABSTRACT

The organization's strategy of a company is determinant in its performance. Failing strategies compromise the achievement of its goals. Thus, the interest in the field of project management has been increasing and has generated several tools used by companies.

The need to develop methodologies to evaluate the performance of projects in organizations has a strong contribution to the development of maturity models. Maturity models help organizations to define their organizational strategy. The lack of knowledge of these maturity models causes organizations to experience problems in the development and improvement of their project management processes.

In this dissertation, it was developed an analysis of the most relevant models of project management maturity by comparing them. The main objective of this dissertation is to adapt and apply a maturity model to assess the evolution of the maturity of project management practices in development teams in the academic environment.

Afterward the theoretical study of the different maturity models, it was applied the Prado Project Management Maturity Model. This simplified model assesses the performance and maturity to development teams in the IT area. The model is applied to the project teams of curricular subjects of Development of Computer Applications of the second academic year and Information Systems and Technologies Project of the fourth academic year of the Integrated Masters in Engineering and Management of Information Systems course at the University of Minho.

To achieve this goal, the methodology used was the Case Study because its purpose is to gather information about the real context that allows a greater and more detailed knowledge about the topic. The Case Study was developed through questionnaires answered by the project managers of the different teams.

Through the application of the model, it was possible to compare the maturity between the two curricular units and to verify the effectiveness of the learning methods and strategies, and results in project management competencies throughout the course. Observing that there is a significant evolution in maturity from the Information Systems and Technologies Project teams compared to Development of Computer Application teams.

KEYWORDS: Project Management, Maturity Models, Project Management Maturity

RESUMO

A estratégia organizacional de uma empresa é determinante no seu desempenho. Estratégias que falham põem em causa o alcance dos seus objetivos. Desta forma, o interesse na área de gestão de projetos tem vindo a aumentar e tem gerado várias ferramentas que podem ser utilizadas pelas empresas.

A necessidade de metodologias de avaliação do desemprenho de projetos nas organizações contribui para o desenvolvimento de modelos de maturidade. Os modelos de maturidade auxiliam as empresas a definir a sua estratégia organizacional. A falta de conhecimento destes modelos de maturidade faz com que as organizações tenham problemas no desenvolvimento e melhoria dos seus processos de gestão de projetos.

No presente trabalho foram analisados os mais relevantes modelos de maturidade de gestão de projetos, através da comparação dos mesmos. O principal objetivo desta dissertação consiste na adaptação e aplicação de um modelo de maturidade para avaliar a evolução da maturidade das práticas de gestão de projetos em equipas de desenvolvimento em ambiente académico.

Após a análise teórica dos diferentes modelos de maturidade, aplicou-se o Modelo de Maturidade em Gestão de Projetos de Prado. Este modelo simplificado restringe a avaliação do desempenho e maturidade a equipas de desenvolvimento na área das TI. Este modelo foi aplicado nas equipas de projeto das unidades curriculares de Desenvolvimento de Aplicações Informáticas do segundo ano letivo e Projeto de Tecnologias e Sistemas de Informação do quarto ano letivo do curso Mestrado Integrado em Engenharia e Gestão de Sistemas de Informação da Universidade do Minho.

Para concretizar o objetivo proposto, a metodologia utilizada foi o Estudo de Caso pois o seu propósito é a junção de informação sobre um contexto real que permite um maior e mais detalhado conhecimento sobre o mesmo. O Estudo de Caso foi desenvolvido através de questionários respondidos pelos gestores de projetos das diversas equipas.

Através da aplicação do modelo, foi possível comparar a maturidade entre as equipas das duas unidades curriculares e verificar a eficácia dos métodos e estratégias de ensino em competências de gestão de projetos ao longo do curso. Observando-se, assim, que existe uma evolução significativa da maturidade de gestão de projetos das equipas de Projeto de Tecnologias de Sistemas de Informação em relação às equipas de Desenvolvimento de Aplicações Informáticas.

PALAVRAS-CHAVE: Gestão de Projetos, Modelos de Maturidade, Maturidade em Gestão de Projeto

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ACRONYMS AND ABBREVIATIONS LIST

CMM- Capacity Maturity Models

CMMI- Capacity Maturity Model Integration

DCA- Development of Computer Applications

ICB- IPMA Competence Baseline

IPD-CMM- Integrated Product Development Capacity Maturity Model

IPMA- International Project Management Association

IEC- International Electrotechnical Commission

IS- Information System

ISO- International Organization of Standards

ISTP- Information Systems and Technologies Project

IT- Information Technology

KPMMM- Kerzner Project Management Maturity Model

MF- Measurement Model

OPM3- Organization Project Management Maturity Model

PAM- Process Assessment Model

PLC- Project Life Cycle

PM- Project Management

PMMM- Project Management Maturity Model

PMBOK- Project Management Body of Knowledge

PMI- Project Management Institute

PMIS- Project Management Information Systems

Prado-PMMM- Prado Project Management Maturity Model

PRINCE- PRojects IN Controlled Environments

PRM- Process Reference Model

SE-CMM- System Engineering Capability Maturity Model

SPICE- Software Process Improvement and Capability dEtermination

SS-CMM- Supplier Sourcing Capability Maturity Model

SW-CMM- Software Capability Maturity Model

1. INTRODUCTION

This chapter consists of an introduction to the dissertation title. Firstly, an overview of the work is presented in the contextualization, followed by the motivation of the work, the research objectives, and the document's structure.

1.1 Contextualization and Motivation

Project management delivers success and can bring additional value. The lack of it exposes teams to chaotic management, unclear objectives, poor quality deliverables, non-compliance of deadline times, and over budget targets.

PRINCE 2 defines project management as "planning, delegating, monitoring and controlling of all aspects of the project, and motivation of those involved, to achieve the project objectives within the expected performance targets for time, cost, quality, scope, benefits, and risks" (Wideman, 2002).

Every organization or team wants to achieve excellence in projects. The basis for achieving excellence in project management is best described by Maturity Models in Project Management, which are composed of stages that describe different levels of maturity in project management (De Souza & Gomes, 2015).

Organizational project management maturity is an indicator or a measurement of a team or organization's ability to deal with projects (Andersen & Jessen, 2003). There is a continuing need for the development of new maturity models since they help decision-makers to achieve the classic project management goals (Mettler, 2009).

Maturity models are being increasingly applied within the field of Information Systems, as an informed approach for continuous improvement. In IT management, maturity models have proved to be an important instrument because they allow for better positioning of the academic project management teams, and help find better solutions to develop their work (Becker et al., 2009).

Universities develop projects in different areas, such as teaching. Such projects also need maturity assessment to measure their efficiency. There is a lack of studies related to maturity at the academic level, requiring an adaptation of the existing models for an educational context.

The importance of the projects for the universities and their consequent project management, becomes relevant in an academic environment. Therefore, the development of the current dissertation is

limited to Information Technology projects in an educational context to provide a comparative analysis throughout the course.

This dissertation involves personal encouragement, due to much interest in the field of IT Project Management.

1.2 Research Objectives

Within the scope of the master's dissertation in Engineering and Management of Information Systems at the University of Minho, the suggested theme consists of the adaptation and application of an assessment of maturity in IT project management teams in the course of Integrated Masters in Engineering and Management of Information Systems.

Since internal and external problems may appear in project management, models and standards were created to help evaluate how prepared or skilled an organization is in managing their projects (Fayol & Management, 2000).

The main objective of this work is to answer the research question: Is there an evolution in project management maturity when comparing the second-grade curricular unit (DCA) and the fourth-grade curricular unit (ISTP)?

This document aims to explore concepts that might contribute to further understanding of IT project management maturity. The secondary objectives to achieve the primary goal are:

- ✓ Definition of Project Management and Project Life Cycle
- ✓ Definition of IT Project Management
- ✓ Explanation of Maturity Models and Maturity in Project Management
- ✓ Implementation of a simplified assessment maturity model for information technology project management teams
- ✓ Verify the project management teams' maturity growth
- ✓ Compare the maturity in project management between "Development of Computer Application" teams and "Information Systems and Technologies Project" teams.
- ✓ Verify the effectiveness of the learning methods and results in project management competencies throughout the course.

1.3 Dissertation's Structure

The present document is structured in five chapters.

The first chapter is the Introduction. It is composed of the contextualization and motivation for the study, the research objectives to achieve, and the dissertation's structure.

The second chapter is the Literature Review, in which is presented the research strategy, as well as the definition of the most relevant concepts for better comprehension and development of the reference theme.

The third chapter is Methodological Approach. In this chapter is described the research methodology used for this dissertation. The Case Study methodology is presented.

The fourth chapter is the practical development of the case study, which includes the accomplishment of the research objectives.

The fifth and last chapter is the Conclusion. It consists of the presentation of final considerations about the developed study and possible future work.

2. Literature Review

2.1 Research Strategy

This topic refers to the research strategy used for the conception of the literature review.

To carry out a competent literature review, the databases used to collect information were:

- ✓ RepositoriUM
- ✓ Google Scholar
- ✓ Science Direct
- ✓ Web of Science
- ✓ ACM Digital Library
- ✓ Research Gate.

The selection of information was filtered by reliable and articles, books, and dissertations.

Afterward, the research strategy was executed based on keywords related to the dissertation's subject, such as:

- ✓ Project Management
- ✓ Project Management Maturity Models
- ✓ Maturity Models
- ✓ Information Systems
- ✓ Information Technology
- ✓ IT Project Management

The criteria for selecting the most relevant articles for this study were the title of the articles, books, and dissertations, secondly were their respective abstracts, and finally, the reading of all the gathered documents.

Zotero was the tool utilized to organize and cite bibliographic references.

2.2 Project Management

2.2.1 Contextualization

The basic project management terms are defined not only by the project management theory but also by the international project management standards. The basic project management standards

include the standard of the Project Management Institute (PMI), the standard of the Association for Project Management called Project IN Controlled Environments 2 (PRINCE 2), and the standard of the International Project Management Association (IPMA) (Turner & Müller, 2003).

Project management is a necessary discipline within corporations that involves planning, organizing, tracking, and controlling companies' resources to complete specific goals and objectives. These goals could be the development or production of unique products, services, or some other metrics improvements, all of which are expected to deliver additional value. Through project management, activities, and processes are conducted using various tools, skill sets, knowledge, methodologies, and techniques to meet the requirements of the projects. The main goal of project management is to ensure that the objectives of the project are achieved within specific constraints (Kerzner, 2017).

Turner says "Project management is about converting vision into reality" because project management is a structured process by which an organization can fulfill its objectives and respond to its market necessity (Turner & Müller, 2003).

The PMBOK defines project management as being "the application of knowledge, skills, tools, and techniques to project activities to meet the project's requirements". Under these standards, managing a project includes identifying needs, gathering information from different stakeholders, and balancing the limitations of the project keeping in mind the scope, quality, plan, budget, resources, and risk of the project (PMBOK®, 2017).

PRINCE2 defines project management as "planning, delegating, monitoring and controlling of all aspects of the project, and motivation of those involved, to achieve the project objectives within the expected performance target for time, cost, quality, scope, benefits, and risks" (Kostalova et al., 2015).

For a better understanding of Project Management, it is indispensable to understand what a project is. According to PMI, "a project is a temporary endeavor undertaken to create a unique product, service, or result. The temporary nature of a project indicates a definite beginning and end. The end is reached when the project´s objectives have been achieved or when the project is terminated because its objectives will not or cannot be met, or when the need for the project no longer exists" (PMBOK®, 2017).

Turner defines a project as "a temporary organization to which resources are assigned to do work and to deliver beneficial change", where human, material and financial resources are organized in three main features: unique because no project will be the same, resources and conditions are hardly replicable. It is transient, projects have a defined beginning and end. And used novel processes because the approach and the final result is intended to be distinctive from other projects" (Turner & Müller, 2003).

Similarly, all these standards particularly point out the temporariness of a project and the uniqueness of the outcome project implementation brings.

Since there are still projects that fail due to poor management, including the applicability of project management tools and techniques, project management provides better development of their projects to ensure better management of the resources, within time, cost, and quality constraints (Atkinson et al., 2006).

According to the Association for Project Management, every project needs a manager to ensure its success. Someone with their eye on every detail at every stage from inception to completion. It is therefore imperative that the project team and especially the project manager have not only the necessary skills but also the best tools to help them get it right the first time. Project manager and their teams face increasing challenges as projects become more complex, due to, for example, increasing technological evolution, multidisciplinary and globalization, along with increasing competitiveness. A successful project needs people with the right skills and knowledge working together. A well-managed team with clear roles and responsibilities will carry a project to its conclusion without compromising on time, cost, and quality (APM, 2012).

Project definitions, although useful for project managers, may not be sufficient for a clear perspective, and understanding some of their characteristics is fundamental. Some characteristics are:

- ✓ Projects are unique undertakings that result in a single unit of output. It is a unique undertaking because the manager of an organization is not likely to repeat this process frequently.
- ✓ Projects are composed of interdependent activities. Every activity has a relationship one to another.
- ✓ Projects create a quality deliverable. A project is not considered complete if the project's deliverable does not meet its quality specifications.
- ✓ Projects involve various resources. To avoid conflicts, due to the multiple resources involved - such as human, technologies, techniques, and approaches– it is needed a very good project managing.
- ✓ Projects are driven by different competing constraints, depending on the priorities established by the managers of an organization. They are a balance between scope, schedule, quality, resources, and budget (Kerzner, 2017).

How a project is managed is determined by which is the driving force of the project. This set of characteristics of a project delivers quality-approved products or services (Frame, 2011).

PMBOK advocates that despite the project's different dimensions and complexities, all of them have identical life cycles.

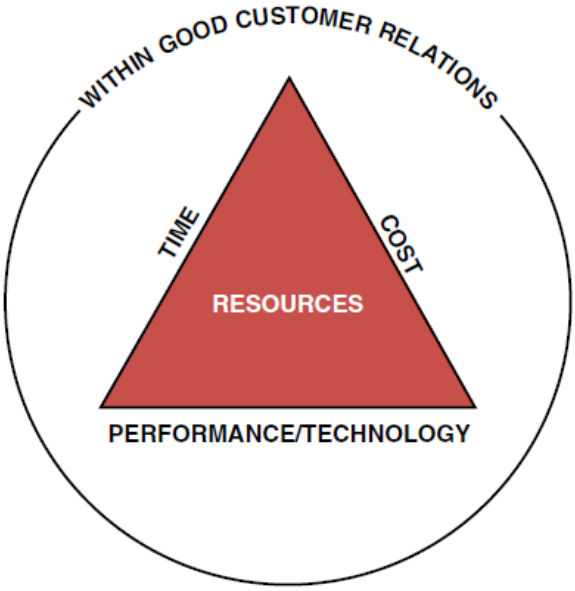

Figure 1- Project Management ((Kerzner, 2017))

2.2.2 Project Life Cycle

Having in consideration that a project has a well-defined beginning and end and is not self-perpetuating, it is associated with a life cycle (Kerzner & Institute for Learning, 2010). The Project Life Cycle (PLC) provides the work that must be done in each phase of the project in its development. Understanding the project life cycle is essential for the initial planning, in what comes to effort and timing, as well as for re-planning all critical milestones (Software Engineering Institute, 2002).

A project's preparation and implementation are constituted by different phases, which together form the project life cycle. Regardless of each phase, this aims to improve the conditions for controlling activities, allowing greater focus on distinctive processes and activities in every phase. If necessary, it is possible to continue the activity of dividing the structure into lower levels until a clear arrangement (Kostalova et al., 2015).

According to the standard of the Project Management Institute, division of a project into partial phases brings better control over the project and better interconnection within the organization (PMBOK®, 2017). Figure 2 represents the project life cycle presented by Kerzner.

Table 1- Project Life Cycle

Project Life Cycle	Description
Kerzner	Conceptual: The first phase includes a preliminary analysis of risk and the resulting impact the time, cost, and performance requirements.
	Planning: The second phase, consists of a refinement of the elements of the conceptual phase, the identification of the resources required, the preparation of necessary documentation to support the projects, and the establishment of the realistic time, cost, and performance.
	Testing: The Testing phase is predominantly a testing and final standardization effort so that operations can begin, and almost all documentation must be completed at this stage.
	Implementation: This phase integrates the project's delivery into the organization.
	Closure: This closure phase evaluates the efforts made in the ongoing project to serve as input to the conceptual phase of the following models that the organization is going to develop.

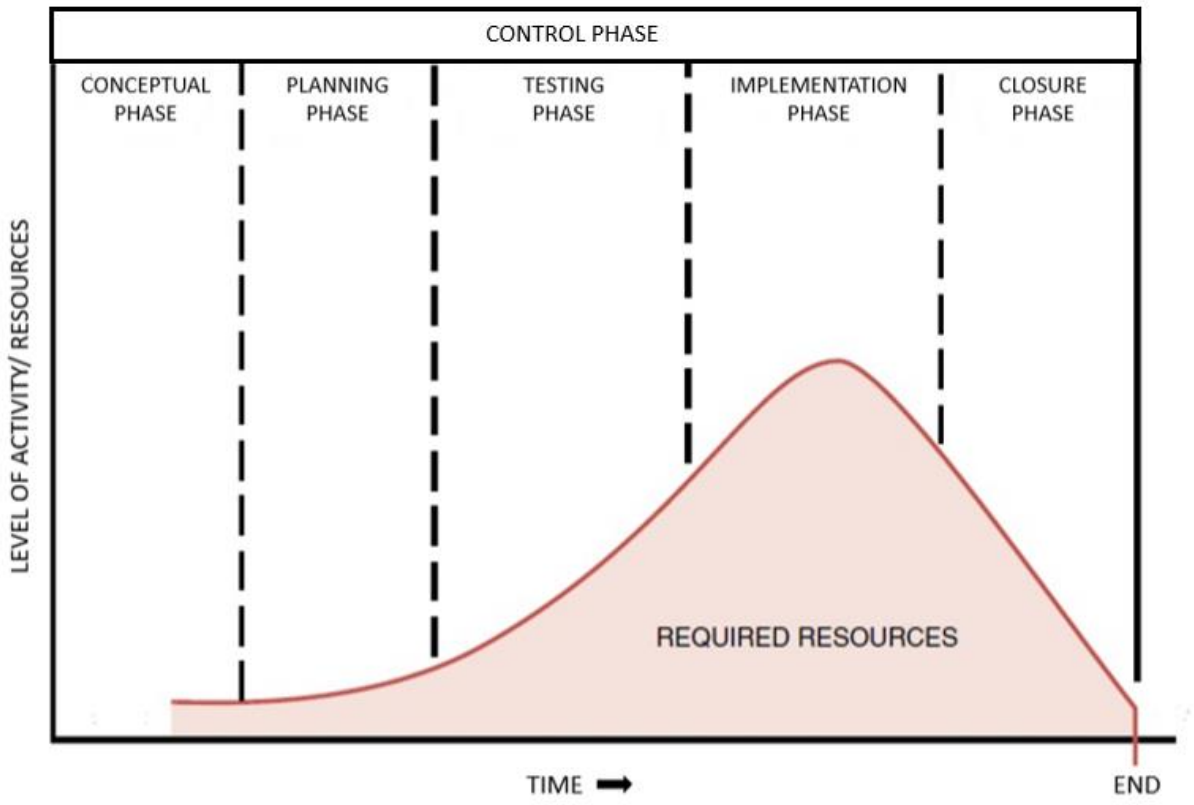

Figure 2- Project Life Cycle (adapted from (Kerzner & Institute for Learning, 2010))

2.2.3 IT/IS Project Management

Information systems (IS) and Information Technology (IT) are the fastest growing industries in developed countries. To maintain a competitive edge, an organization's success depends on the effectiveness of developing IS. The nature of Project Management Information Systems (PMIS) has changed and is still developing considerably from single-user/single-project management systems to complex, distributed, multi-functional systems that no longer only cover project planning (Ahlemann, 2009).

Using PMIS to manage projects, while not sufficient to ensure project success, has thus become a necessity. PMIS helps to reduce the time spent in project management, simplifying the implementation of the related methods, tools, and techniques thus increasing the success rate. PMIS is projected to support project management during all phases of the project life cycle (Kostalova et al., 2015).

PMIS allows its users to follow a project since the idealization phase up to its conception and provide fundamental information to the project managers and other elements, such as resources, budget, suppliers, time management, tasks assignment, quality control, documentation, and collaborative tools (Braglia & Frosolini, 2013).

Important quality indicators of a PMIS are its ease of use, flexibility, agility, intuitiveness, and capacity of integration with other systems. The quality of PMIS is a strong indicator of the quality of the provided information. PMIS is useful to project managers, improving the effectiveness and efficiency of their tasks in terms of planning, scheduling, monitoring, and controlling. Usually, they have benefits in the decision-making process and their advantages are not limited only to individual performance. Thus, these PMIS have a direct impact on the project's success (Raymond & Bergeron, 2008).

Many organizations employ IT in one form or another to manage their knowledge. It is primarily used to store and transfer explicit forms of knowledge. However, IT is not just about computers. IT should be understood less in its storage capacity but more in its potential to aid collaboration and cooperation between people. IT should be seen as a tool to assist project management in organizations, such a process relies more on the face-to-face interaction of people on static reports and databases (Davenport & Prusak, 2000).

The rapid development of IT has profound ramifications of project management, particularly in changing the way projects are planned and managed in a near future. Projects tend to be more and more complex, with thousands of activities and resources. Also, it will allow a larger number of options, products, and solutions to be considered, appraised, and implemented (Jaafari & Manivong, 1998). The result should have significant benefits in both time and cost, as well as an improved realization of project value and goals.

The PMI can provide significant benefits if designed properly, such as:

- ✓ Integrating information across the entire project life cycle, from feasibility study through to execution and finalization.
- ✓ Providing the information needed for the various stakeholders on time.
- ✓ Lowering the cost of collecting the right information.
- ✓ Processing and reporting to highlight the status of the project at any point in its life.
- ✓ Providing the current information needed for decision making.
- ✓ Providing value to the company.
- ✓ Inter-operability and compatibility. In a multidiscipline project, the PMIS must be fully interfaced with other systems and in use on the project. PMIS must act as the governing system, making information selectively available to other systems or teams because of the need to exercise centralized control over the management of the entire project information sets. (Jaafari & Manivong, 1998)

2.3 Maturity Models

2.3.1 Contextualization

Maturity models are a mechanism capable of numerically quantify an organization's ability to successfully manage projects (Prado & Oliveira, 2013).

Maturity models as based on the premise that people, organizations, functional areas, and processes, evolve through a process of development or growth in the direction of more advanced maturity, going through a distinct number of levels. A level is a model in a base from which evolution to a higher maturity level can be planned and implemented (Mettler & Rohner, 2009).

The maturity model aims to quantify the activities carried out, make them measurable, and develop, in other words, make them be matured over time (Goksen et al., 2015).

The concept of maturity models is increasingly being applied within the fields of information systems (IS), both as an informed approach for continuous improvement and its purpose is to identify the gap which can then be closed by subsequent improvement actions.

The commonly used basis for assessing maturity in IS are therefore people, processes, or objects. However, today most of the models are multidimensional, including affected processes, organizational units, problem domains, etc. (Wendler, 2012). Maturity is in most instances reflected on a unidimensional manner:

- ✓ Process maturity (a specific process is explicitly defined, managed, measured, controlled and effective)
- ✓ Object maturity (object like a software product, a company report or similar reaches a predefined level of sophistication)
- ✓ People capacity (the workforce can enable knowledge creation and enhance proficiency) (Software Engineering Institute, 2002).

Organizations face constant pressure to achieve and maintain a competitive advantage by inventing and reinventing new products and services, reduce costs, time to market, and at the same time improve the quality. There is a continuing need for the development of new maturity models since they help the decision-makers to achieve these goals (Mettler, 2009).

Developing maturity is a continuous process. Improvements in maturity depend on a concentrated effort to develop, improve, and foster communication between executives and professionals in project management (De Souza & Gomes, 2015).

A maturity model consists of a sequence of maturity levels for a class of objects (organizations or processes). It represents an anticipated, desired, or typical evolution path of these objects shaped as discrete stages. The bottom stage stands for an initial state that can be, for instance, characterized by an organization having little capabilities in the domain under consideration. In contrast, the highest stage represents a conception of total maturity. Advancing on the evolution path between the two extremes involves a continuous progression regarding the organization's capabilities or process performance. The maturity model serves as the scale for the assessment of the position on the evolution path. It provides criteria and characteristics that need to be fulfilled to reach a specific maturity level. During a maturity assessment, a snapshot of the organization regarding the given criteria is made. The characteristics found are evaluated to identify the appropriate organization-individual maturity level (Becker et al., 2009).

Cooke-Davies suggests, maturity models "seek to do for organizations seeking to implement strategy through projects what 'bodies of knowledge' have done for individual practitioners seeking to improve their ability to manage projects" (Crawford, 2006).

Maturity models can be used to support the analysis and assessment of skills and development-levels of products, processes, or organizations by defining different levels of maturity, to assess the extent to which an object fulfills defined qualitative requirements. The various levels of maturity within such models can be used to describe the different achievable skill levels. Maturity models not only include methods of the assessment of skill levels but also provide incentives and measures to increase the degree of maturity. After the introduction of measures to increase the skill level of maturity, these models are also suitable to measure and evaluate the progress made (Kluth et al., 2014).

Maturity models for evaluation issues have several benefits such as finding vulnerabilities and identification of improvement measures, better control over costs and time, or an earlier and more accurate predictable release and introduction of complexity management activities. Further, the companies get the capability for self-assessment and comparison with other companies by getting transparency of the organizational, technical, and operational status as well as the early identification of deviations from targets and risks (Kluth et al., 2014). Maturity models are increasingly popular frameworks for supporting assessment and guiding organizational improvement (Mullaly, 2014).

These models were developed as a response to the need of measuring progress achieved by the organization as the result of continuous improvement. They constitute an attempt at a quantitative evaluation of qualitative features. Becoming more mature means systematic improving organization business processes, that they are capable of delivering higher performance over time (Hammer, n.d.). The maturity model is a framework of tools and practices, enabling a comprehensive assessment of the

organization's key competencies in managing and improving crucial factors leading to the established goals (Kosieradzka, 2017).

The distinction between organizations with more or less mature systems relates not only to the results of the indicators used but also with the fact that mature organizations measure different indicators when comparing to less mature organizations (Proença & Borbinha, 2016). Maturity models have become an important topic in both Information Systems (IS) research and practice. Organizations will increasingly adopt maturity models to stimulate and guide the development of there IS capabilities. The need for new maturity models will not diminish, as they are valuable tools to assist decision-makers in practice (Mettler et al., 2010).

As to the purposes of maturity models, it has consistently been argued that they can support the self of third-party assessment, as well as benchmarking, and provide a roadmap for continuous organizational improvement. So, a descriptive, comparative, and prescriptive purposes of maturity models were identified. The descriptive purpose of use maturity assessment, which can be thought of as a snapshot of an organization regarding its performance at a certain point. Based on the descriptive purpose, a comparison can then be made in the form of benchmarking against best-in-class organizations. Finally, because many maturity models also have prescriptive components, they further allow for organizational improvement, that is, step-by-step progression on the predetermined sequence of maturity stages (Poeppelbuss et al., 2011).

Maturity models vary in terms of application (processes vs organizations vs humans) and purpose (improvement vs description).

The basic components of maturity models are:

- ✓ Number of levels (typically three to six)
- ✓ A descriptor for each level (such as the CMM's differentiation between initial, repeatable, defined, managed, and optimizing processes)
- ✓ A generic description or summary of the characteristics of each level as a whole
- ✓ Number of dimensions (such as the "process areas" in CMM)
- ✓ Number of elements or activities for each dimension
- ✓ A description of each element or activity as it might be performed at each level of maturity (Mettler et al., 2010).

Three basic maturity model designs can be distinguished:

- ✓ Maturity grids: aim at illustrating the number of levels of maturity in a simple, textual manner

- ✓ Likert-like questionnaires are comparable with maturity grids, but the focus is more inclined on to scoring specific statements of "good practice" and not to describe the overall levels of maturity
- ✓ CMM-like models: which are based upon a more formal architecture, specifying the number of goals and key practices to reach a predefined level of sophistication (Mettler et al., 2010).

2.3.2 CMMI

The Capability Maturity Model Integration (CMMI) is a model for integrating capacity maturity establishing a guide to be used in the development of the processes' organization. CMMI was developed to integrate the various Capability Maturity Models (CMM) into a single improvement framework. The purpose of CMMI is to provide improvements for organizations' processes and the ability to manage the development, acquisition, and maintenance of products and services (De Souza & Gomes, 2015).

CMMI was created for two basic objectives, which are to guide process improvement efforts in software development organizations and to help identify skilled and qualified organizations to perform software work (Goksen et al., 2015).

According to the CMMI Institute, a process area for CMMI consists of a set of related practices in an area that satisfies various process goals considered important for making significant improvements in that area. These process areas can be grouped into four categories such as engineering, project management, process management, and support (Software Engineering Institute, 2002).

CMMI Institute released CMMI V2.0. Due to the feedback of thousands of customers, CMMI V2.0 is an evolution of the CMMI, and this upgrade has impact changes in four main areas:

- ✓ Focus on performance: allows organizations to understand performance needs, and consequently how to establish these performance goals and measure them to achieve the intended maturity;
- ✓ Integrated Agile with Scrum, safety, and security: helps organizations, which already have an agile practice in place, to improve these same practices to address critical business needs;
- ✓ Value-added appraisals: focus on lowering the total life cycle costs and developing time, to ensure and enhance confidence and reliability to appraisal results;
- ✓ Easier to use and access: due to the less technical knowledge needed to use CMMI. There is also an online platform where users can build models that fit best to specific business needs (Software Engineering Institute, 2002).

CMMI framework contemplates the following models:

- ✓ CMMI-SW: which contains Software Engineering subjects
- ✓ CMMI-SE: which contains System Engineering subjects
- ✓ SMMI-SW/SE: which integrates Software and Systems Engineering subjects
- ✓ CMMI-SW/SE/IPPD: which integrates Software and Systems Engineering and Integrated Product and Process Development subjects
- ✓ CMMI-SW/SE/IPPD/SS: which integrates Software and Systems Engineering, Integrated Product and Process Development, and Supplier Sourcing subjects (Software Engineering Institute, 2002).

The CMMI categories are process management, project management, engineering, and support. Each of these categories are composed of different process areas. Maturity levels consist of a predefined set of process areas. The maturity levels are measured by the achievements of the goals that apply to each predefined set of process areas (De Souza & Gomes, 2015).

To decide which CMMI model best fits each organization, it must be selected a representation, either continuous or staged.

A staged representation provides a proven sequence of improvements, beginning with basic management practices and progressing through a predefined and proven path of successive levels, each serving as a foundation to the next. It permits comparisons across and among organizations by using different maturity levels, providing better assessment results. A staged representation provides a strategy for the organization, a structured path towards continuous improvement, indicating one-step at a time, which are the maturity levels.

While in a continuous representation, it is expected that the model allows selecting the order of improvement that best meets the organization's business objectives. The continuous representation consists of the same process areas as the staged representation. However, no process area is assigned to a certain maturity level. Instead, they are assigned to a capability level. This representation enables comparisons among and across organizations on a process area by comparing results through using equivalent staging (Huang & Han, 2006; Software Engineering Institute, 2002).

The maturity levels are related to the staged representation and are applied to represent an entire organization. The capacity levels are related to the continuous representation and are applied to Process Areas that establish the organizational improvement process.

Whether used for process improvement of assessments, both representations are designed to offer essentially equivalent results. Figure 3 presents the comparison between capacity and maturity levels.

Levels	Continuous representation (Capability Levels)	Staged representation (Maturity Levels)
0	Incomplete	
1	Performed	Initial
2	Managed	Managed
3	Defined	Defined
4	Quantitatively Managed	Quantitatively Managed
5	Optimizing	Optimizing

Figure 3- Comparison between Capacity and Maturity levels (adapted from (Duarte & Martins, 2011))

CMMI is constituted by five maturity levels: Initial, Managed, Defined, Quantitatively Managed, and Optimized. Each achieved level represents the increasing maturation of the software development process.

The first level, Initial, is a level where the processes are unpredictable and poorly controlled. It represents the absence of defined and stable processes for the development and maintenance of software. At this level, the processes are like a black box where the interior visibility is very limited.

Figure 4- CMMI Maturity Level 1 (adapted from ((Sousa & Catarino, 2009))

The second level, the Managed level, assures that the basic project management processes are established and documented, allowing to monitor variables such as time, cost, and effort. These basic project management processes are requirement management, project planning, and measurement and analysis.

At this level, there are points of control through the project, which provides better visibility of the processes and the project. Although, there are still black boxes between the points of control.

The projects are based on lessons learned about previous similar experiences.

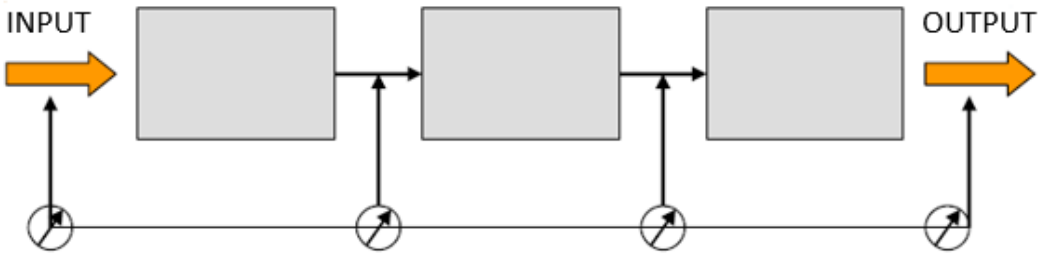

Figure 5- CMMI Maturity Level 2 (adapted from ((Sousa & Catarino, 2009))

The third level is the Defined level. In this third level of maturity, the software processes are standardized and documented, following an organizational standard. Therefore, every project follows an approved and adapted version of the organization's standard software development process. This improves the organization's productivity.

Besides the points of control through the project, at this level, there is the visibility of the activities in each process.

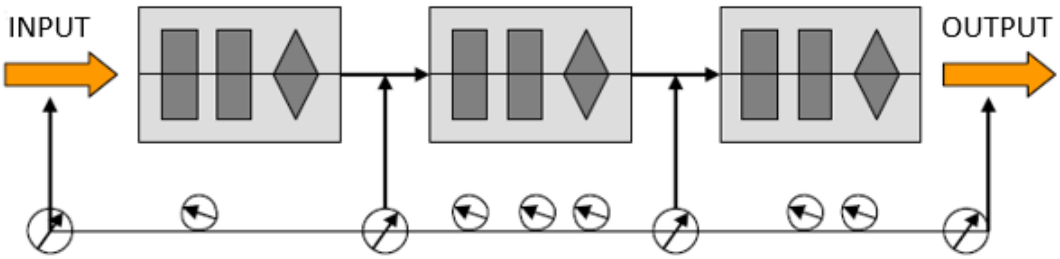

Figure 6- CMMI Maturity Level 3 (adapted from ((Sousa & Catarino, 2009))

The fourth level, Quantitatively Managed, is monitored by detailed and consistent measures.

The processes' quality and performance are managed and understood in statistical terms. At this level, the process is measured, and these measures provide input to feed their processes.

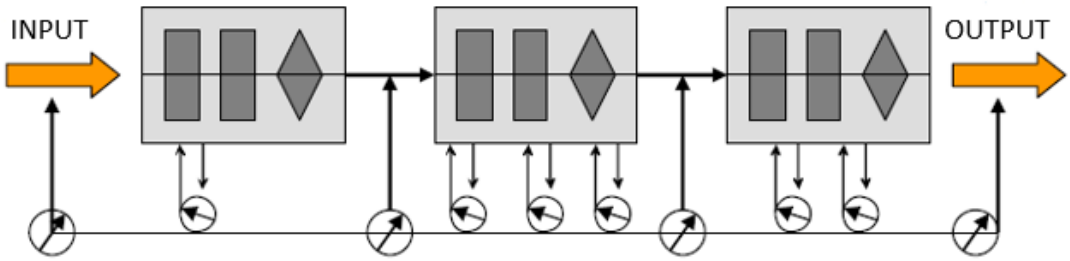

Figure 7- CMMI Maturity Level 4 (adapted from ((Sousa & Catarino, 2009))

The Optimized level focuses on continuous Process and Technology Improvement. Process and technology improvements are already planned and managed, and its purpose is to optimize the organization's overall activity.

At this level, the goals are to prevent weaknesses, and the lessons learned are used in other projects of the organization.

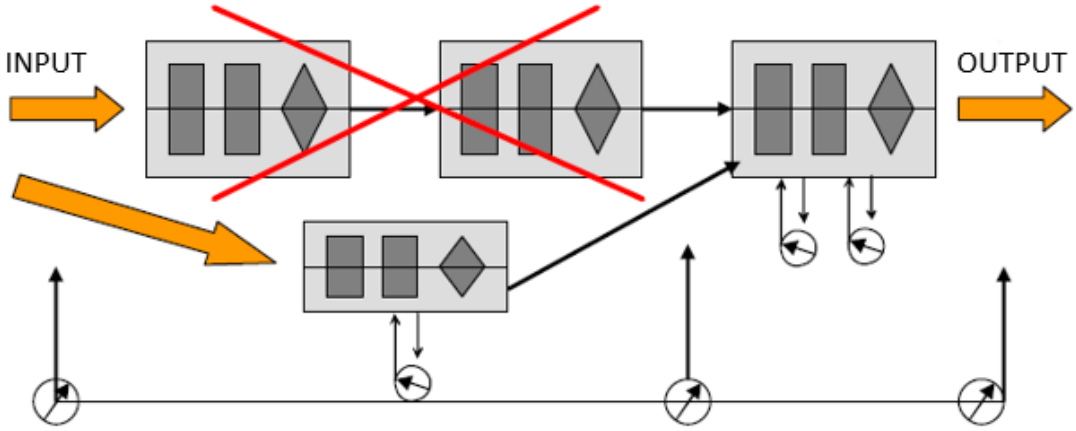

Figure 8- CMMI Maturity Level 5 (adapted from ((Sousa & Catarino, 2009))

2.3.3 ISO 33000

The Software Process Improvement Capability dEtermination (SPICE) includes the well-known ISO/IEC 15504 as a model applied in many organizations for improving and evaluating processes. The recent ISO/IEC 33000 series replaces the previous series 15504 and enlarges its application field and scope (Fernández Del Carpio, 2018).

ISO/IEC 33000 defines all essential objectives required for adequate software engineering and is applied to every software organization who aims to ensure software development, operation, improvement, and support adequacy.

After more than 20 years, since the first release of the ISO/IEC 15504 standard, the experience of the application of such standard shows that the basic structure of its process assessment model is valid and effective. SPICE was one of the main inputs to CMMI's initial project (meant as an evolution of the old CMM-SW) and the basic model for a series of customizations for different application domains (Lami et al., 2014).

The key concepts ISO/IEC 33000 relies on the key elements of the overall model for a software process assessment as defined in the ISO/IEC 33000, such as: Process Reference Model (PRM) which is composed of a set of interrelated processes, Measurements Framework (MF) for measuring quality

characteristics of capability, and Process Assessment Model (PAM) for assessing quality characteristics of processes (Fernández Del Carpio, 2018; Lami et al., 2014).

The Process Reference Model (PRM) is composed of a set of interrelated processes. These defined processes shall be part of a life cycle and shall contain a declaration of the domain of the process reference model; the description of the processes' purpose and outcomes necessary and sufficient to achieve the purpose of the process, together with an architecture scheme that describes the relationship between the processes of the model. The PRM addresses sustainability both in their purpose statement and in the list of process outcomes. This sustainability proposal aims to strengthen PRM and make them more compatible with the sustainability that the Measurement Framework is addressed (García-guzmán et al., 2013).

The Measurement Framework (MF) is a model used to assess quantitative rating to a quality characteristic of a process. In this way, the new ISO/IEC 33000 standard series represents a great opportunity to take advantage of the efforts made in defining and applying SPICE, by measuring process sustainability and not only capability. The assessment components of a Measurement Framework are the Levels (points on an ordinal scale), the Process Attributes (measurable characteristics of a process), and Rating Scale (a set of values/categories to which an attribute is scaled).

The Process Assessment Model is a model for assessing the quality characteristics of the processes. So far, only process quality characteristics of capability have been addressed. And once a sustainable Measurement Framework and PRM have been defined, the PAM can be used without any change (Fernández Del Carpio, 2018; Lami et al., 2014). Figure 9 presents the ISO 33000 structure.

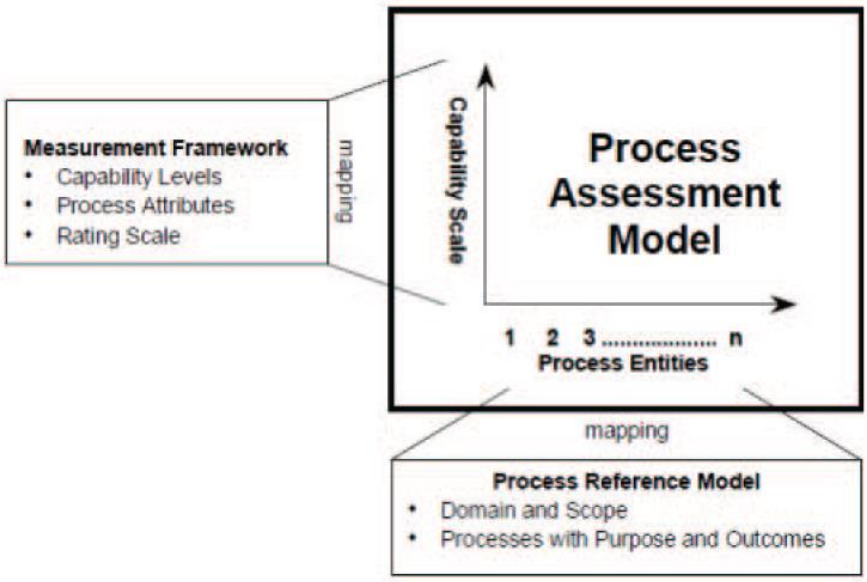

Figure 9- ISO 33000 Process Assessment Model structure ((Lami et al., 2014))

2.4 Maturity in Project Management

2.4.1 Contextualization

Measuring the maturity of an enterprise regarding its project or program management success capabilities has become an important subject (R. D. Archibald & Prado, 2014). "The concern with maturity in project management has arisen in organizations because projects represent the best way to change a complex situation" (Rabechini Jr. & Pessôa, 2005).

Improving organizational project management maturity is a concern for organizations because evaluating the current performance of an organization is easier in theory than in practice. It is so complicated that it is necessary to use models to simplify the interpretation of the entire organization (D. Silva et al., 2014).

Organizational project management maturity is an indicator or a measurement of an organization's ability to deal and implement with projects both efficiently and effectively (Andersen & Jessen, 2003; Görög, 2016). The concept of project maturity is closely linked to their potential for success/failure. Maturity models seek to quantify the ability of a company to manage projects successfully (De Souza & Gomes, 2015).

Instead of making action plans when the value obtained does not match the planned values, high maturity project management avoids the problems proactively by predicting them before they occur (Cerdeiral & Santos, 2019).

Over time, organizations have observed that the adoption of a project management methodology does not guarantee the success of a project. Organizational factors, external to the project, influenced the success of the projects, arising the need to prepare and adjust the entire organization for project management (Prado, 2010).

Measuring maturity will perhaps always be more subjective than objective (Andersen & Jessen, 2003). Non-factors influence project management capability. Multiple non-process factors are attributed to a mature project management capability responsible for undefined projects. They include human factors, such as trust, attitude, and motivation, along with increased customer involvement and a more adaptable organizational environment (Miklosik, 2015). Every aspect of project management has two dimensions: a technical dimension and a human dimension. The technical dimension encompasses practices or processes that are integral to project management. While the human dimension includes not only the people who are operating these industries but their expertise (Cooke-Davies & Arzymanow, 2003).

However, many companies report difficulties in achieving high maturity. The most-reported difficulties are the effort to gather, understand and analyze data to ensure its integrity; the amount of historical data needed to collect to achieve confidence in statistical analysis; the correlation between organizational and project goals; and the need for solid correlation between critical sub-processes that support those goals (Cerdeiral & Santos, 2019).

The term project maturity might be used as an indicator or a measurement of the organization's ability to use projects for different purposes (Andersen & Jessen, 2003). The purposes of these models are to:

- ✓ Assess the current state of maturity and identify where improvements are required
- ✓ Improve both the selection and the execution of the enterprise´s programs and projects by providing guidelines to reach higher level maturity
- ✓ Benchmark with other organizations, one enterprise of one division of an enterprise against its competitor
- ✓ Give clear indicators of strengths and weaknesses
- ✓ Collect potential value to create significant competitive advantages: such strategic value) higher-level maturity is a competitive advantage), benchmarking value (highlight needs for developing maturity), and performance value (higher-level maturity leads to better performance) (R. D. Archibald & Prado, 2014; Görög, 2016).

2.4.2 Prado Project Management Maturity Model (Prado-PMMM)

The Prado Project Management Maturity Model (Prado-PMMM) was developed in 2002 by Darci Prado in partnership with Russel Archibald.

The Prado-PMMM was based on the CMMI model and has the objective to evaluate the maturity of an organization's department, such as engineering, information technology, product development, and many more since it is a departmental model.

It provides two types of maturity assessment: sectorial, which assesses only a certain sector or department of the organization; and corporative, which assesses the entire institution.

Prado examined the level of maturity compared to organizational practices and the evidence points to a positive relation between maturity levels and good organizational practices (R. D. Archibald & Prado, 2014).

The maturity levels of the model are: Initial, Known, Standardized, Managed, and Optimized. The maturity levels are explained in table 2 and graphically represented in figure 10.

Table 2- Prado PMMM Maturity Levels (adapted from (R. D. Archibald & Prado, 2014; Prado, 2010))

Maturity Levels	Description
Initial	Level 1 is the Initial level, where there is no planning, control, standard procedures. This level demonstrates a total misalignment between the project's stakeholders and project management practices.
Known	Level 2, named as Known, represents the awakening of project Management, it involves an introduction in project management and the use of necessary tools. There are isolated initiatives for planning and control of some projects, in other words, each professional works in its way, because of the lack of a standardized platform for PM, consisting of processes, tools, and organizational structure.
Standardized	Level 3 represents the situation where project management has been implemented. It involves the existence of project management practices, the use of baseline and performance measurement, and consequently an evolution in skills.
Managed	Level 4 is the Managed level and it represents the situation where the project management is an incorporated tool for every activity and runs naturally in the departments. It involves the elimination of anomalies; professionals consistently demonstrate a high level of competence and the results are consistent with what is expected.
Optimized	This level consists of doing the right thing, at the right time, with minimal costs and low stress. At this stage, there is a total alignment between the project's stakeholders and project management practices. This level provides the practice of continuous improvement, and technological and process innovation.

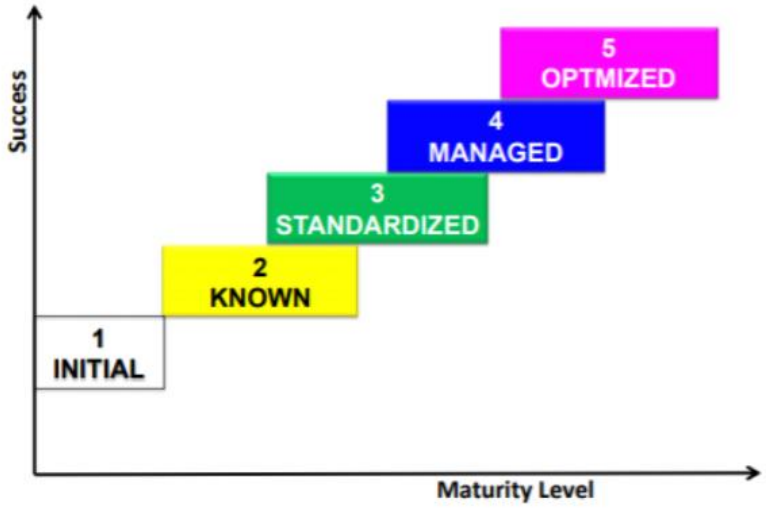

Figure 10-Prado Project Management Maturity Levels (Prado, 2010)

Prado PMMM dimensions or fundamental aspects, together with the maturity levels, provide a better maturity assessment. The progression through the five levels is based on Project Competence, Methodology Usage, Computerization, Behavioral Competence, Technical and Contextual Competence, Organizational Structure. Each maturity level can contain these dimensions:

- ✓ Project Management Competence: This dimension represents the basics knowledge in project management and the knowledge of other management practices applied throughout the organization. It is from the second level – Known – that this dimension begins its structuring, extending to the remaining levels.
- ✓ Technical and Contextual Competence: People involved in this area must be competent in technical aspects of the product/service as well as on aspects of the organization.
- ✓ Behavioral Competence: This dimension aims to provide the improvement of interpersonal relationships, minimizing the daily conflicts between the project's stakeholders. It is from the fourth level – Managed – that this dimension becomes more evident. People involved must be competent in behavioral aspects such as leadership, organization, motivation, and negotiation.
- ✓ Methodology: In this dimension, it is presented a definition of a unique methodology for the organization, as well as the use of methods, techniques, and tools, for example, the PMBoK Guide. The "Methodology Usage" dimension contributes to a greater emphasis on the model on the third level – Standardized. There must be a project management methodology, which involves an entire cycle that needs to be followed.

- ✓ Computerization: A computerized system is the repository of the planning and monitoring data of each project. Relevant aspects of the methodology must be computerized, and the system must be easy to follow.
- ✓ Strategic Alignment: The alignment of the organization's current and future projects, along with its strategic objectives, are the principal focuses of this dimension. It is necessary for a Strategic Alignment because it defines functions, rules, and regulate relationships between project managers and the various areas of the organization involved with projects.
- ✓ Organizational Structure: It consists of an appropriate structure for project management simultaneously with the structure of the organization. Organization Structure consists of structuring an appropriate organizational system that focuses on maximizing results and minimizing conflicts (Prado, 2010).

Figure 11 presents the Prado Project Management Maturity Platform.

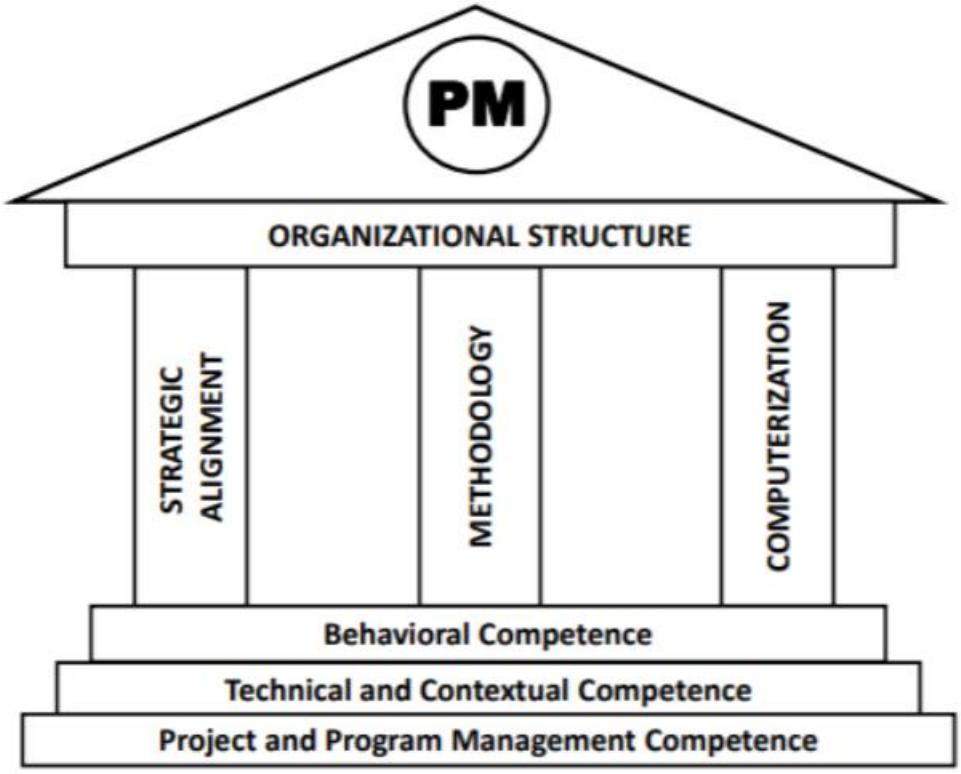

Figure 11- Prado Project Management Platform ((R. D. Archibald & Prado, 2014))

The following figure describes the relation between the six dimensions and the maturity levels above described.

Table 3- Relation between Maturity Dimensions and Maturity Levels (adapted from (B. R. D. Archibald & Prado, 2014))

Maturity Dimensions	Maturity Levels				
	Level 1 Initial	Level 2 Known	Level 3 Standardized	Level 4 Managed	Level 5 Optimized
Project Management Competence	Nonexistent	Basic	Basic	Advanced	Advanced
Technical and Contextual Competence	Nonexistent	Basic	Basic	Advanced	Advanced
Behavioral Competence	Good Will	Basic	Some Advance	Advanced	Mature
Methodology	Nonexistent	Isolated Initiatives	Standard and Implemented	Improved	Stabilized
Computerization	Isolated Initiatives	Isolated Initiatives	Implemented	Improved	Stabilized
Strategic Alignment	Nonexistent	Nonexistent	Nonexistent	Aligned	Aligned
Organizational Structure	Nonexistent	Nonexistent	Implemented	Improved	Stabilized

Through the application of a forty-question questionnaire, Prado-PMMM quantifies a value for the maturity of the organization's project management, as well as obtaining a perception of the development in each of the five levels of maturity. The model relates the results obtained with the dimensions of the model, assigning a percentage value to each dimension. This model is not restricted to the resulting data provided by the assessment. Such results are basic for a growth plan. In parallel with the model, the author provides studied information on the Brazilian scenario in project management, which is updated annually and includes various business areas. This fact makes it possible for organizations to orient themselves and set goals for their future growth (Prado, 2010).

The author assumes that an organization's project management success grows continuously as the organization progresses through the model's maturity levels. Thus, the more mature an organization is, the more successful it will be (Prado & Oliveira, 2013).

The case study presented corresponds to research that aimed to outline the profile of the Junior Company Movement ("*Movimento Empresa Júnior*"). This case study is compared to previous studies about private Brazilian organizations.

Out of one hundred and eight questionnaires, thirty-three questionnaires were answered. In this work are listed the thirty-three junior organizations such as its respective state and working area. The distribution percentage of the three principal respondents by the state is 24,3% from Rio de Janeiro, 21,2% from Minas Gerais, and 15,9% from Pernambuco. The distribution percentage of the three principal working areas are 35,3% are Administration, 20,6% are Engineering, and 14,7% are Computation. After a maturity assessment of the Junior Company Movement, the distribution percentage of the maturity levels are 26,5% in the Initial level, 55,9% in the Known level, 14,7% in the Standardized level, 2,9% in Managed level, and 0% in Optimized level.

The average maturity of the thirty-three respondent organizations is 2,41. This value is almost identical to the value obtained by the assessment of maturity in private organizations, which is 2,45, both using the Prado Project Management Maturity Model.

Important data was obtained by comparing the previous researches mentioned, using Prado PMMM. This indicates that the level of maturity of the Junior Company Movement is very similar to the levels of private organizations, including the third sector and the government. This generates greater reliability for junior companies to society since this junior sector is like the other sectors. From this study case, it can be traced some initiatives to implement maturity seeking to reach an even better level of excellence.

Prado-PMMM was applied in dozens of organizations and the results shown are consistent with the results of a thorough diagnosis conducted in parallel. A practical application of Prado-PMMM was made in the Federal Government Institute of Science and Technology in Brazil. This Institute has a vast project portfolio and aims to increase knowledge in science-technology solutions through development and innovation. This maturity has been proved useful in establishing a growth plan for the organizations and has received compliments about its simplicity and ease-of-use (Emmanuel & Carneiro, 2005). Figure 12 represents the maturity level by area of expertise.

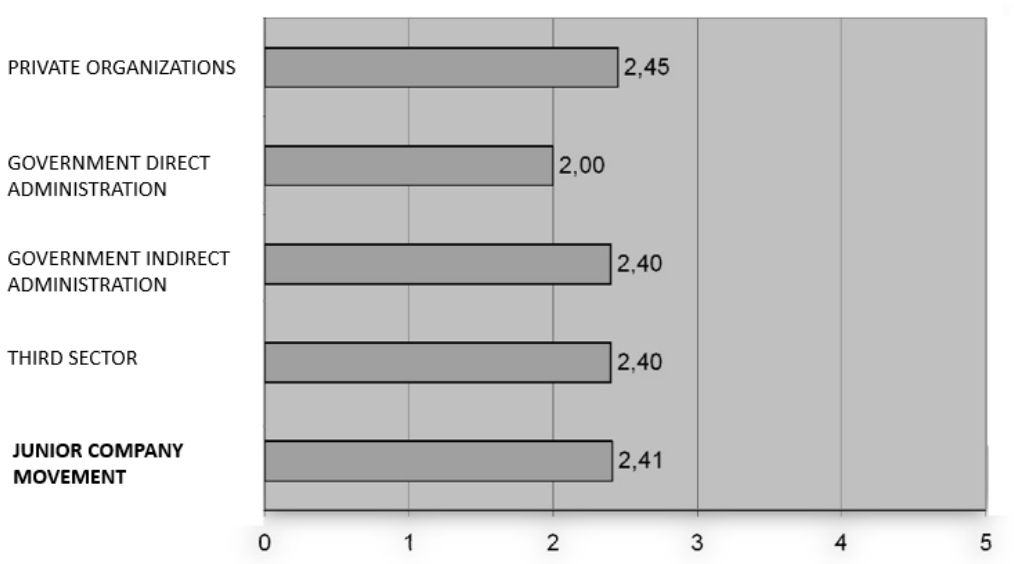

Figure 12- Maturity Level by Area of Expertise (adapted from (Emmanuel & Carneiro, 2005))

2.4.3 Kerzner Project Management Maturity Model (KPMMM)

The Kerzner Project Management Maturity Model, created by Dr. Harold Kerzner, in 1998, defines the actual stage, plan, and actions to implement and develop project management gradually (Kerzner, 2004). The model presents itself as an extension of the CMMI model, focused on the field of project management. The model proposed by Harold Kerzner is distinguished from the others by offering methods to assess each level of maturity (De Souza & Gomes, 2015).

This Project Management Maturity Model stands out because of its versatility and its ability to control time and cost most effectively. It is the practical application of change management, which is supposed to minimize the resistance of the system application through the dissemination of the project management culture and guide the implementation plan.

The model provides best practices that allow the organizations to identify what steps must be taken and what deeds must be accomplished, to ensure the organization's effectiveness at performing project management tasks. The objective is to verify the degree of the organization's adherence at every level (De Souza & Gomes, 2015; Demir & Kocabaş, 2010).

Kerzner's model allows measuring how an organization is positioned at five levels. Each of these levels represents a different stage of maturity (R. D. Archibald & Prado, 2014; Demir & Kocabaş, 2010; Kerzner, 2017).

The model is aligned with the PMBOK Guide and its constituted by five levels of maturity, which are: Common Language, Common Processes, Singular Methodology, Benchmarking, and Continuous Improvement.

Table 4- KPMMM Maturity Levels (adapted from (Kerzner, 2004; Oliveira & Oliveira, 2015))

Competitive Advantage		Description	
Immaturity	Level 1 Common Language	At this initial level, there is sporadic use of project management. The organizations recognize the importance of project management, even though there are small focus and no investment in this discipline.	
	Level 2 Common Processes	At the second level, there is management support across the organizations. The common processes level is achieved when the organization recognizes that common processes need to be defined and developed so that success factors on a project can be repeated on other projects.	
		Life Cycle of Level 2	
		Embryonic	There are recognition and acceptance of the importance and the benefits of project management for the organization.
		Executive Management Acceptance	It is characterized by the involvement of top management on the project.
		Line Management Acceptance	It is characterized by the involvement of line management on the project and the training of these professionals.
		Growth	Initiation of a project management process and commitment to carry out and put in practice the planning.
		Maturity	Initiation of the development of a formal integrated system to support and increase the competences of the professionals involved in project management.

Maturity	Level 3 Singular Methodology	This third level integrates the processes. Organizations recognize the positive effect of combining all enterprise methodologies into a singular methodology. Project management is the main method of this combination of processes. The characteristics of this level are Integrated Processes; Cultural Support; Management Support; Informal Project Management; Training and education; Behavioral Excellence. These six characteristics formulate the "Hexagon of Excellence". The Hexagon of Excellence differentiates those companies excellent in project management from those with average skills in project management.
Excellence	Level 4 Benchmarking	Benchmarking consists of a continuous process of comparing the project management practices developed between a company and other organizations. Level 4 is composed by quantitative and qualitative analysis and assessments. Process improvement is necessary to sustain competitive advantage, using benchmarking.
	Level 5 Continuous Improvement	The final level is constituted by the acknowledgement of lessons learned. The organization keeps optimizing processes and evaluates if information obtained through benchmarking to identify and define what will be incorporated into the organization's method for its improvement.

A practical case of study of KPMMM was carried out in two organizations, organization A and organization B. The organizations chosen as units of analysis for this study are representative of the telecommunication sector, being the two biggest Brazilian organizations in this sector. Which means, organization A and B are more than half of the Brazilian market in this sector of activity, demonstrating high relevance of these two organizations.

To assess project management activity, the researcher chose to collect data through questionnaires and interviews.

It was decided not to evaluate Level 1 of KPMMM because it was expected that it would be minimal maturity in the two organizations. Related to Level 2, Kerzner states that a score equal to or greater than fifty percent in each set of questions at this level points out that a certain degree was achieved. Both companies reached the minimum score of maturity in Level 2. At level 3 of KPMMM are assessed the six dimensions of the "Hexagon of excellence". Organization A reached higher scores that organization B in every dimension except in Management Support. Organization A scored between 147 and 168 points and organization B scored between 90 and 146. According to Kerzner, organization A has good project management but still needs more effort, while organization B has minimal and

superficial management. Benchmarking corresponds to Level 4 of KPMMM and at level, there are three-three types of benchmarking analysis: qualitative, quantitative, and both. Organization A had higher scores on the three analyses. This means organization A is doing good benchmarking, the information is correct and is being considered, and there is a great balance between qualitative and quantitative. While organization B is not doing benchmarking. At level 5, the last level of the model, organization A scored above 20 and organization B below 20. This means organization A is doing benchmarking, is continuously improving, and probably leads the market and has greater knowledge in project management than its competitors, while organization B shows strong resistance to change or is lacking high management support. Organization A is more mature than Organization B.

From the collected data, the organizations can be able to plan actions to maintain or improve their maturity level in project management or competitive advantages. This study also presents some limitations such as the fact that it is a short term assessment and organizations cannot rely on the results for a long time: and the fact that it is a very qualitative assessment, the study does not cover every area of the organizations.

It is concluded that the evaluation of maturity can bring sustainable competitive advantages filling the theoretical gap by establishing a relationship between project management and competitive advantage, connecting project management to the corporative strategy (Kerzner, 2017; Pistillo Fernandes & Garcez, 2019). The following figure 13 represents the percentage of maturity level scores by each company.

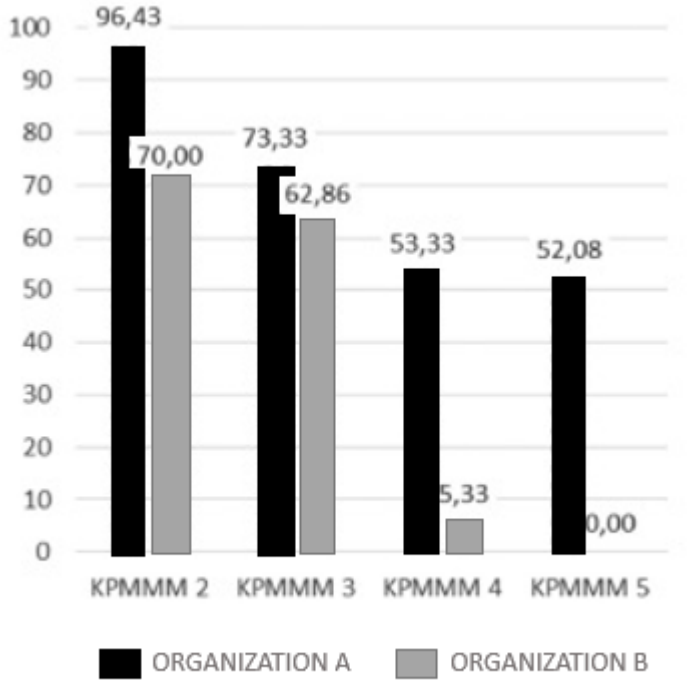

Figure 13- Percentage of Maturity Level Scores by each company (adapted from (Pistillo Fernandes & Garcez, 2019))

2.4.4 Organizational Project Management Maturity Model (OPM3)

In 1998, PMI presents a standard to help organizations to upgrade and improve its capabilities in project management and create its organizational strategy, starting the development of OPM3 (Zaguir & Martins, 2007).

OPM3 is an acronym for the Organizational Project Management Maturity Model. The purpose of this model is to provide a way for organizations to understand project management, and for measuring the maturity in contrast to a set of best practices in project management. OPM3 also helps organizations to plan for improvement, to increase their organizational project management maturity (De Souza & Gomes, 2015; Project Management Institute., 2008).

There are two important concepts in OPM3, organizational and maturity. Within the theoretical framework of OPM3, the organizational concept refers to the broadening of the scope of the project management model, which goes beyond the project itself to the entire organization. This broadening shifts the operational focus to the strategic focus, and for this reason, besides projects, programs and portfolios, the model promotes the projects' alignment to the business strategy (PMBOK®, 2017).

On the other hand, the maturity concept embraces the best practices and capabilities that the organization has and those that need to be developed to sustain and enhance a culture so that projects

can be successfully executed and aligned with the objectives defined in strategic planning (PMBOK®, 2017).

To carry out the maturity assessment, OPM3 has a questionnaire with 125 questions that allows a self-assessment about the maturity level of the organization in all domains: projects, programs, and portfolios. After this self-assessment, it is possible to define an action plan to elevate the level of the organization's maturity, through the help of a database with more than 600 cataloged best practices. Once the action plan is executed, a new assessment must be done. This knowledge analysis (best practices), which is the assessment and the execution of an action plan, can be carried out for the whole organization, or for a single domain or for a single process, according to the organization's priorities. This flexibility to evaluate the maturity in different perspectives allows the organizations to be more flexible and supportive in decision-making, as well as in defining and planning the improvements to be implemented (PMBOK®, 2017; Prado, 2010).

OPM3 covers three basic elements that are applied in the organizations: Knowledge, Assessment, and Improvement. Knowledge is the OPM3 Standard presented to the organizations, acquainting the professionals with their concepts and methodologies. This element describes the organizational project management and the organizational maturity in project management. The Assessment provides a comparing method between the organization strategy and the OPM3 Standard. This element presents methods, processes, and procedures by which an organization can self-assess its maturity. The Improvement element defines the organization's maturity level and suggests improvements. This element provides a process to improve from the current level to a higher level of maturity. The result of the assessment includes a list of capabilities not properly developed by the organization. This list of capabilities, in order of sequence and importance, form the basis for a development plan.

The key element of the model is the set of aggregated and linked knowledge. The Knowledge drives the Assessment, which in turn drives Improvement.

These three elements of the OPM3 benefits organizations because:

- ✓ It provides a way to advance an organization's strategic goals through the application of project management practices, filling the gap between strategy and individual projects. Which means, this linkage makes projects more predictable, reliable, consistent, and correlated with organizational success.
- ✓ An organization can determine exactly which Best Practices and Capabilities it does and does not have. This assessment forms a basis for deciding whether to pursue specific domains, such as Project, Program, and Portfolio Management.

- ✓ It guides prioritizing and planning in case the organization decides to pursue improvement (Project Management Institute., 2008).

These elements are the basis for a maturity improvement cycle of an organization. Five steps constitute this cycle.

The first step is the Prepare for Assessment. This step is for the organization to prepare for the process of assessing its organizational project management maturity. This involves the understanding of the organization's strategic objectives, and the degree needed to achieve such objectives.

The second step is divided into two phases: Perform High-Level Assessment and Perform Comprehensive Assessment. The Perform High-Level is to assess the organization's degree of maturity in project management. To do this, an organization must be able to compare the characteristics of its current maturity state. Therefore, this phase is to review which best practices are not currently demonstrated by the organization and to identify the organization's maturity position. The results of this first phase of Perform High-Level Assessment give the organization a basis from which to scope areas for improvement.

After completing the first phase, the Comprehensive Assessment provides a more in-depth and precise view of an organization's current state of maturity by determining which best practices to investigate and by determining is specific capabilities exist within the organization. The results of these two phases may lead an organization to plan for improvement, repeat the process, or exit the process.

The third step is the Plan for Improvement. For the organizations that have chosen to pursue improvement, the results of the previous step will form a basis for an improvement plan. This information enables the development of a specific plan to achieve the outcomes associated with the capabilities or targeted best practices.

The fourth step is the Implement Improvements. Once the plan has been established, the organization will have to implement the plan over time, that is, execute requisite organizational development activities advancing on the path to increase maturity.

The fifth is Repeat the Process. Having completed some improvements, the organization considers whether to reassess its current maturity by repeating the assessment or to return to Plan for Improvement (step three) to work towards non-priority best practices identified previously in the assessment but not implemented (Foundation, n.d.; Project Management Institute., 2008). Figure 14 presents the OPM3 cycle.

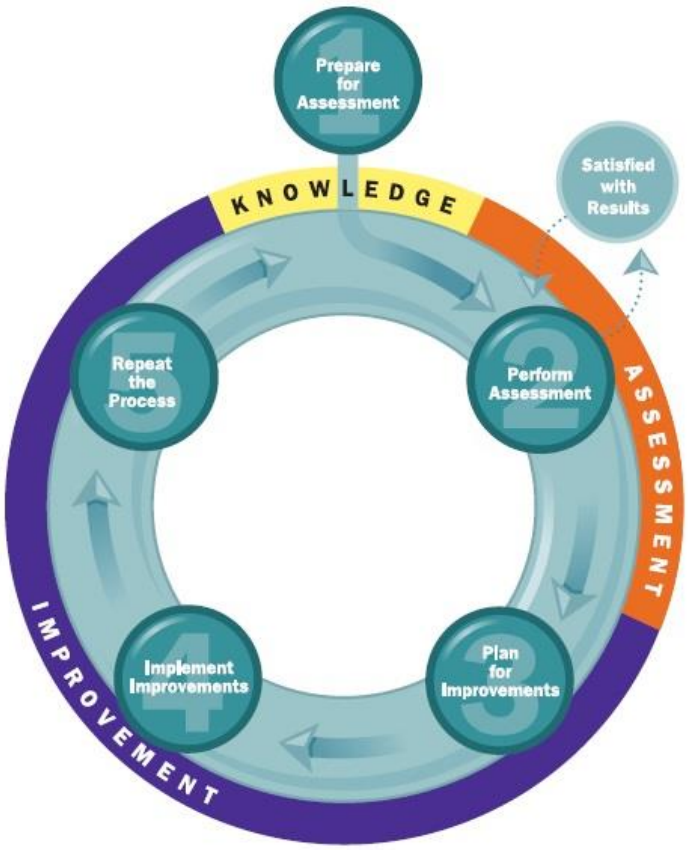

Figure 14- OPM3 Cycle (Project Management Institute., 2008)

OPM3 is constituted by four levels of maturity and by three domains. They intersect defining the degree of maturity. These four levels of maturity are Standard, Measure, Control, and Continuous Improvement, which apply to the Project, Program, and Portfolio domains (Project Management Institute., 2008). Figure 15 shows the maturity evolution combining the levels and the domains.

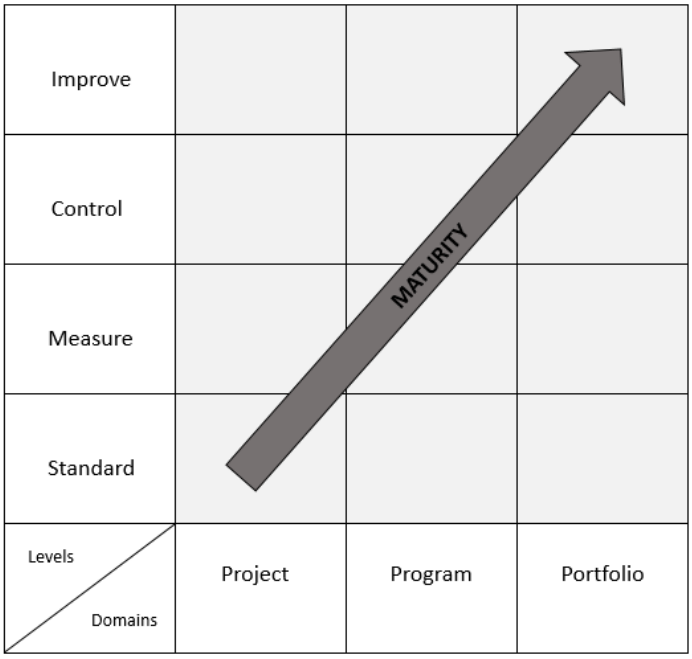

Figure 15- Maturity Evolution- Levels and Domains (adapted from ((Project Management Institute., 2008))

A practical example of the application of OPM3 is "OPM3 Portugal Project" which chartered based on the need that Ambithus, that leads a project to improve the way Portuguese industry initiate, choose, manage, control and close their projects. The objective of this project is to assess 100 organizations, from various activity sectors, and perform an analysis of their organizational PM maturity, presenting an improvement plan to each of them.

At the first level, the Planning and Organizing were documented identified areas of good practice and possible improvements. A management information system, designed by Ambithus was created for company assessments by supporting the process of collecting information, and to complement Product Suite, an information processing system on assessment results that produces certified OPM3 reports and improvements from PMI.

At the second level, the Company Assessments, starts the assessment of the current capabilities. In this intervention process, it was established a quality control process to assure that all collected data were properly recorded in the information system. After this, a report was generated and presented to the company management.

At the third level, the Industry Sectorial Assessment, the findings of the different organization assessments are summarized to create industry sector level measures of PM capability by industry. Following the analysis and validation of the results achieved, an industry sector improvement plan was presented and discussed.

At the final level, the Country Assessment, the findings from the sectorial level were compared to identify areas of strengths and were also synthesized to create an overall measure of country PM capability.

This project created multiple benefits to Portuguese organizations, such as improving the relationship between strategic planning and execution, identification of best practices that support organizational strategy for implementing successful projects, and the identification of specific skills that the organization has and which can be best practices (D. Silva et al., 2014).

Another practical study of the application of the OPM3 assessment is the Porto Digital case. Porto Digital is composed of a set of software development companies in the city of Recife, in Brazil. It currently has more than 100 organizations among information and communication technology companies. There are five researched companies.

The project management maturity assessment of these five companies was carried out using only one version of the OPM3 questionnaire, with no use of the software assessment. Since the software assessment was not used to analyze the answers to the questionnaire, and, consequently, to calculate the maturity level, the calculation was carried out considering the existence of the processes related to the project domain. Through the calculation of the Number of existing Processes divided by the Processes of the Project Domain, it is possible to find the percentage of maturity of the Project domain.

The five companies were divided according to their annual gross revenues and the number of staff.

Company/ Annual gross renevues	Company A	Company B	Company C	Company D	Company E
Less than 500.000,00 R$	X				
Between 500.000,01 and 1.000.000,00 R$		X	X		
Between 1.000.000,01 and 5.000.000,00 R$					
Above 5.000.000,00 R$				X	X

Figure 16- Annual Gross Revenues by each Company (adapted from ((Carneiro, 2007))

Company/ Number of Staff	Company A	Company B	Company C	Company D	Company E
Less than 20	X				
Between 21 and 50		X	X		
Between 51 and 100					
Above 100				X	X

Figure 17- Number of Staff by each Company (adapted from ((Carneiro, 2007))

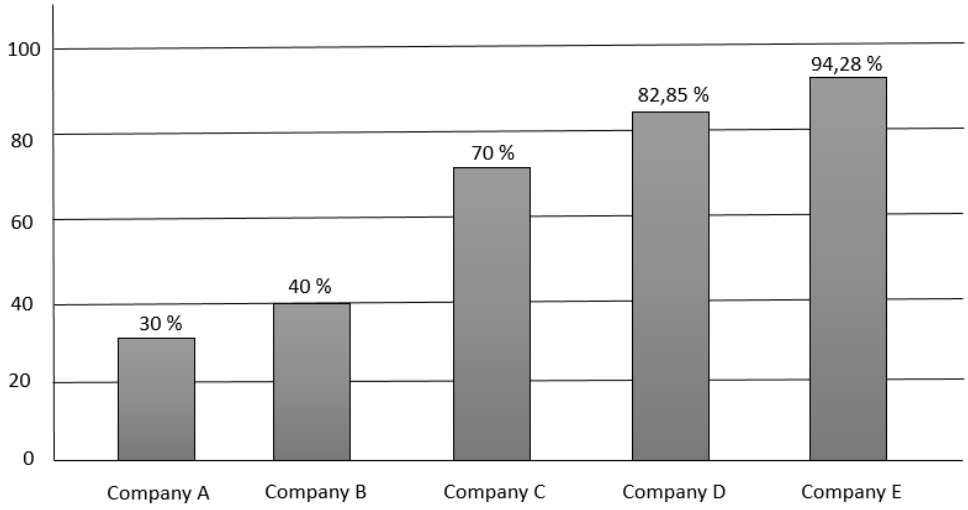

Figure 18- Level of Maturity in the Project Domain (adapted from ((Carneiro, 2007))

The small-sized enterprises, represented by Company A, obtained a very low rating on Projects (30%) showing that this company needs the best practices in the Project Domain to raise its level of maturity.

The medium-sized enterprises, represented by Company B and Company C, obtained a rating of 55% on Project Domain.

The large-sized enterprises, represented by Company D and Company E, obtained an excellent rating of 88,56% on Project Domain, showing that almost every best practice of the Project domain suggested by OPM3 is already implemented.

In general, the level of maturity of the organizations under assessment in this case of study is 57,86% (Carneiro, 2007).

3. METHODOLOGICAL APPROACH

According to the structure and objectives of this project dissertation and after analyzing the various methods of scientific investigation, in this chapter is presented the methodology Case Study.

3.1 Case Study

The purpose of a Case Study is to gather detailed and systematic information about a phenomenon, focusing on understanding the dynamics of the real context that allows broad and detailed knowledge (Freitas & Jabbour, 2011).

A Case Study is more suitable to increase the understanding of a phenomenon that to delimit it (Caso et al., 1999).

To discuss the Case Study strategy three aspects must be considered: the nature of the experience, the knowledge that intends to achieve, and the possibility of generalizing studies using the method (Caso et al., 1999).

Each stage of the methodology consists of procedures recommended in the literature, followed by the application of those procedures.

1- Develop the case study protocol:
2- Determine the objective and the purpose of the study: compare the maturity between Development of Computer Applications and Information Systems and Technologies Project, and verify the effectiveness of the learning methods of the course based on the maturity growth of the project management teams.
3- Conduct the case study:
    - Prepare for data collection
    - Distribute questionnaires- Prado-PMMM questionnaires
4- Analyze case study evidence:
    - Analytic strategy
5- Develop conclusions, recommendations, and implications based on the evidence (Tellis, 1997).

The following figure 19 graphically show these procedures, used in most of the defined surveys as a case study.

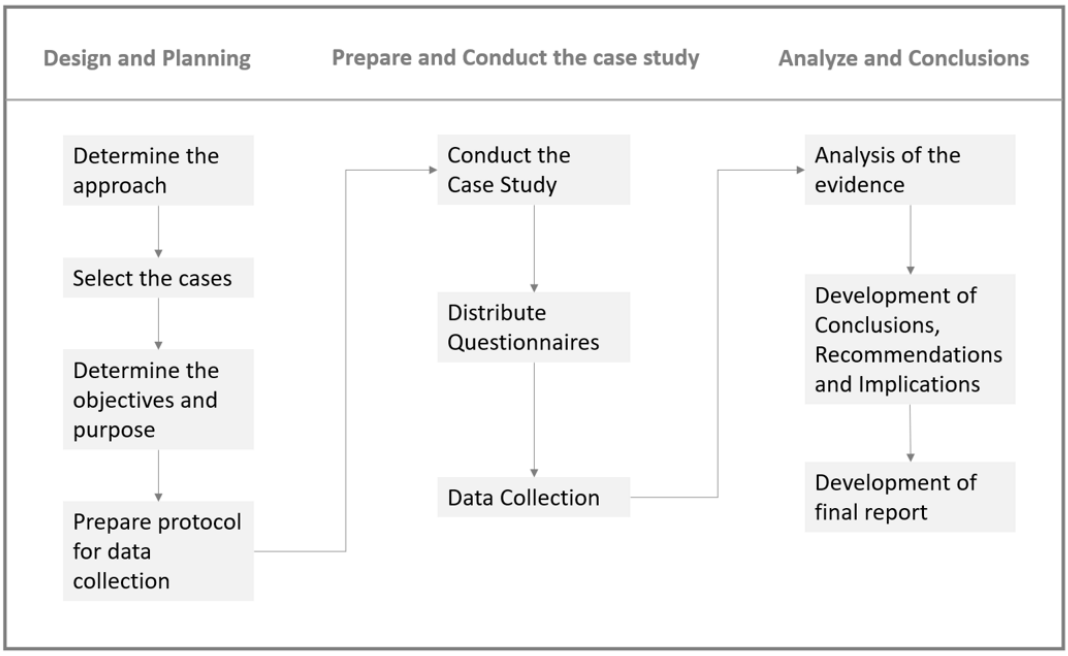

Figure 19- Case Study Procedures (adapted from (Freitas & Jabbour, 2011))

Some of the main reasons to develop a case study are:

- ✓ Information Systems are study in their natural environment
- ✓ The data is obtained by different collection techniques
- ✓ One or more entities are analyzed
- ✓ There is no manipulation or control of the environment
- ✓ The focus is a contemporary event.

This case study is predominantly qualitative, despite the use of quantitative techniques, because it is not purely empirical nor merely interpretative**.** The quantitative approach supplies statistical treatment for the data obtained, thus providing greater knowledge of details. The qualitative method is the most adequate for the proposed work since it is primarily concerned with increasing the understanding of an area, rather than producing an explanation for it. Using this method, the problems are often analyzed by means of investigating and interpreting human or organizational aspects in relation to technology.

Regarding the nature of research in case studies, in addition to the case study being seen with more emphasis on qualitative methodologies, this does not mean that they cannot contemplate more quantitative perspectives. The distinction between qualitative and quantitative methods is a matter of emphasis since reality is a mixture of both (Yin, 1994).

Yin has identified some specific types of case studies: Exploratory, Explanatory and Descriptive.

This dissertation project is a Descriptive study. The descriptive research aims to describe the characteristics of a population or phenomenon or the establishment of relationship between variables,

such as situations, events, attitudes, or opinions. This type of research is used to achieve the objective of the work, since it identifies the characteristics of a researched population based on the practices in project management (Freitas & Jabbour, 2011; RICHARSON, 1999).

This descriptive case study involves the use of standardized data collection techniques, structured questionnaires.

In this project, the data collection technique is Questionnaires. The Questionnaire cannot be said to be one of the most representative techniques in qualitative research, as its use is more associated with quantitative research techniques. However, as a data collection technique, the questionnaire can provide an important service to qualitative research. The questionnaires are mainly justified to measure perceptions at the individual level and requires some specific types of statistical analysis (Lehmann & William, 1971).

In this work the questionnaire was applied to capture the data in a structured way, facilitating the qualitative analysis of the identified environment.

4. Description of the Case Study

The present work carried out a project management maturity assessment of two-course units of Integrated Master's in Engineering and Management of Information Systems, and the respective comparison between them.

The course units are Development of Computer Applications (DCA) and Information Systems and Technologies Project (ISTP). This project used as the main data collection tool an adapted questionnaire from Prado-PMMM.

4.1 Contextualization

Comparing the project management maturity models mentioned in the Literature Review- OPM3, KPMMM, and Prado PMMM- the most adequate questionnaire for this case study was the Prado Project Management Maturity Model. The three models were compared according to different variables.

Prado-PMMM allows measuring different maturity levels for each organizational dimension. Therefore, each maturity dimension crosses all the maturity levels of the model indicating different scenarios and different percentages of adherence. The other models do not allow this visualization of dimensional growth of maturity.

According to the Assessment format, all the models have an evolutionary scale to identify maturity. The OPM3 presents assessment instruments based on the verification of organizational processes. The KPMMM presents a different assessment framework for each maturity level of the model. On the other hand, Prado PMMM has a simple application and understanding questionnaire that allows evaluating every level and dimension of the model.

Regarding Suggest alternatives for advancing maturity, all the models present guidelines for maturity growth. The OPM3 provides a set of "best practices" in project management. The KPMMM presents critical success factors for the implementation of each maturity level. The Prado PMMM recommends the development of a growth plan and provides some guidelines for making this progress feasible.

About Benchmarking, the OPM3 does not have this characteristic. The KPMMM refers to this aspect only by recommending benchmarking with other organizations. The model does not present a benchmarking study. The Prado PMMM is the only model to present a benchmarking study with Brazilian companies that allows comparisons between organizations from different sectors. Therefore, it is

emphasized that an organization becomes a reference for other organizations when it comes to culture and processes that promote the institutionalization of project management.

When it comes to Easy and simple understanding of the questionnaires, the OPM3 is a simple questionnaire, yet is considered repetitive and bureaucratic. Another criticism is about the absence of a measurable level of maturity, as established by the other maturity models, which restricts the understanding, the communication, and the establishment of measured goals. The KPMMM is the most difficult to understand because it has a different questionnaire for each level of maturity, requiring a further theoretical study of the model. The Prado PMMM has a simpler theoretical basis and application when compared to OPM3 and KPMMM.

Referring to the Dimensions/Factors considered by the model, the OPM3 refers to methodologies, human resources, project support, strategic alignment, organizational learning. The KPMMM is the model with more factors described due to the individualized approach for each level. The Prado PMMM covers most of the variables that can better reflect the current state of the project management of an organization, with emphasis on the behavioral competence, only addressed by this model, which has become a critical success factor for project management.

According to the Organizational strategy, the OPM3 and the Prado PMMM follows the organizational strategy, yet the KPMMM only refers to it on level 2 and 3.

About Organizational culture, all the models have in consideration the organizational culture except the OPM3. The OPM3 does not theoretically address this characteristic, although this factor is identified in the questionnaire.

The results of the analysis show that Prado PMMM is the most adequate for the maturity assessment of this project's dissertation. The objective was not to identify the best model for application but to compare the characteristics that best fit this specific case study (Restri & Nascimento, 2013; R. R. da Silva & Santos, 2016)

4.2 Nature of the sample

The Development of Computer Applications is a course unit of the second grade of the course. This course unit promotes the initial training plan from a software engineering perspective. The purpose is to introduce the analysis and design of IT systems. The activities are organized around a medium complexity of IT system projects, using UML within the scope of RUP's procedural framework to support the implementation of WEB solutions with relational repositories.

The students of this course unit should be able to:

- ✓ Identify the typical problems of the development of IT systems
- ✓ State and explain the fundamental principles of software engineering
- ✓ Discuss and know how to solve problems related to the analysis and design of IT systems, from a functional, structural, and behavioral perspective
- ✓ Execute the analysis and design of IT systems projects.

Information Systems and Technologies Project (ISTP) is a course unit of the fourth grade of the course. This unit is based on a project-based-learning approach because it integrates the technical and scientific knowledge covered during the course.

The project developed to take place in a real context, possibly in an organization, and allows to apply, exercise, and develop the main professional skills of IT engineers and manager, specifically:

- ✓ Improve work situations and organizational processes, considering the organization's strategy:
- ✓ Explore opportunities created by IT technological innovations
- ✓ Present IT applications that support organizational work, satisfy the organization's management information need and ensure information security
- ✓ Identify and evaluate IT solutions and present ways to obtain them
- ✓ Provide an operative version of the proposed technological solution

The students of this course unit should be able to:

- ✓ Discuss alternatives for the application of PMBoK techniques in IT projects
- ✓ Develop a plan for an information systems development project, following the guidelines of the PMBoK
- ✓ Understand and apply the appropriate methods to track the progress of a project (Project Execution)
- ✓ Apply the techniques proposed by the PMBoK to monitor the progress of a project (EVM-Earned Value Management)
- ✓ Understand the principles, themes, and processes proposed by the PRINCE2
- ✓ Demonstrate proper management of the projects under development.

4.3 Questionnaire Structure

The original maturity questionnaire consists of forty questions and is divided into four groups, ten questions per level. Each group is related to each level of maturity.

The questionnaire was adapted to the context of this dissertation. According to Prado, level 1 is not in the questionnaire because it is the initial stage of maturity, it represents a very bad performance scenario (Prado, 2010). Level 5 of maturity is also not considered in this present study because it is the excellence in project management performance. The study sample is academic IT projects, so the students do not have experience enough to achieve such level, therefore the fifth level was irrelevant and not appropriate for this case study.

The number of questions is eight questions per level because there was a need to adapt the number of questions to the real context of the case study since it is an academic context and not a real enterprise.

Therefore, the present questionnaire consists of twenty-four questions and three maturity levels.

Each question has five answer alternatives, a, b, c, d, and e, corresponding to 12.5, 8.75, 5, 2.5, and 0 points, respectively. The five answer options correspond to the different stages in which the sector is, in relation to the question.

The following tables show the criteria required for each level of maturity.

Table 5- Criteria required for Level 2 (Prado, 2010)

Answer	Description
A	The situation presented is well known, accepted, and stimulated over the last 6 months
B	The situation exists, but it is slightly lower than that presented in option "A"
C	The situation exists, but it is significantly lower than that presented in "A"
D	Efforts were initiated in relation to that presented in option "A"
E	No effort has been initiated.

Table 6- Criteria required for Level 3 (Prado, 2010)

Answer	Description
A	The situation presented is: ✓ Implemented and it is apparently complete, according to the needs of the sector ✓ Represents the best situation possible now ✓ In use over a year.
B	The situation exists, but it is slightly lower than that presented in option "A"

C	The situation exists, but it is significantly lower than that presented in "A"
D	Efforts were initiated in relation to that presented in option "A"
E	No effort has been initiated.

Table 7- Criteria required for Level 4 (Prado, 2010)

Answer	Description
A	The situation presented: ✓ Improved ✓ Proved to be very complete, adequate, and efficient, according to the need of the sector ✓ In use over two years.
B	The situation exists, but it is slightly lower than that presented in option "A"
C	The situation exists, but it is significantly lower than that presented in "A"
D	Efforts were initiated in relation to that presented in option "A"
E	No effort has been initiated.

The relationship between the maturity level and the dimensions is explicit in the questionnaire. It is possible to observe the dimensions across each level of maturity in the questionnaire because each question contains an aspect of maturity of a certain dimension valid for that level. Therefore, the Prado PMMM is not only an organizational model but a sectorial model, in which the focus is the organization (R. D. Archibald & Prado, 2014). The following table shows the relation between the questions and the dimensions.

Table 8- Relation between questions and Maturity Dimensions (adapted from (B. R. D. Archibald & Prado, 2014))

Dimensions	Levels of Maturity		
	Level 2	Level 3	Level 4
Project Management Competence	1, 2, 4, 5, 7, 8	1, 6	2, 5
Technical and Contextual Competence	1, 2, 4, 6, 7, 8	2	2, 5

Behavioral Competence	7	-	2, 5, 8
Computerization	3, 6	2, 3	3, 6
Methodology	3, 5	1, 2, 3, 4, 5, 6, 7, 8	1, 3, 7
Strategic Alignment	3, 4	3, 5, 6	4
Organizational Structure	4	5, 7	1, 2, 4, 8

Since the questionnaire was adapted to an educational context, the dimensions also went through minor changes due to the organizational context being different from the educational context.

At the Project Management Competence dimension, the requirement of competencies in project management is equally necessary in both contexts. In the organizational context, the management practices are applied throughout the organization, and in this case study the management practices are applied in the project teams.

At the Technical and Contextual Competence dimension, the required competencies are essential for the development of projects and the difference is between the environment these competencies are applied to, whether the organizational or the academic context.

At the Behavioral Competence dimension, the personal competencies of the academic context are similar to the organizational context.

At the Methodology dimension, the organizational context it is presented a unique project management methodology for the organization, which involves the entire cycle. In the academic environment, the project teams follow the PMBoK Guide and the practices are applied to the projects.

At the Computerization dimension, aspects of the methodologies used in both the organizational and the academic contexts are computerized to represent additional value.

The Strategic Alignment of an organizational context refers to the alignment of the current and future projects and the alignment between the various areas of the organization. The Strategic Alignment of an academic context refers to the alignment of the course and the university objectives and the project management teams are monitored by the professors.

The Organizational Structure of an organizational context consists of structuring an appropriate organizational system according to the structure of the organization. While the Organizational Structure of an academic context the stakeholders are the educational entities involved in the projects and the projects are well structured due to the guidance of the professors.

4.4 Results

This project had the participation of twenty-nine project manager students who answered the questionnaire on maturity in project management, according to Appendix I.

The applied questionnaire contains six questions to characterize the profile of the research teams, and twenty-four questions about project management adapted from Prado Project Management Model.

The characterization questions had the purpose to identify variables that influence the maturity level of the researched group. These questions were about the name of the team, the curricular year they attend, the number of students in a team, the age, the role developed in a team, and the gender.

In DCA the average number of students per team is 11,8. The number of students vary from 10 to 14 students per team. The adherence percentage of answered questionnaires of the curricular unit DCA is 90,99%, representing a total number of 10 answered questionnaires out of 11 teams.

In ISTP the average number of students per team is 5,32. The number of students vary between 5 and 6 students per team. The adherence percentage of answered questionnaires of the curricular unit DCA is 95%, representing a total number of 19 answered questionnaires out of 20 teams.

The following figure 20 presents the age range of the project managers of the curricular unit DCA.

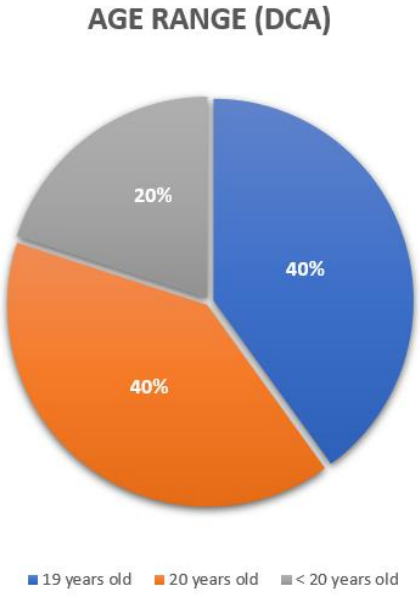

Figure 20- Age Range of "DCA" Students

The age range is predominantly between 19 and 20 years old since the curricular unit corresponds to the second year of the course. The range corresponding to “above 20 years old” consists of two students, one of 28 years old and another of 30 years old.

The following figure 21 presents the age range of the project managers of the curricular unit ISTP.

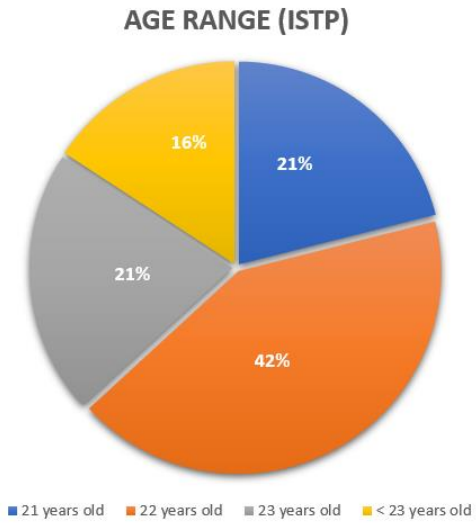

Figure 21- Age Range of "ISTP" Students

Since this curricular unit corresponds to the fourth year of the course, the major range of ages is between 21 to 23 years old. The principal age range is 22 years old, corresponding to 42% of the students. Equally corresponding to 21% each, are the students of 21 and 23 years old. The minor range of 16% of the students corresponds to "above 23 years old". It consists of three students, one student is 30 years old and two students are 33 years old.

4.4.1 Results of the Adherence to Maturity Levels

The adherence to the maturity levels of project management was calculated from the documentary analysis of the projects compared to the results of the Prado PMMM questionnaires.

According to Prado, the adherence to maturity levels is measured through points.

The obtained results reflect how well the curricular units are positioned in the requirements of their respective levels. The points should be interpreted as:

- ✓ Until 20 points: Very low adherence
- ✓ Until 40 points: Low adherence
- ✓ Until 75 points: Regular adherence
- ✓ Until 90 points: Good adherence
- ✓ Until 100 points: Great adherence (Prado, 2010)

The following figure 22 presents the results to the adherence to the levels of maturity in DCA.

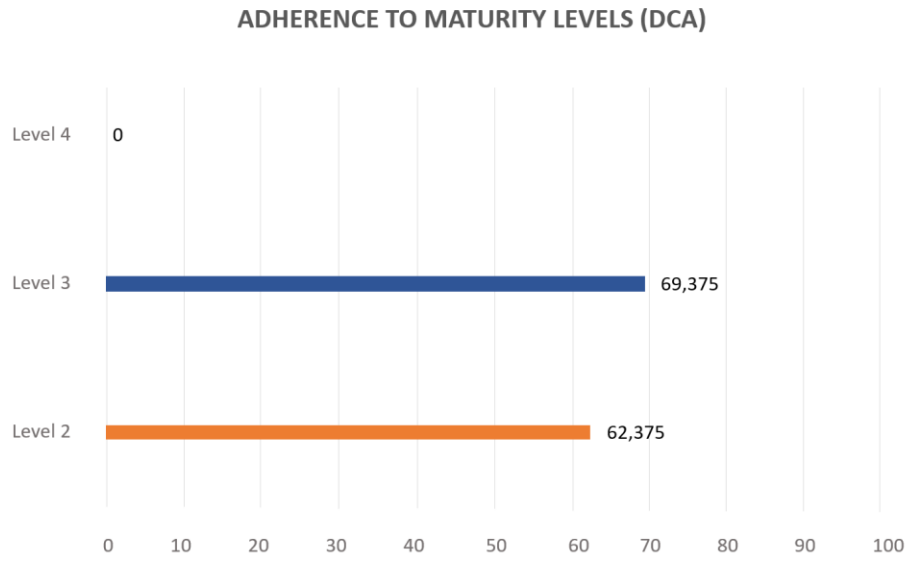

Figure 22- Adherence to Maturity Levels (DCA)

The adherence points of maturity levels of DCA is 62.375 points for Level 2 and 69.375 points for Level 3. The answers of DCA for Level 4 is always 0 points because in the questionnaire the Level 4 refers to two or more years of experience using project management practices.

These results are interpreted as being in a Regular adherence to the levels.

Through the values presented in Figure 22, it can be determined the final level of maturity in DCA. The Final Maturity Assessment represents an average of the adherence rates at the various levels, calculated by the following equation. (R. D. Archibald & Prado, 2014)

$$Final\ Maturity\ Assessment = \frac{(100 + Total\ of\ Points\ Obtained)}{100}$$

Therefore, the Final Maturity Assessment of DCA is 2,318, being at Level 2 of maturity, according to the equation.

$$\text{DCA}\ Final\ Maturity\ Assessment = \frac{100\ +\ (62.375 + 69.375 + 0)}{100} = 2.318$$

A project can adhere to different levels. The percentage of adherence is used together with the Final Maturity Assessment for a better understanding of the maturity stage of the project.

Although the average is tending to Level 2. Being a Level 2 of maturity represents the awakening to the subject project management. The main characteristic of this effort was to introduce a common

language of project management through training. This training involves introductory knowledge of project management and software tools, isolated initiatives for planning and monitoring projects, and the awareness of the importance of implementing and follow a standard methodology.

However, Level 3 showed greater adherence. In this sense, there is a great demand for the implementation of a standardized methodology which is frequently seen from Level 3 of maturity. It represents the students are aware of the importance of a methodology and are making great efforts towards a standard methodology, but it is required more effort and training in project management.

The following figure 23 presents the results to the adherence to the levels of maturity in ISTP.

The adherence points of maturity levels of ISTP is 79.00 points for Level 2 and 87.105 points for Level 3, and 72.829 points for Level 4. These results are interpreted as being in a Good adherence to Level 2 and Level 3 and Regular adherence to Level 4.

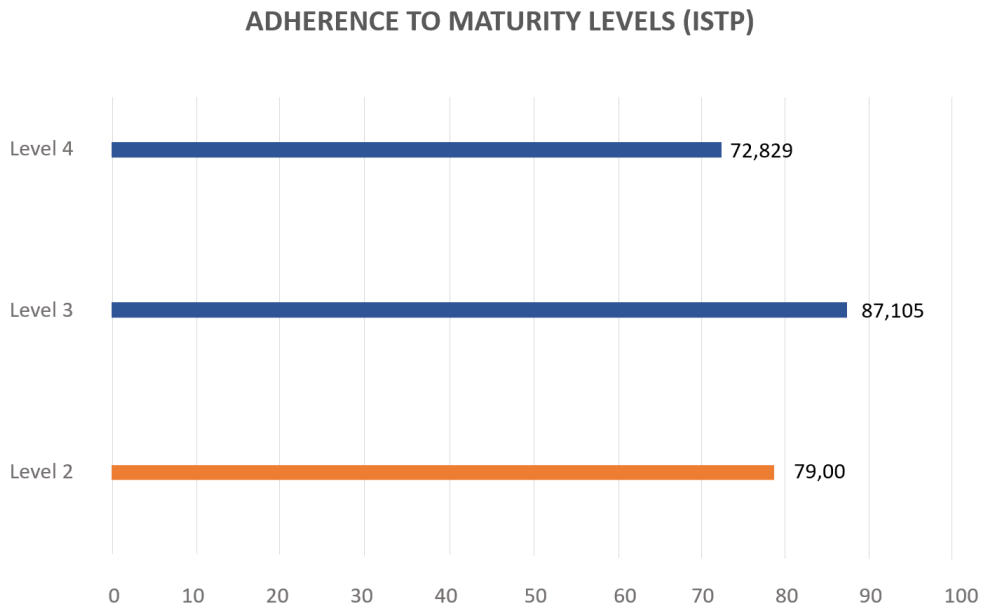

Figure 23- Adherence to Maturity Levels of ISTP

Through the values presented in Figure 23, it can be determined the final level of maturity in ISTP. The Final Assessment Maturity of ISTP is 3.389, being at level 3, according to the following equation.

$$\text{ISTP } \textit{Final Maturity Assessment} = \frac{100 + (79.00 + 87.105 + 72.829)}{100} = 3.389$$

The assessment is tending to Level 3, and there is very good adherence to Level 2 and Level 4. Being a Level 3 represents a scenario in which a standardized methodology for project management is

implemented and in use. For a team to be at level 3 of maturity it means that along with the methodology being implemented, the computerization is also implemented; it is measured the performance of closed and previous projects; and there is an advance in the consolidation of project, technical, and contextual competencies. Perhaps, the major benefit of this level is the greater predictability of the project's teams in terms of achieving their goals.

Figure 23 shows a regular adherence to Level 2, which means there is continuous and improved training of the knowledge in project management. There is also a low adherence to Level 4, this adherence is seen as big efforts being made towards the consolidation of Level 3, with the presence of project managers with more autonomy, with consequent efficiency in human relationships.

The results of the Final Assessment Maturity vary from 1 to 5 and should be interpreted according to the following figure 24.

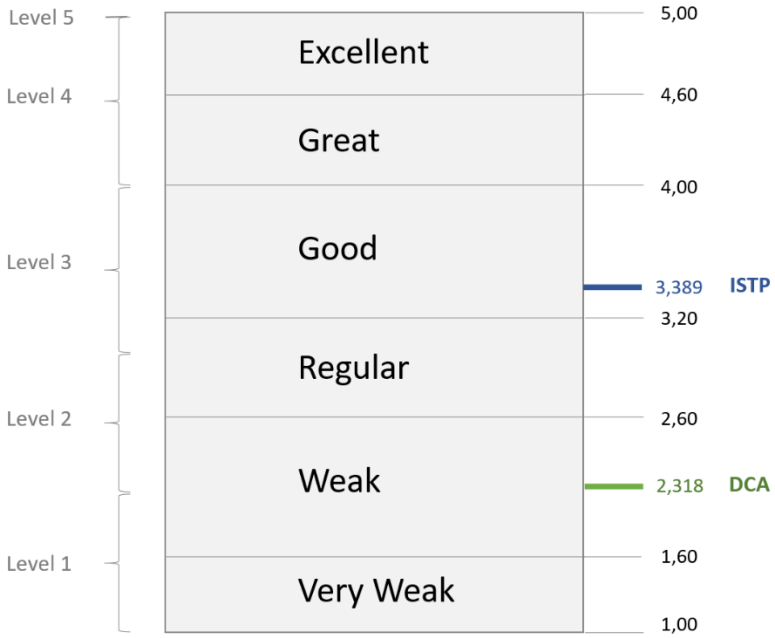

Figure 24- Results of Maturity Levels (adapted from (B. R. D. Archibald & Prado, 2014)

As mentioned above, the maturity in project management of the curricular unit DCA is 2,318. Therefore, it is in a "Weak" stage of maturity. At this stage, it can be concluded that the students have started to invest in knowledge in project management and its respective competences, leading to the creation of a new culture in project management. However, there is no sustainability of constant results because these initiatives are dispersed and not a standardized methodology (B. R. D. Archibald & Prado, 2014).

ISTP maturity is 3.389. ISTP is in a "Good" stage of maturity, according to Figure 24. At this stage, it is noticeable the existence of a developed, implemented, tested, and in use methodology.

4.4.2 Results of the Adherence to Maturity Dimensions

In addition to the initial analysis, it is calculated the index of adherence to organizational dimensions, which is the percentage value required for each of the 7 dimensions.

According to Prado, the maturity dimensions are measured through percentages.

Similarly to the adherence to maturity levels, the obtained results to the adherence to maturity dimensions reflect how well the curricular units are positioned in the requirements of each dimension. The points should be interpreted as:

- ✓ Until 20%: Very Low adherence
- ✓ Until 40%: Low adherence
- ✓ Until 75%: Regular adherence
- ✓ Until 90%: Good adherence
- ✓ Until 100% Great adherence (Prado, 2010)

Through the individual analysis of each dimension, it is possible a better interpretation of the results.

The Project Management Competence has adherence above the average maturity of each curricular unit, as shown in Figure 25. DCA shows Regular adherence percentages to Level 2 and Level 3 and 0 adherence to level 4, while ISTP has Good adherence percentages to Level 2, Great adherence to Level 3, and Regular adherence to Level 4. These percentages in project management competence show a good diffusion between knowledge and standardized practices of project management (common language). These values represent good capacity, by the project management team members, related to areas of knowledge and processes, such as PMBoK, IPMA, Prince2. These capacities are much more developed in ISTP, showing that the teams know the concepts and properly apply the practices of project management. Whilst DCA teams need to make more efforts to improve these skills, but despite the lower average maturity, it shows good results in relation to its maturity level.

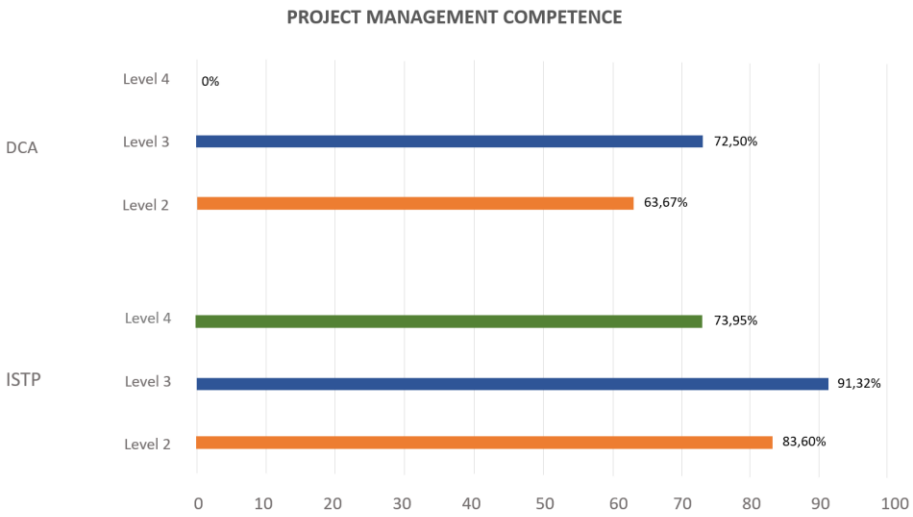

Figure 25- Project Management Competence

The Technical and Contextual Competence adherence of DCA teams is lower than the project management competence adherence. This comparison is presented in Figure 26. It is possible to see that adherence to Level 3 is significantly lower, with a percentage of 51%. The key roles of technical and contextual expertise are confirmed as primary elements to fulfill the objectives of the projects. The Technical and Contextual Competence of ISTP presents Good percentage to Level 2 and Level 3 and Regular percentage of adherence to Level 4. The lower results from DCA represent the teams are training in technical and contextual competencies, yet these competencies are not properly applied in the project development and the initiatives are isolated. These results represent that ISTP has invested in training and evolved their knowledge and experience in technical aspects related to the project being developed, such as technologies and information systems, as well as related to contextual aspects, such as methodologies and organizational processes.

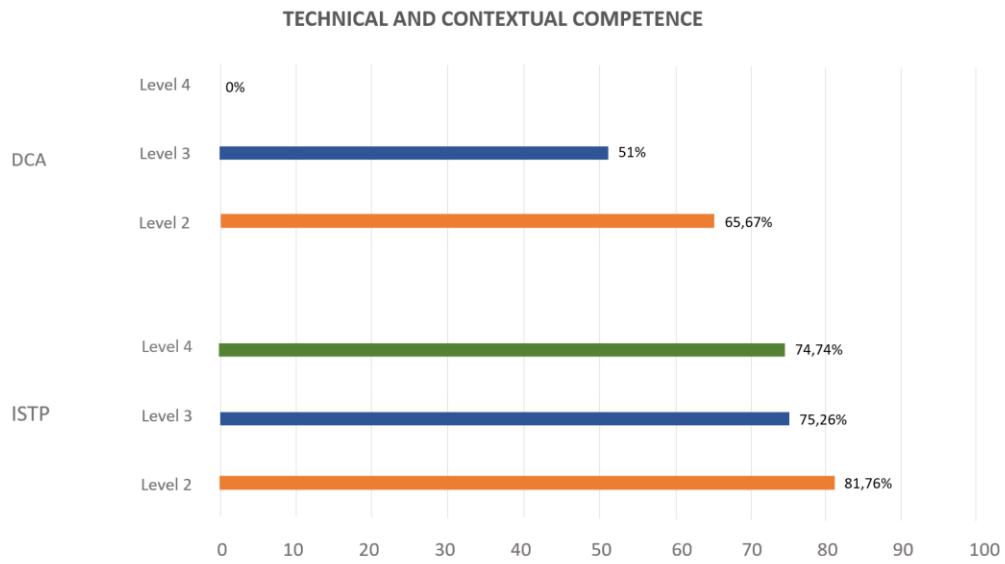

Figure 26- Technical and Contextual Competence

The Behavioral Competence in DCA is at a Regular adherence stage, while ISTP is at a Good adherence of maturity for Level 2 and Regular adherence for Level 4. According to previous assessments made by Prado, project management seems to act primarily on procedures, methods, tools, and facilities, rather than on people and their proper management (Prado, 2010). However, the impact of the low adherence to Behavioral Competence dimension is a critical factor which needs improvement, since the interpersonal relations have a great impact on the maturity growth of any project or any organization, in aspects such as conflict resolution, motivation, and leadership. ISTP behavioral competence shows that project managers and their teams are aware of the importance of behavioral competence. The results demonstrate a concern around the ability of the team members to communicate, to lead, to motivate, and to solve daily conflicts. This improvement reflects greater results in ISTP maturity. Of all dimensions, the Behavioral Competence dimension got the lower maturity adherence due to the fact the project teams are not sufficiently mature to develop and apply such competencies through the entire cycle of the project, and due to the fact these competences are directly related to human behavior and area the linkage between professional behavior and personal behavior. Thus, this dimension is the most difficult to measure quantitatively. The Behavioral Competence is not assessed at Level 3, therefore the Level 3 does not exist in the results of this dimension. The following figure represents the results for the Behavioral Competence dimension.

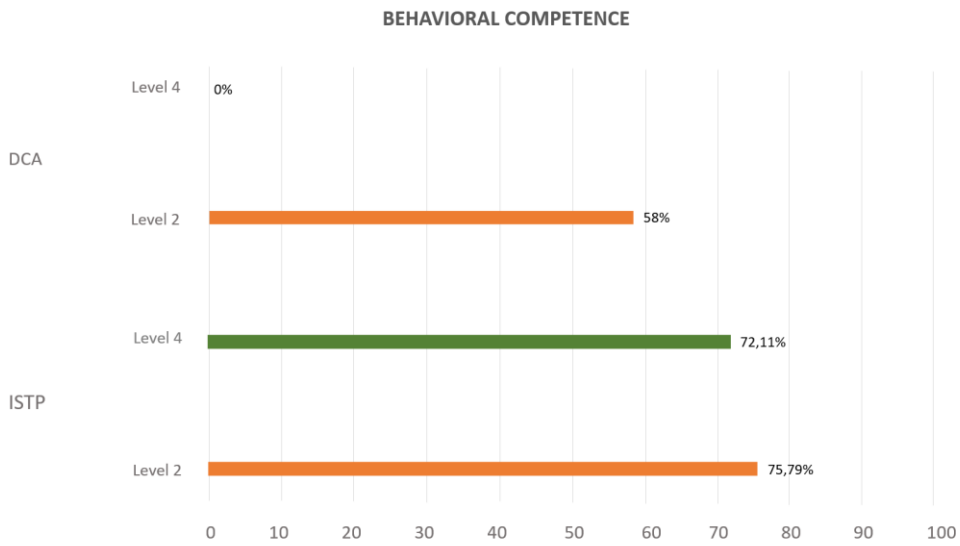

Figure 27- Behavioral Competence

The Methodology percentage of ISTP is noticeably superior to DCA, as presented in Figure 28. Currently, ISTP presents the use of an adequate methodology for project management. The methodology practically used by ISTP project teams is PMBoK, which has a series of steps to be followed to ensure the correct application of the methods. The results obtained from the ISTP assessment show this methodology is well understood, and it is implemented by the project members. The use of a methodology is very important for the maturity growth and the project's success, and it is evident when comparing the two curricular units, one with isolated initiatives towards a methodology understanding and implementation, and the other with an implemented and in use methodology. Through this comparison, it is possible to see an increased maturity, since teams are better prepared to be involved in the entire cycle of developing, implementing, and monitoring project activities.

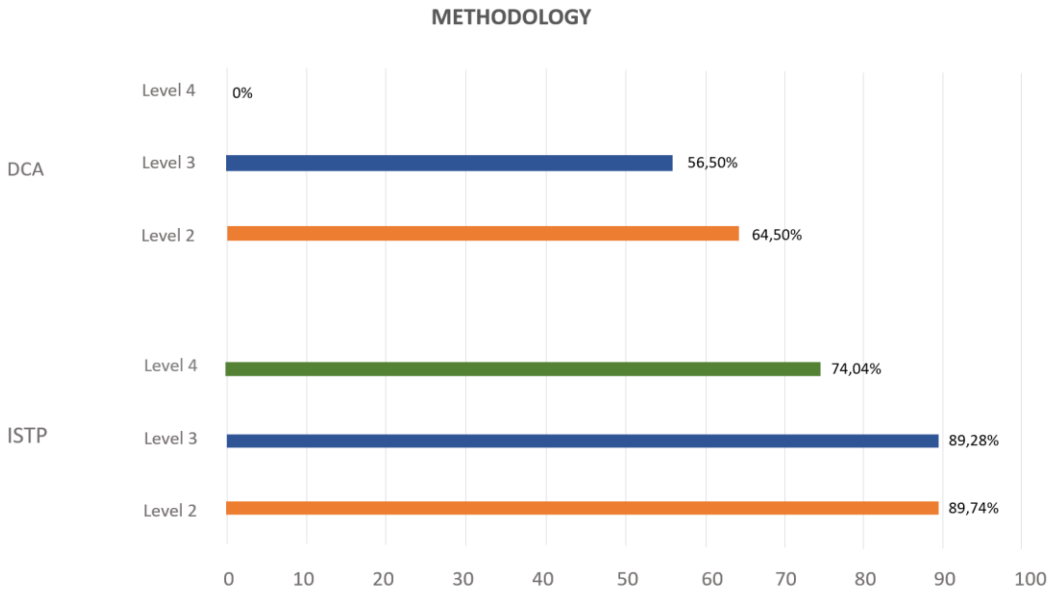

Figure 28- Methodology

The average percentage of Computerization dimension for the curricular unit DCA is at a Regular stage of adherence to Level 2 and Level 3, and 0 adherence to Level 4, and ISTP is at a Good stage of adherence for Level 2 and Level 3, and a Regular stage of adherence for Level 4. ISTP is again better positioned on the scale. The computerization is directly connected to the Methodology results mentioned above. The importance of IT is recognized for supporting the project's management and the related information. Together with the methodology, the computerization represents an added value. Thus, the management of project activities and information through computerization needs an implemented methodology. For this reason, the results obtained from DCA are lower than ISTP because the initiatives for computerization are dispersed and isolated but efforts toward improving in computerization are noticed by DCA. While in ISTP the relevant aspects of the methodology are computerized, the system is friendly to users and supports decision-making. Eventually, for greater adherence to this dimension, every process and activity must be computerized to increase maturity. Figure 29 presents the results for the Computerization dimension.

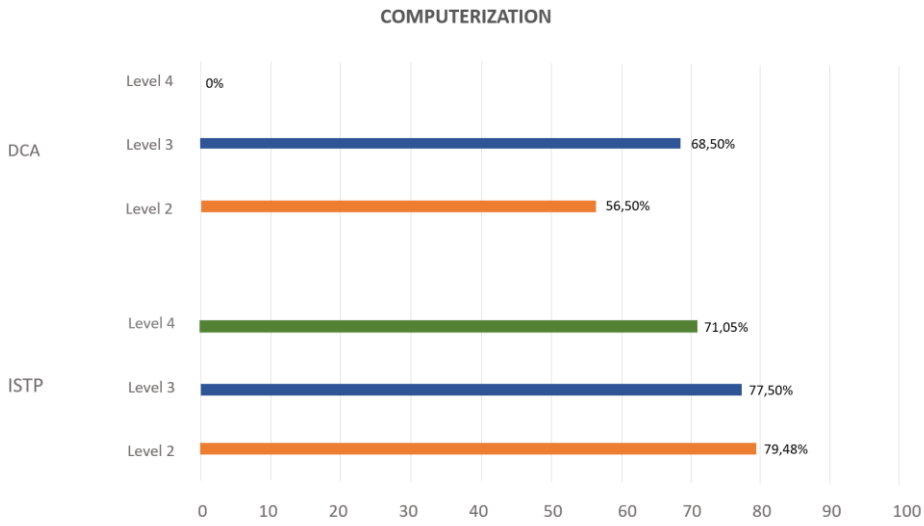

Figure 29- Computerization

The average percentage of the Strategic Alignment dimension for the curricular unit DCA is Regular for Level 2 and Good adherence for Level 3, and for ISTP is Great adherence to Level 2 and Level 3 and Good adherence to Level 4. Both DCA and ISTP show good adherence to the level in which they are. The projects are strategically aligned with the course and the university because of the academic environment they are in, being necessarily aligned with the course objectives. The project management teams are monitored and influenced by the professors, guaranteeing good strategic alignment of the projects, contributing to the success of the work developed. To increase maturity in Strategic Alignment, the projects must have the methodology processes and activities computerized and the current organizational structure must be adequate. This is the principal difference between DCA and ISTP results, according to the answers of the questionnaires. As presented below in Figure 30, the adherence to maturity of this area is greater in ISTP, consequently delivering more maturity to this curricular unit.

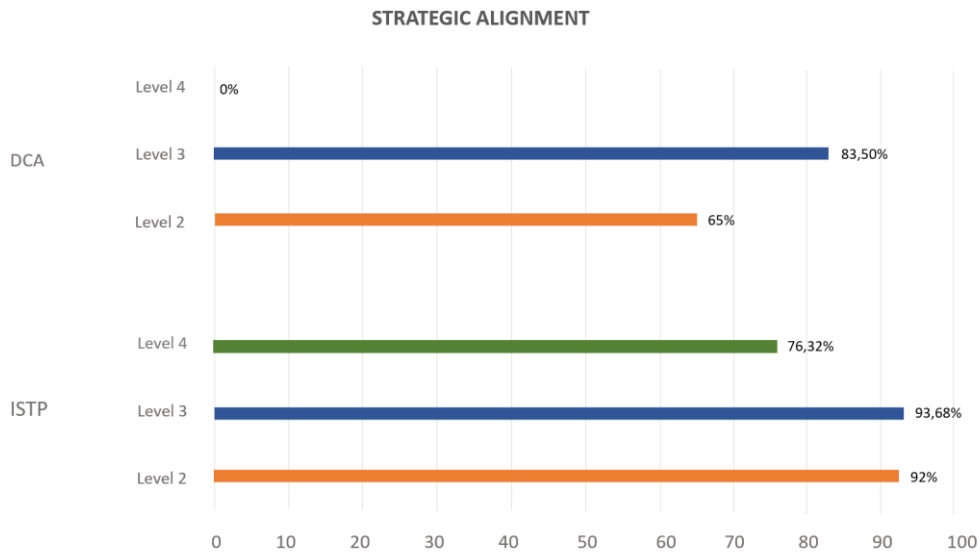

Figure 30- Strategic Alignment

The Organizational Structure dimension shows Regular adherence percentages to the maturity level 2 and Good adherence to level 3 for DCA. And ISTP shows Good adherence to Level 2, Great adherence to Level 3, and Regular adherence to Level 4. The stakeholders involved in this case study are the project managers, the team members of the project, the curricular unit professors, the director of the course, and other entities of the University of Minho. According to the results presented in Figure 31, both course units' projects are organizational structured since the projects are developed in an academic environment and the curricular unit professors are monitoring the projects, providing guidance and support, leading to success. According to the answers of the questionnaire, in DCA the variance of the values of Organizational Structure dimension corresponds to the questions directly related to the project teams, such as the lack of an organizational structure autonomy by the project manager; and the lack of correct team roles defined for each member inside the project teams. ISTP has achieved better results in this dimension, demonstrating training and improvement in this area.

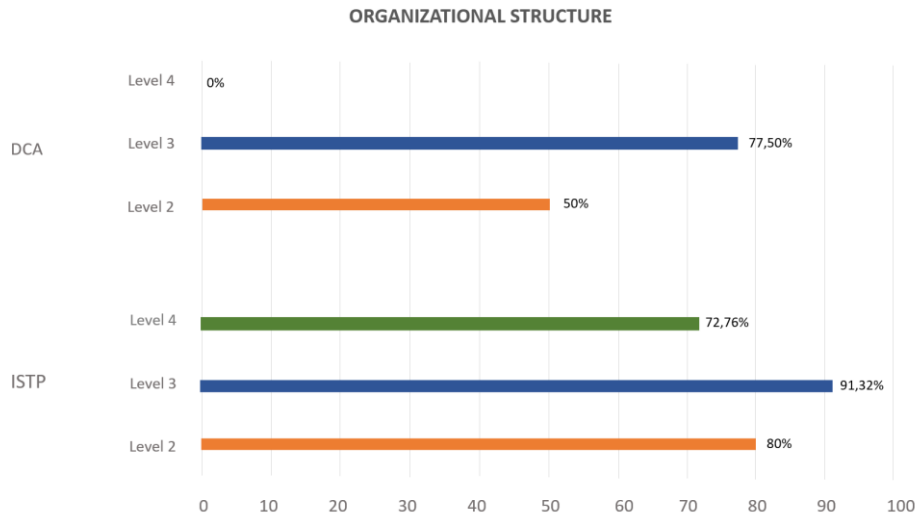

Figure 31- Organizational Structure

In Figure 32 is shown an analysis of adherence for each dimension in the Prado Project Management Maturity Model.

From the data analyzed it is possible to observe the expected growth between the second-year curricular unit DCA and the fourth-year curricular unit ISTP. The adherence of the final assessment of project management maturity of DCA and ISTP is also reflected in the adherence to the dimensions, respectively, proposed by Prado-PMMM.

According to the results obtained in DCA, the figure shows a balance between the organizational dimensions, with an average of 41.867% of adherence, being in the lower limit of Regular adherence. While according to the results obtained in ISTP, the figure also shows a balance between the dimensions, with an average of 80.447%, being at a Good adherence stage.

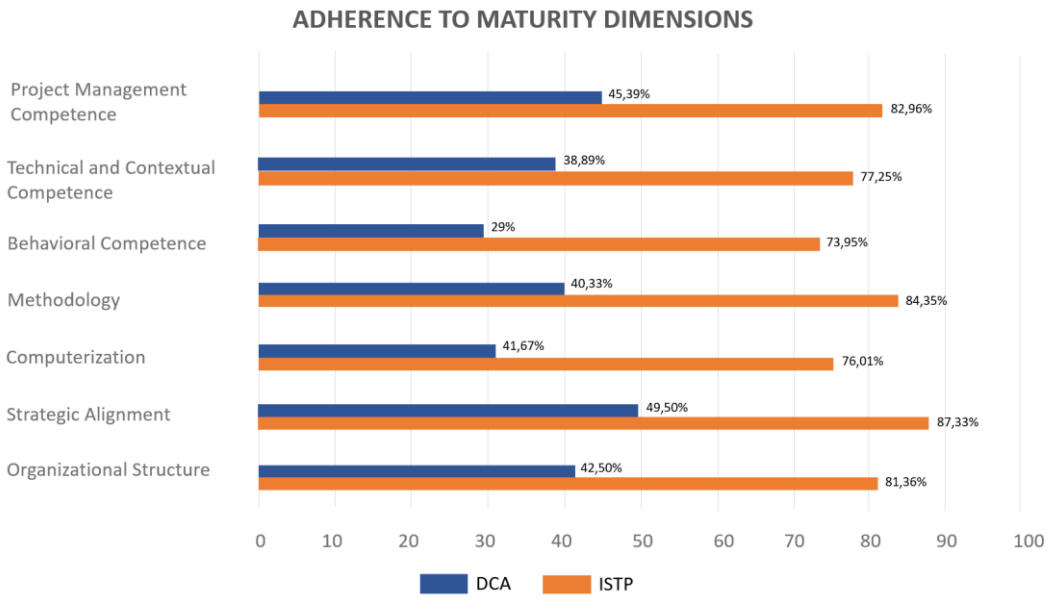

Figure 32- Results of the general Adherence of Maturity Dimensions

Figure 33 shows a relation between the maturity levels and the dimension of the curricular units DCA and ISTP. Through this figure is possible to observe a direct relation between each dimension and each level of maturity. In each cell is described the percentage of the maturity dimension for a specific level.

Regarding to DCA, levels 2 and 3 are very well positioned for the final average that the curricular unit obtained, with level 4 being at 0%, thus lowering the overall average curricular unit maturity.
Regarding ISTP, the average maturity levels are slightly above the curricular unit average maturity, with level 4 being below the average.

According to Prado, as there are advances in maturity, the expectation of success associated with the projects also improves. This improvement in the performance of the projects is related to the experience acquired and the removal of failure factors. Therefore, and as expected, the projects developed by ISTP students have higher success rates than projects developed by DCA students, as it could be observed in this chapter an in the results presented in the figure below which shows this comparison.

Dimensions / Levels	Project Management Competence	Technical and Contextual Competence	Behavioral Competence	Methodology	Computerization	Strategic Alignment	Organizational Structure
Level 4	VL (0%) R (74%)	VL (0%) R (74%)	VL (0%) R (72%)	VL (0%) R (74%)	VL (0%) R (71%)	VL (0%) G (76%)	VL (0%) R (73%)
Level 3	R (73%) GR (91%)	R (51%) G (75%)	———	R (57%) G (89%)	R (69%) G (78%)	G (84%) GR (94%)	G (78%) GR (91%)
Level 2	R (64%) G (84%)	R (66%) G (82%)	R (58%) G (76%)	R (65%) G (89%)	R (57%) G (80%)	R (65%) GR (92%)	R (50%) G (80%)

VL- VERY LOW L- LOW R- REGULAR G- GOOD GR- GREAT

DCA **ISTP**

Figure 33- Maturity Levels and Maturity Dimensions

5. Conclusion

Project management and its measurement through project management maturity questionnaires provide continuous improvement of products and services. In this dissertation, through the application of an adapted version of the Prado Project Management Maturity Model, it was possible to compare the maturity of project management teams in an educational context.

This document began with the contextualization and motivation of the project's dissertation and the research objectives, which the main contributions of the objectives are the comparison of maturity growth in project management between Development of Computer Applications teams and Information Systems and Technologies Project teams, and the verification of the effectiveness of the learning methods and results in project management throughout the course.

After, it was developed the literature search to identify the existing models and theories related to project management maturity. In the literature review were defined the concepts of project management, maturity models, and maturity models in project management. After the models and theories were selected, they were described to provide a comprehensive view of the models and the theories, along with a practical case example for each maturity model.

The application of the best practices of project management and instruments for assessing the maturity level in project management must be natural at a university. A questionnaire was applied to project managers of the course Engineering and Management of Information Systems at a public university to identify the perception of project management maturity levels.

The application of the questionnaire is relevant not only to identify the maturity levels, but also to identify the maturity dimensions in project management, which contributes to a growth plan to achieve excellence in project management.

The main goal of this work was to provide an assessment of maturity between the Development of Computer Applications of the second year of the course and the Information Systems and Technologies Project of the fourth year of the course. It was possible to conclude that in general, the results were the expected, showing an increase of maturity for ISTP rather than DCA. Also, according to the data gathered in this study, it is provided a more detailed comparison providing further understanding of the results due to the description of the current stage of each unit course related to each dimension.

This project dissertation was developed following the methodology Case Study.

Through the analysis of the results of the questionnaire, the average of the final assessment maturity of the DCA projects are 2.318 and ISTP projects are 3.389. These values, within a measurement scale of 1 to 5, indicates that DCA is at the Known and ISTP at the Standardized level of maturity in

project management. DCA is at level 2 and being at level 2 of maturity represents the awakening to the subject project management. The main characteristic of this effort was to introduce a common language of project management through training. ISTP is at level 3 and being at level 3 represents a scenario in which a standardized methodology for project management is implemented and in use. For a team to be at level 3 of maturity it means that along with the methodology being implemented, the computerization is also implemented.

In the results of the dimension assessment, it is also possible to verify both a better general and individual maturity of ISTP that of DCA.

The dimensions with less adherence indicate the weakest aspects in project management university teams, which prioritize attention to maturity growth.

Therefore, the expected results were successfully achieved.

About future work, based on the lessons learned in this research it is suggested to develop improvement plans and growth strategies. The plans and strategies aim to achieve better results in future projects and to improve less-developed aspects that these curricular unit projects demonstrated.

Another suggestion for future work is to assess the maturity of projects from other courses in the university- such as, for example, Electronical Engineering, Computer Engineering, Mechanical Engineering- which do not have project management subjects in the course, therefore they have no knowledge of PMBoK, nor other project management practices.

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APPENDIX I- PRADO-PMMM QUESTIONNAIRE

Questionnaire Departmental Maturity Evaluation

Version 2.2.0 (adapted to teams in an educational environment)

Name of the team

Curricular year:

Number of students per team:

Age:

Team role:

Gender (M/F):

Level 2

1. Regarding the course lessons in the last 6 months, related to basic aspects of project management, select the most appropriate option:

a) Many elements of the team had lessons about project management in the last 6 months. The lessons covered areas related to knowledge and processes (such as available standards, PMBOK, IPMA, Prince2, etc.).

b) The situation is slightly inferior than that described in option A.

c) The situation is significantly inferior than that described in option A.

d) There is some effort in this direction.

e) There is no effort in this direction.

2. Regarding the usage of time management software (task sequencing, timelines, Gantt, etc.), select the most appropriate option:

a) Many elements of the team had lessons about applications for time management in the last 6 months and used them in the projects.

b) The situation is slightly inferior than that described in option A.

c) The situation is significantly inferior than that described in option A.

d) There is some effort in this direction.

e) There is no effort in this direction.

3. Regarding to experience in project planning and control by the elements of the team, select the most appropriate option:

a) In the last 6 months, many elements of the team have been planning, monitoring, and closing a reasonable number of projects, based on known standards (PMBoK, etc.) and on computer tools (MSProjects, etc.)

b) The situation is slightly inferior than that described in option A.

c) The situation is significantly inferior than that described in option A.

d) There is some effort in this direction.

e) There is no effort in this direction.

4. Regarding the acceptance, by the professors, students, course administration and other entities of University of Minho, of the importance of the subject project management to add value to the course, select the most appropriate option:

a) This is an already consolidated or evolving theme. Initiatives towards development/improvement of understanding of the subject has been observed in the last 6 months. Such as lessons to discuss the subject, workshops, courses, etc.

b) The situation is slightly inferior than that described in option A.

c) The situation is significantly inferior than that described in option A.

d) There is some effort in this direction.

e) There is no effort in this direction.

5. Regarding the acceptance, by the professors, students, course administration and other entities of University of Minho, of the importance of a project management methodology, select the most appropriate option:

a) This is an already consolidated or evolving theme. Initiatives towards development/improvement of the subject has been observed in the last 6 months. Such as lessons to discuss the subject, workshops, etc.

b) The situation is slightly inferior than that described in option A.

c) The situation is significantly inferior than that described in option A.

d) There is some effort in this direction.

e) There is no effort in this direction.

6. Regarding the acceptance, by the professors, students, course administration and other entities of University of Minho, of the importance of a project management computer-based system, select the most appropriate option:

a) This is an already consolidated or evolving theme. Initiatives towards development/improvement of the subject has been observed in the last 6 months. Such as lessons to discuss the subject, workshops, etc.

b) The situation is slightly inferior than that described in option A.

c) The situation is significantly inferior than that described in option A.

d) There is some effort in this direction.

e) There is no effort in this direction.

7. Regarding the acceptance, by the professors, students, course administration and other entities of University of Minho, of the importance to evolve in behavioral competencies aspects (leadership, negotiation, communication, conflicts, etc.), select the most appropriate option:

a) This is an already consolidated or evolving theme. Initiatives towards development/improvement of the subject has been observed in the last 6 months. Such as lessons to discuss the subject, workshops, etc.

b) The situation is slightly inferior than that described in option A.

c) The situation is significantly inferior than that described in option A.

d) There is some effort in this direction.

e) There is no effort in this direction.

8. Regarding the acceptance, by the professors, students, course administration and other entities of University of Minho, of the importance to evolve in technical and contextual competencies (subjects related to technologies, information systems, methodologies, organizational processes, etc.), select the most appropriate option:

a) This is an already consolidated or evolving theme. Initiatives towards development/improvement of the subject has been observed in the last 6 months. Such as lessons to discuss the subject, workshops, etc.

b) The situation is slightly inferior than that described in option A.

c) The situation is significantly inferior than that described in option A.

d) There is some effort in this direction.

e) There is no effort in this direction.

Level 3

1. Regarding the use of project management methodology by the students involved in the project, select the most appropriate option:

a) There is a methodology containing the processes and areas of expertise required and aligned to any of the existing standards (PMBoK, Prince2, IPMA, etc.). It differentiates by sice (large, médium and small) and is under usage for over a year.

b) The situation is slightly inferior than that described in option A.

c) The situation is significantly inferior than that described in option A.

d) There is some effort in this direction.

e) There is no effort in this direction.

2. Regarding the computerization of project management processes, select the most appropriate option:

a) There is an apparently complete, adequate, and friendly system. It allows diffent sizes and it is possible to store and query data from closed projects. It is under usage by the students for over one year.

b) The situation is slightly inferior than that described in option A.

c) The situation is significantly inferior than that described in option A.

d) There is some effort in this direction.

e) There is no effort in this direction.

3. Regarding the processes mapping and standardization (if applicable) the proposal of the idea, the technical and the feasibility studies, the negotiations, resource allocation, project's implementation and use, select the most appropriate option:

a) All the above processes were mapped, standardized, and some computerized (both from the perspective from product development and its management). The existing material is apparently complete and adequate and is under usage for over a year.

b) The situation is slightly inferior than that described in option A.

c) The situation is significantly inferior than that described in option A.

d) There is some effort in this direction.

e) There is no effort in this direction.

4. Regarding the Project Plan document, which must contain the approach to execute each project in terms of its complexity, and be used to monitor project progress, changes, risks, and stakeholders, select the most appropriate option:

a) The creation of this document demands the approval of the baseline, with its goals for time, cost, and outcome indicators (if applicable). This process is under usage for over one year and is well accepted.

b) The situation is slightly inferior than that described in option A.

c) The situation is significantly inferior than that described in option A.

d) There is some effort in this direction.

e) There is no effort in this direction.

5. Regarding the interaction with the Professors to monitor the projects during their execution, select the most appropriate option:

a) They were deployed, there are regular meeting and they have strong influence in the progress of projects under its monitoring. They are well accepted and are under usage for over a year.

b) The situation is slightly inferior than that described in option A.

c) The situation is significantly inferior than that described in option A.

d) There is some effort in this direction.

e) There is no effort in this direction.

6. Regarding each project monitoring, at meeting held by the project manager with the team to update the project plan and manage exceptions and risks, select the most appropriate option:

a) Regular meeting to ensure everyone knows the project progress are realized. Data are collected and compared with the baseline. In case of deviation, countermeasures are implemented. And risk analysis is carried out. It is under usage for over a year.

b) The situation is slightly inferior than that described in option A.

c) The situation is significantly inferior than that described in option A.

d) There is some effort in this direction.

e) There is no effort in this direction.

7. Regarding change management (time, scope, results, etc.) of ongoing projects, select the most appropriate option:

a) The baseline values are respected throughout each project life and changes are avoided. In cases of change requests, stringent criteria are used for analysis and approval. The model works properly for over a year.

b) The situation is slightly inferior than that described in option A.

c) The situation is significantly inferior than that described in option A.

d) There is some effort in this direction.

e) There is no effort in this direction.

8. Regarding the definition of success and the creation and use of metrics to evaluate the projects' success (goals, achievement, results obtained, delays, performance, etc.), select the most appropriate option:

a) At the end of each project a success evaluation is carried out and the causes of deviation are analyzed. The database is periodically analyzed to identify the main negative factors. It is under usage for over a year.

b) The situation is slightly inferior than that described in option A.

c) The situation is significantly inferior than that described in option A.

d) There is some effort in this direction.

e) There is no effort in this direction.

Level 4

1. Regarding the elimination of deviations (delays, excessive working hours, non-compliance of the scope, quality, results, etc.) coming from the team or external factors (interfaces), select the most appropriate option:

a) All major deviations were identified and eliminated (or mitigated) by establishing actions (countermeasures) to prevent these causes from recurring. This scenario has been operating successfully for over 2 years.

b) The situation is slightly inferior than that described in option A.

c) The situation is significantly inferior than that described in option A.

d) There is some effort in this direction.

e) There is no effort in this direction.

2. In a good governance environment, we have efficiency and effectiveness due to correct organizational structure (team roles well defined). Moreover, the main stakeholders are competent, proactive and correctly utilize available resources (processes, tools, etc.). Select the most appropriate option:

a) There is good governance (Professors) in the teams. The right decisions are taken at the right time, by the right person and produce the right and expected results. This governance is happening for over 2 years.

b) The situation is slightly inferior than that described in option A.

c) The situation is significantly inferior than that described in option A.

d) There is some effort in this direction.

e) There is no effort in this direction.

3. Regarding Continuous Improvement, practiced in projects, select the most appropriate option:

a) There is a system to periodically evaluate these aspects and the ones that show weakness or inadequacy are discussed and improved. It is well accepted and practiced by the main stakeholders for over 2 years.

b) The situation is slightly inferior than that described in option A.

c) The situation is significantly inferior than that described in option A.

d) There is some effort in this direction.

e) There is no effort in this direction.

4. Regarding monitoring of the project teams, by the Professors, and the incentive provided to them in order to achieve their projects' goals, select the most appropriate option:

a) There is an evaluation system of project teams, which establishes goals and, in the end, evaluate how well the teams performed. The system works successfully for over 2 years.

b) The situation is slightly inferior than that described in option A.

c) The situation is significantly inferior than that described in option A.

d) There is some effort in this direction.

e) There is no effort in this direction.

5. Regarding the improvement of project managers' capacity, with emphasis on human relationships (leadership, negotiation, conflicts, motivation, etc.), select the most appropriate option:

a) Virtually all project managers have great capacity in human relationships. This capacity for human relationships has been working successfully in teams for over 2 years.

b) The situation is slightly inferior than that described in option A.

c) The situation is significantly inferior than that described in option A.

d) There is some effort in this direction.

e) There is no effort in this direction.

6. Regarding a computer-based system:

a) An IT system which addresses all stages from initial idea (or opportunity or need) to the delivery of the product has been in use for over 2 years.

b) The situation is slightly inferior than that described in option A.

c) The situation is significantly inferior than that described in option A.

d) There is some effort in this direction.

e) There is no effort in this direction.

7. Regarding historical data of closed projects in relation to the aspects: Evaluation of Obtained Results, Lessons Learned, Best Practices, etc., select the most appropriate option:

a) For over 2 years a database of great quality containing this information is available. This system is in use by the teams to avoid risks, past mistakes, and to optimize the planning, execution, and closure of new projects.

b) The situation is slightly inferior than that described in option A.

c) The situation is significantly inferior than that described in option A.

d) There is some effort in this direction.

e) There is no effort in this direction.

8. Regarding the prevailing climate in the teams, for project management, select the most appropriate option:

a) The subject project management is seen as “something natural and necessary” for at least 2 years. The projects ate aligned with the strategies and execution occurs without interruption, in a climate of low stress, low noise and high success.

b) The situation is slightly inferior than that described in option A.

c) The situation is significantly inferior than that described in option A.

d) There is some effort in this direction.

e) There is no effort in this direction.

APPENDIX II- GENDER RANGE AND NUMBER OF STUDENTS PER TEAM

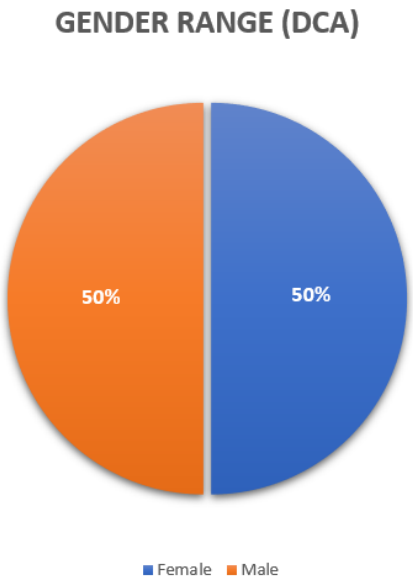

Figure 34- Gender Range of "DCA" Students

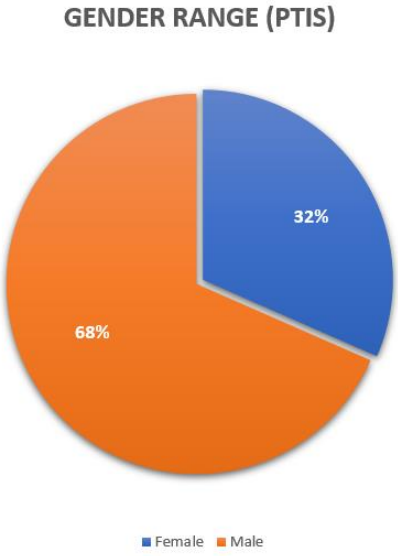

Figure 35- Gender Range "ISTP" Students