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How Artificial Intelligence Can Provide Support in Project Resource Management

Ricardo Miguel Silva Nobre

Master of Science in Business Administration

Supervisor:
Professor Leandro Pereira, Auxiliary Professor, ISCTE Business School

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-Spine-

Acknowledgements

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Abstract

With the exponential advancement of technology, most companies are starting to adopt these innovative systems to improve their performance and a major player in this advancement is the development of Artificial Intelligence (AI). The following dissertation explores the application of AI in Project Resource Management in order to understand how this technology can support and improve the management of Human and Physical resources in Projects. By taking a sample of professional Project Managers in the Portuguese labour market, it was identified their major difficulties in the different Project Resource Management Processes, if they used AI before and if they would be willing to use AI to manage Resources in Projects. It was possible to understand that most Project Managers had difficulties in Human Resource Management and Physical Resource Acquisition, most of them have had contact with AI technologies and the majority perceive this technology as being useful and would use it for their daily tasks.

Keywords: Artificial Intelligence; Management; Project Management; Project Resource Management AI Usefulness;

JEL Classification System:

M10 – Business Administration: General

M15 – IT Management;

Resumo

Com o aumento exponencial da tecnologia, uma grande parte de empresas estão a começar a adotar os sistemas mais inovadores do mercado e um grande *player* neste desenvolvimento é sem dúvida a Inteligência Artificial (IA). Esta dissertação visa explorar a aplicação de IA na Gestão de Recursos em Projetos de modo a compreender como é que esta tecnologia consegue providenciar apoio e melhorar a gestão de recursos Humanos e Materiais em Projetos. Utilizando uma amostra de Gestores de Projetos profissionais no mercado de trabalho português, identificando quais as maiores dificuldades que estes sentem nos diferentes Processos da Gestão de Recursos em Projetos, se os mesmos já tinham utilizado IA anteriormente e se estariam dispostos a utilizar IA para gerir recursos em Projetos. Os resultados mostraram que as maiores dificuldades se encontraram nos processos de Gestão de Recursos Humanos e na Aquisição de Recursos Materiais, que muitos dos mesmos já tinham contatado com IA anteriormente e que a maior parte reconhece a utilidade desta tecnologia e estariam dispostos a utilizarem a mesma no dia a dia.

Palavras Chave: Inteligência Artificial; Gestão; Gestão de Projetos; Gestão de Recursos em Projetos; Utilidade da IA;

JEL Classification System:

M10 – Business Administration: General

M15 – IT Management;

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1. Introduction

With the exponential advancement of technology, a broad variety of innovations have been developed with the intuition of facilitating, augmentation and even automating a lot of previously human performed tasks, most of it through machines.

One of the most impacting technological advancement is without any doubt the development of Artificial Intelligence (AI), not only because of the time saving and economic related impacts, but also because of the social effect that this advancement has introduced, where many human tasks are being performed by autonomous machines and various digital technologies.

1.1. Research Context

The introduction of AI into to our daily routines is a reality that is becoming more frequent each day, as shown by observable examples of these agents acting in various daily routines, such as smart supermarket checkouts, self-driving vehicles, voice recognition technologies, among others, indicating that this trend will further develop into many more areas and industries (Steels & De Mantaras, 2018).

More so is the introduction of Artificial Intelligence into the Project Management professional and academic world, where several software-based solutions are facilitating various tasks that were previously highly time consuming and costly, such as communication, monitorization processes, information gathering, data analysis, and many other variables (Prasad & Vijaya Saradhi, 2019).

But when it comes to critical decision making within Projects, Project Managers still rely on experienced validation of choices and intuition to perform critical decision making when it comes to all knowledge areas in the Project Management discipline (Magaña Martínez & Fernandez-Rodriguez, 2015). This paradigm can soon change with the further development of AI capable of delivering fast responses and making choices based on the perfect balance of all the different inputs and variables that compose the development of Projects.

1.2. Research Problem

While studying the application of AI in Project Management, a research gap in the Management field of studies has been identified and an important question must be answered: Can Artificial Intelligence provide support for Project Team Members in managing Human and Physical Resources?

Decisions such as resource planning, estimation, distribution and maintenance, scheduling, task distribution and prioritization, team development and management would be conducted by machines who would evaluate the current state of the Project on a time-cost-quality paradigm and perform the appropriate actions to guarantee the maximum efficiency of the Project development. The AI would not substitute the Project Management in its current stage of development, but it does put into consideration their role in the Project when it comes to human and physical resource management.

This dissertation will provide insight in how Artificial Intelligence can provide support or even improve Project Management as a powerful software tool. The study will evaluate the different existing tools, how they are combined to improve the user experience and how it can make a difference in the Projects developed in the future. The fundamental task in this dissertation will be to understand how users perceive AI in the Project Resource Management scope and how it could help said users to further develop their work.

1.3. Dissertation Structure

To develop this study, initially the research will be based on a Literature Review that defines Project Management, Project Resource Management, Artificial Intelligence, its general application and the AI European and Portuguese context. Followed by a careful analysis of the existent AI technologies that support Project Management and Project Resource Management. Afterwards, a Critical Analysis of the Literature Review is used to identify gaps in the theory and practice, which will be used to develop the study and carefully select the method for collecting the necessary data.

After collecting the data, a Descriptive Analysis is performed, followed by a Pearson's *r* Correlation Analysis of the variables. This analysis will provide us with finding and conclusions to answers our Research Questions and fulfil our Research Objectives, provide further research proposals and identify the weaknesses in our study.

2. Literature Review

In this section the theorical foothold for the Project will be described based on the essential theorical literature that was found during the research, as well as supportive literature that'll aid in understanding the fundamentals necessary to properly execute the Project and reach the desired goals.

2.1. Project Management

As one of the major schools of the managerial scientific field, Project management is described as the full employment of different techniques, knowledge, skills and tools to develop the Project at hands, properly applying them successfully to achieve the objectives of said Project as described by the Project Management Institute (2017).

Also, it is important to understand that a Project is a *"... temporary endeavor undertaken to create a unique product, service, or result."* (Project Management Institute, 2017) requested by a company or client, making every Project unique even if it relates in nature with other Projects, since they have different driving factors or lack routine elements that make it a repetitive application of skills, resources, knowledge or funds, seeking a sort of long-lasting result that helps the company or client either in the short, mid, or long-term.

As any other scientific area, Project management as many methodologies that help us define the appropriate and effective way to develop a Project. In a study conducted by Jovanovic & Beric, (2018) they analysed the existing Project Management methodologies in order to understand how they can choose the best methodology that could be applied in any Project. They concluded that typical traditional methodologies (PMI, IPMA, APM, YUPMA, PRINCE 2) are more appropriate for long lasting and complex Projects, like construction or military Projects, while agile methodologies are more appropriate for smaller and less complex Projects, such as IT. They also noted that each methodology needs to be correctly chosen and applied to the proper Project, in order to guarantee the best efficiency and results in developing the Project.

One of the studied methodologies by Jovanovic & Beric (2018) is in fact the Project Management Institute's framework (PMI) and referring to the literature presented by the Project Management Institute (2017), the book divides the Project Management discipline into ten major Knowledge Areas and links them with the five main group Processes that divide the

typical scheme for a Project. The following table shows just how these different Areas relate to the Processes needed to develop the Project:

Table 1.1 - Project Management Process Group and Knowledge Area Mapping (Source: Project Management Institute, 2017)

Knowledge Areas	Project Management Process Groups				
	Initiating Process Group	Planning Process Group	Executing Process Group	Monitoring and Controlling Process Group	Closing Process Group
4. Project Integration Management	4.1 Develop Project Charter	4.2 Develop Project Management Plan	4.3 Direct and Manage Project Work 4.4 Manage Project Knowledge	4.5 Monitor and Control Project Work 4.6 Perform Integrated Change Control	4.7 Close Project or Phase
5. Project Scope Management		5.1 Plan Scope Management 5.2 Collect Requirements 5.3 Define Scope 5.4 Create WBS		5.5 Validate Scope 5.6 Control Scope	
6. Project Schedule Management		6.1 Plan Schedule Management 6.2 Define Activities 6.3 Sequence Activities 6.4 Estimate Activity Durations 6.5 Develop Schedule		6.6 Control Schedule	
7. Project Cost Management		7.1 Plan Cost Management 7.2 Estimate Costs 7.3 Determine Budget		7.4 Control Costs	
8. Project Quality Management		8.1 Plan Quality Management	8.2 Manage Quality	8.3 Control Quality	
9. Project Resource Management		9.1 Plan Resource Management 9.2 Estimate Activity Resources	9.3 Acquire Resources 9.4 Develop Team 9.5 Manage Team	9.6 Control Resources	
10. Project Communications Management		10.1 Plan Communications Management	10.2 Manage Communications	10.3 Monitor Communications	
11. Project Risk Management		11.1 Plan Risk Management 11.2 Identify Risks 11.3 Perform Qualitative Risk Analysis 11.4 Perform Quantitative Risk Analysis 11.5 Plan Risk Responses	11.6 Implement Risk Responses	11.7 Monitor Risks	
12. Project Procurement Management		12.1 Plan Procurement Management	12.2 Conduct Procurements	12.3 Control Procurements	
13. Project Stakeholder Management	13.1 Identify Stakeholders	13.2 Plan Stakeholder Engagement	13.3 Manage Stakeholder Engagement	13.4 Monitor Stakeholder Engagement	

It is important to mention that the Areas of Knowledge presented in the book are a suitable way of grouping different important functions that every Project requires without having to pursuit the PMI methodology has a basis for this research, meaning that the PMI methodology is not necessarily the methodology that will have to be used in order to apply the findings in this dissertation.

2.2. Project Resource Management

The major Knowledge Area that will be covered in this dissertation is related to the Project Resource Management which includes *"... the processes to identify, acquire and manage the resources needed for the successful completion of the Project."*(Project Management Institute, 2017) where the considered resources fall into the human and physical properties, including the necessary skills, knowledge, equipment, raw materials, supplies, etc., to ensure that all the activities that compose the Project are properly executed. All Project Team Members have specific roles and responsibilities for the Project and involving them in the planning and development processes could be beneficial for the Project according to the Project Management Institute (2017).

The tasks performed in the Project are grouped into different processes that are performed during different stages of the Project development known as Process Groups. In the Project Resource Management Knowledge Area, there are the following Processes:

Table 1.2 - Project Resource Management Processes (Source: Project Management Institute, 2017, adapted, 2020)

Process	Process Group	Definition
Plan Resource Management	Planning	*"The process of defining how to estimate, acquire, manage, and utilize physical and team resources."*
Estimate Activity Resources	Planning	*"The process of estimating team resources and the type and quantities of material, equipment, and supplies necessary to perform Project work."*
Acquire Resources	Executing	*"The process of obtaining, team members, facilities, equipment, material, supplies, and other resources necessary to complete Project work."*
Develop Team	Executing	*"The process of improving competencies, team member interaction, and the overall team environment to enhance Project performance."*
Manage Team	Executing	*"The process of tracking team member performance, providing feedback, resolving issues, and managing team changes to optimize Project performance."*
Control Resources	Monitoring and Controlling	*"The process of ensuring that the physical resources assigned and allocated to the Project are available as planned, as well as monitoring planned versus actual use of resources, and performing corrective action as necessary."*

2.2.1. Human Resource Management

When it comes to Human Resources, a Project Manager must make sure that all Team Members match the required necessities to develop the Project, acting as both a leader and a manager. This means that the Project Manager must ensure that the team has the necessary training, development, material and equipment availability, proper communication between stakeholders, technical and psychological support, and if the team is being properly rewarded for the tasks that they are developing and the milestones they achieve (Project Management Institute, 2017).

2.2.1.1. Human Resource Planning and Estimation

According to the Project Management Institute (2017), first the Project Manager is responsible for defining the desired Project Team during the Planning stage of the Project, identifying and establishing the required roles for Team Members including their authority, responsibility and competence, as well as estimating the necessary workforce to perform all the required tasks for the Project.

To do so Project Managers use a set of tools and techniques that facilitate the decision-making process, which include, but are not limited to, Expert Judgement, Bottom-Up Estimating, Analogous Estimating, Parametric Estimating, Data Analysis, Project Management Information System and Meetings. The efforts put into planning beforehand the different steps that compose the Project has a strong influence on the Project success, as well as its efficiency, increasing them both (Dvir, 2005).

2.2.1.2. Human Resource Acquisition

After deciding which resources are necessary, it is up to the Project Manager to acquire the team of professionals that have the specific tailored considerations for the venture during the Execution stage. It is important to mention that the Project Manager may not have direct or full control over the acquisition of human resources due to economical restraints, allocation to other assignments, geographical and cultural constraints, or lack of influence with others who are in position to provide such employees (Project Management Institute, 2017).

In order to acquire these Team Members, Project Managers perform decision making by applying multicriteria analysis methods to select potential candidates. These criteria include

cost, ability, experience, knowledge, skills, attitude, and international factors, which concern geographical location, time zone and the ability to communicate. It is also important to consider the interpersonal and team skills of the Project Team since some members, if not all, will have to negotiate for specific materials, supplies, equipment, or influence a decision from an external party that may affect the venture. Furthermore, some Team Members might already be pre assigned for the Project if they are *"... part of a competitive proposal or if the project is dependent of the expertise of particular persons."* (Project Management Institute, 2017).

2.2.1.3. Human Resource Team Development and Management

Once the team is gathered, it is up to the Project Manager to ensure that the team receives proper development, which includes improving the team's competencies, team environment and the interaction among Team Members.

The application of appropriate leadership styles while managing Human Resources is crucial for the development of newly formed teams and its management. Leadership is described as *"... process whereby an individual influences a groups of individuals to achieve a common goal."* (Northouse, 2016) ultimately inspiring them to have more involvement and dedication to the task at hands. In a study conducted by Ceri-Booms, Curşeu, & Oerlemans, (2017) they were able to demonstrate that the application of leadership behaviours can have a positive outcome in team performance relating to person focused behaviours and task-focused behaviours stating that *"... Project teams can benefit from person-focused and task-focused leader behaviors."* and also that team leaders must realize that the allocation and coordination of tasks is essential for effective team work. One of the major findings in their research indicates that the high level of task interdependence creates a necessity for more person-focused behaviours, such as transformational leadership, charismatic leadership and emotionally intelligent leadership.

Dabirian, Abbaspour, Khanzadi, & Ahmadi (2019) state that the "*Allocation of human resources can be regarded as the main core of the processes of human resource processes…"* proposing that timely and well-scheduled Human Resource allocation can make a significant difference in the Project's outcome when it comes to cost and time performance parameters, while also allowing workers to gain new skills and develop existing ones during the development of the Project.

To guarantee high productivity and output for any team, the Project Manager must ensure that the suitable training and competency development is guaranteed for the Project Team. This can be accomplished by providing online based classes, coaching or mentoring sessions, or even on-the-job training (Project Management Institute, 2017). These techniques further develop the skills of the Team Members or allow them to obtain a set of new ones that are retained and can even be useful for future Projects.

Communication is another crucial factor to include in team management, since it allows the Project Manager to follow the team's progress, provide timely and important feedback, as well as ensuring that Team Members have all the emotional and technical support they need, cultivating their dedication to the Project (Project Management Institute, 2017). Including Team Members in meetings, decision-making and team building activities can improve communication. Zulch (2016) found that effective communication abilities promoted a better application of leadership styles and resulted in higher performances in Projects, as well as increased success rates.

The enhancement of an appropriate work environment in order to improve employee satisfaction and performance and applying necessary changes to the team is also important in Projects. Project Managers can do so *"… by providing challenges and opportunities, providing timely feedback and support as needed, and recognizing and rewarding good performance."* (Project Management Institute, 2017) securing team-building opportunities, conflict management solutions and more effective communication.

A study conducted by Thamhain, (2004) shows that assigning professionally challenging tasks and providing the appropriate support to Project teams increases commitment and lowers communication barriers and conflict risk, improving the overall performance of the Project team. Popaitoon & Siengthai (2014) conducted a review on the relationship between human resource management practices focused on Project management and Project performance, and found that behaviours that focused on employee training, participation and rewarding were key to improve Project efficiency.

While managing the team, the Project Manager must also assess the work progress and quality, since it provides understanding of the team's or a specific team member's strengths and weaknesses, while also helping to understand their aspirations, how they organize their work and make decisions, and their interaction with other Team Members (Project Management Institute, 2017). This assessment requires the Project manager to perform monitoring/control

actions over the development of the Project activities in order to avoid delays, quickly respond to changes in the Project and execute necessary changes and actions and maintain scheduled activities or reduce impacts related to delays (Aljamee & Naeem, 2020).

Rewarding the Project Team and Team Members is also crucial to increase engagement in the Project. Identifying and rewarding constructive behaviour will provide further motivation, since they will feel valued by the organization and recognized. These rewards may come in the form of monetary compensation, new opportunities to grow professionally or gain added responsibilities to feel more included. These compensations should be provided throughout the Project's development, instead of waiting for the Project's completion (Project Management Institute, 2017).

2.2.2. Physical Resource Management

When it comes to Physical Resource management there are specifications that must be met do develop the Project. By Physical Resources, this dissertation considers materials, equipment/tools, supplies, software, machinery, infrastructures and facilities (Project Management Institute, 2017). Project Managers have to identify the key physical resources and equipment for each task, determine how and when to acquire them, control the materials and monitor their use over time.

2.2.2.1. Physical Resource Planning and Estimation

First, the Project Manager must lay out a formal plan that specifies the estimation, acquisition and proper management of Physical Resources, identifying the appropriate approach to ensure resource availability to complete each task. By using a stipulated project charter, project documents that include a schedule, requirements, distribution of available facilities and resources, the Project Manager is able to postulate this plan with the help of data representation, meetings and expert judgement (Project Management Institute, 2017).

As for the estimation of the necessary resources there are many existing methods to do so, such as the estimation of activity resources by determining activity lists, attributes, cost estimates, calendarization, risk consideration, bottom-up estimations, analogous estimations, parametric and data analysis, meetings, and expert judgement (Project Management Institute, 2017).

2.2.2.2. Physical Resource Acquisition

The stage of Physical Resource allocation is focused on outlining the selections of required resources, assigning them to the respective activities and acquiring them for the Project, being periodically performed along the Project's lifecycle, and the required resources may be internal or external for the company that is performing the Project (Project Management Institute, 2017).

To select the required physical resources to be attained, a multi-criteria analysis is usually ensued, utilizing availability, cost, geographical location, resource properties and time related factors to decide which resources are the most advantageous. As mentioned for the human resources, physical resources may be pre-assigned to Projects if they represent any sort of competitive value for the company (Project Management Institute, 2017).

Procurement is another major necessity in physical resource management, since internal resources are usually assigned to the Project, while external resources are procured, either by the Project Manager, the Project team or by other parties such as the procurement office. This task requires *"... agreements that describe the relationship between two parties – a buyer and a seller."* (Project Management Institute, 2017) and different agreements have different levels of complexity, being bond by contracts that stipulate deliverables and expected results. It is also important to mention that when conducting business internationally there are cultural aspects and legal requirements that are crucial to track.

Selecting a supplier for an assignment and evaluating its performance during the contract's validity is important in ensuring a good outcome, which proposes two major phases in procurement, supplier selection and supplier evaluation (Araújo, Alencar, & de Miranda Mota, 2017). Choosing criteria to select and evaluate is an issue that can influence the entire process and should be stipulated based on the client's needs, since Projects usually aim for good results that regard cost, quality and time.

Negotiation is usually required when it comes to acquiring resources, be it due to the related costs, availability, necessity or time restraints. Project Managers or Team Members that have a high degree of negotiation skills will be able to secure the best resources for the Project (Project Management Institute, 2017). Negotiation can be described as the *"... process of potential opportunistic interaction by which two parties accomplish their interests through a jointly agreed action."* (Falcão, 2018). This negotiation process is important, since it can create long-term and trustworthy relationships among different organizations, companies or individuals that may prove to be valuable assets in the future for other Projects.

2.2.2.3. Physical Resource Management

This process is usually performed throughout the Projects' lifecycle, similarly to the acquisition of resources, where the Project Manager is responsible for the proper assignment and allocation of the physical resources for all the activities that compose the Project according to established plan, carrying out corrective actions if any issues arise. This grants the physical resources' user timely and well placed resources, avoiding delays and guaranteeing a better performance (Project Management Institute, 2017). The main techniques utilized to manage these physical resources include alternative analysis, cost-benefit analysis, performance reviews and trend analysis.

There are many logistic-based methods to deal with the material resource allocation issue, and the assumptions are usually the same: (1) how much inventory should Project Managers keep and (2) how do they allocate the available material to ensure that on-going processes are kept within schedule (Lu, Wang, Xie, & Wang, 2018). The variability of the Projects' environment and progress causes material availability and necessities fluctuations, which affect expert decision making in these sorts of cases. Therefore, there is the need for tools that help Project Managers reach their goals and the current trend is based on Artificial Intelligence.

2.3. Artificial Intelligence

With the exponential advancement of technology, a broad variety of innovations have been developed with the intuition of simplification, augmentation and even automation of various previously human performed tasks through machines. The most impacting technological advancement is without any doubt the development of artificial intelligence, not only because of the time and economic related benefits, but also because of the social effect that this advancement has introduced, where many human tasks and schedules are being performed by machines, social interactions become simplified and this reality is becoming more frequent each day.

But what kind of programs or machines can truly be categorized as Artificial Intelligence? The term was initially devised in 1956 by John McCarthy as the science and engineering of making intelligent machines (Copeland, 1993) and later Poole, Alan, & Goebel (1998) defined Artificial Intelligence (AI) as an agent that has the ability to react to its environment and performs a set of actions that enables it to achieve the specified goals with

maximum efficiency, by interpreting inputs and data, analysing historical results and even learning what is the correct method to approach any given situation by experience. Most importantly, it is a set of codes humanly designed to facilitate activities and solve problems, able to read large amounts of data in reduced lengths of time.

This technology is mostly recognized for mimicking the human intellects and its capabilities for problem-solving, complex planning, reasoning, negotiating, decision-making, prediction, adaptation to new environments, understanding different languages, argumentation and visual/audio recognition (Coordination Office of INCoDe.2030 Initiative, 2019).

Due to the problem-solving capacities that AI presents to its users, the amount of functions that AI is performing for human beings is increasing and companies are turning their attention to this technology, assuming that the performance is greater, and the costs are lower in the long run. In fact, AI as such a vast application in the modern world that it is present in most aspects of our daily lives, such as navigation systems like Google Maps that provide us with the most efficient route through GPS and real-time traffic feedback, Apple's Siri and Microsoft's Cortana which are Internet of Things (IoT) models that use Natural Language Processing to receive and process information from its user (Su, Hassan Awadallah, Wang, & White, 2018) and provide feedback by performing phone calls, sending text messages, finding restaurants and many other things.

Similar technologies are also applied to more crucial areas such as the health care sector, where AI can use machine learning to detect dermal cancer in patients (Haenssle et al., 2018) or in the oil industry with the forecasting of crude oil prices through a time series analysis (M. Wang et al., 2018). Therefore, it is possible to understand that the applications of AI are virtually boundless and are only limited by the current technological advancement.

This development of sapient machines creates a sentiment of both excitement and doubt, since machines capable of human learning at a greater factor, capable of replicating and improving themselves, and with the capacity of accessing all the information available on the Internet are highly likely to become smarter than humans and someday outrun them (Steels & De Mantaras, 2018). Researchers believe that this reality is still farfetched, but we must always keep in mind that even if it's minimal, the risk is still lurking about.

Within the areas that are incorporating AI driven functions, managerial areas are also implementing these technologies in their daily activities and Project Management is one such area that is currently trying to further automate the required functions to develop any Project.

2.3.1. Artificial Intelligence in the European Context

As AI continues to demonstrate great promise, more research is being performed to include this technology into our way of life. There is an unremitting increase of research laboratories working on the subject, more AI star-up companies are appearing and there is a high degree of investment towards its research. This is beginning to force European companies and governments to develop a strategic planning to understand how they can keep up with the exponential advancement of AI (Steels & De Mantaras, 2018), since this rush for the implementation of AI comes mostly from the clear understanding of the economical and functionality benefits this technology offers.

Currently there are three major players in the AI development and deployment spectrum, which are the European Union (EU), the United States of America (US) and China. According to a report developed by Bughin *et al*. (2019), partners of the McKinsey Global Institute, the EU is currently lagging behind the other two parties when it comes to digital technologies, and the gap between them is widening with the inclusion of AI.

This lag is shown by factors such as the GDP of Europe's Information and Communications Technologies (ICT) which is 1.7% as compared to China's 2.2% and the US's 3.3%, the investment per capita in digital technologies which is €220 in the US while €123 is invested in Sweden on top of the European spectrum and €3 in Italy (Bughin et al., 2019). The authors appoint this difference in economic output to the digital hubs that exist in several US cities such as Silicon Valley, Seattle and Boston, whose research and develop of digital technologies have a high focus on AI based technologies and are more welcoming to researchers and developers in this area, offering more professional and academical growth options.

Another key factor that affects the implementation of AI by companies is due to the fact that workers may not have the necessary skills or ability to utilize AI based tools and there is not enough knowledge in companies to provide and develop AI systems and applications that conform to their work methodology (Bughin et al., 2019).

Nonetheless the report states that Europe has solid foundations for the diffusion of AI, with entrepreneurial tech hubs based on computer science being hosted in London, Copenhagen, Munich, Zurich, Berlin and even Lisbon, currently with 5.7 million professionals working in the area spread through the EU, and a 10% yearly growth on the number of available experts. Companies are reporting that AI is seen as a competitive advantage and are developing

efforts to include these technologies in their structure, with tech savvy companies using it to expand revenue growth and less AI proficient companies use it to cut costs (Bughin et al., 2019).

The report also predicts that the number of jobs that AI implementation will develop as many new job vacancies as the ones it changes or substitutes, as companies develop new products and services relying more heavily on AI (Bughin et al., 2019).

With all this in mind, the growth of AI has to be regulated in some way due to its autonomous learning capabilities and its capacity of making decisions, since it has been proven that AI can have biases in decisions when it comes to personal aspects of individuals based on gender, ethnicity, disabilities and even gross income, being borderline discriminatory towards minorities, as well as raising cybersecurity and privacy issues for users (Y. Wang, 2020).

In May of 2016 the European Parliament's Committee on Legal Affairs proposed a report on Civil Law Rules on Robotics that focused on recommendations for the use of robotics and AI. The report indicated that the impact on the European workforce should be monitored, digital skills should be fostered and improved on the general populous and tax regimes should cover the negative impacts on wealth and social inequality, as well as an ethical framework and guiding principles complementary to legislation (Cath, Wachter, Mittelstadt, Taddeo, & Floridi, 2018).

On April of 2018 the European Union's Member States agreed on a Coordinated Plan voted on the European Parliament that would provide guidance with the development of national strategies for each country to incentivise the research and innovation of AI based systems, incorporating ethical principles since it would impact society at a socio-economical level, allowing Europe to *" become a leading player in AI, it needs to build on its strengths and support the development of an ethical, secure and cutting-edge AI made in Europe."* (European Commission, 2018). This plan would also include financing from the European Commission of €2.6 billion in research programs and AI related areas, as well as a total of €20 billion of combined public and private funding during the period of 2018 to 2020 (European Comission, 2019).

The application of the set of guidelines would be dependent on the economical capability of each company to finance this initiative and on the cultural traditions, since these will condition the reciprocity of this technology.

2.3.2. Artificial Intelligence Used in Portuguese Companies

As a small country, Portugal tries to keep up in the global technological advancement having its own share of AI start-up companies lead by visionaries that what to invest in the future, such as Unbabel, Talkdesk, DefinedCrowd and Feedzai, as well as capable professionals that are currently involved in the efforts to develop this technology even further (Guerra, 2019).

Data shows that different countries in the EU have different performances when it comes to the implementation of AI systems, where Northern European countries have a higher capability to implement AI and Southern and Eastern countries are lagging in comparison (Bughin et al., 2019). This is due to the lower set of skills in workers to take advantage of these technologies and a lower share of innovative firms that leverage AI into their structure.

In these countries, Portugal is also included, although it presents a higher level of AI readiness than what it would be expected, being in the top 50% of 28 EU countries that innovate in AI, but it is placed in the bottom 25% of countries with capable human skills to fully utilize and develop AI (Bughin et al., 2019).

According to the information available at the Pordata (2019) website there are currently 4.913 million employed workers in Portugal and according to the Atomico (2019) web page there are a total of 93800 professional developers and researchers with proficiency in AI available to work in this area in Portugal, which corresponds to 1.9% of the total Portuguese workforce, a rather low number when its intended to further integrate the technology in the country.

Attending to the efforts that the European Commission is putting together to advance AI, a program developed by INCoDe.2030 jointly with the approval and support of the Portuguese Republic called *"AI Portugal 2030"*. This program seeks to develop a sustainable strategy to implement AI in all levels of the Portuguese societal fabric, including public administration, transportation, health care system, cybersecurity, smart urbanization infrastructures, energy regulatory systems, biodiversity, environmental supervision and support, in public education, financing and supporting academical research programs, in industry and in all business structures, while developing social and ethical guidelines to develop and use AI as well develop a legal framework for the same purpose (Coordination Office of INCoDe.2030 Initiative, 2019).

To reach these strategic goals, INCoDe.2023 developed a set of axes in which they will base the necessary actions to reach the above-mentioned goals. They indicate that Inclusion

and Education of the majority of Portuguese citizens is crucial to help them understand how to take advantage of the AI technologies that will be available by introducing early on education on computer science subjects for young Portuguese students, and the general public.

Qualification is also crucial to meet the requirements for a more educated workforce that would support the AI based systems and promote active roles in the employment of the technology, as well as developing qualification programs to educate workers, and with Specialization the growth of the number of graduates specialized in computer science and AI fields of research will help support the national research of the subject and increase the amount of international collaborations with other academical researchers and professionals.

Finally, they underline the requirement for Research to overcome any issues that AI systems may have that could affect its functionality and impact society, such as learning from small data sets and avoiding biases in judgements and decisions, as well as boosting its development for a quicker and more efficient deployment.

2.4. Artificial Intelligence Applied to Project Management

Integration of AI in Project Management is becoming increasingly more frequent, with new tools being developed with different applications throughout the years. These tools take the form of various algorithms and machine learning programs that enable the user to predict Project scope, budget and success, create preliminary schedules and resource allocations and identify with higher accuracy any control, monitorization or cost related issues.

Martínez & Fernandez-Rodriguez (2015) identify the basic Project control and monitoring tools utilized in Project management and suggest that the implementation of AI is imperative to achieve higher success rates in Projects. The tools reviewed in this article are focused on Project success estimation by identifying critical success factors through Artificial Intelligence technologies, including Neural Networks, Genetic Algorithms and Bayesian Models.

The authors state that most Project Managers still rely on expert judgement, which can be biased, and parametric tools in order to advance/complete Projects, but with the cumulative complexity of the various Projects undertaken by companies it has become increasingly difficult to maintain precision and predicting Project success, so by identifying and reviewing these tools, Magaña Martínez & Fernandez-Rodriguez (2015) where able to detect that these

Artificial Intelligence based tools are much more accurate than traditional tools, although they remain complementary for the time being, since they are mostly used has a means of monitorization and control. They recognised that fusing the existing base tools is becoming an increasing trend in order to tackle the weaknesses in the models and increase their strengths.

This indicates that a coordination process among different tools that tackle Project management is still missing. To further support this statement Prasad & Vijaya Saradhi (2019) developed a report that indicated an up to date characterization of machine learning software and technology available for Project management. They describe the key issues that affect Project management are related with the scheduling and timeframe that most companies present the managers with, in order to complete the Project, combined with unproductive monitoring and control practices. For each different kind of task there are specific tools based on machine learning methods that improve the manager's performance throughout the Project, with Adaptive Boosting Neural Networks and Fast Messy Genetic Algorithms being used to predict Project success, Genetic Algorithms, Fuzzy Cognitive Maps, Neural Networks and Bayesian Models provide identification of critical path related success conditions. As for Project monitoring and execution tools methods such as the RAG (Red-Amber-Green) status evaluation through NLP (Natural Language Processing) and Genetic Algorithms can be utilized to track task progression and resource allocation.

The authors determined certain common aspects and stages believe that the critical factor in Project management tracking and implementation is based on the decision of which is the right kind of methodology, and which Project tools better support this methodology, followed by estimating the Project resources and schedules, and monitoring/controlling the Project scenario. They conclude that there exist many different machine learning models that are useful in Project Management, but there is a lack of a holistic solution that would facilitate its full integration into every step of Project Management.

2.4.1. Artificial Intelligence Tools in Project Resource Management

Within the specific field of studies related to Project Resource Management, there are already solutions in place to help Project Managers improve their efficiency when it comes to planning, acquiring and managing these resources. In fact, there are some compounded tools that may help Project Managers with decision making when it comes to resources.

Aziz, Hafez, & Abuel-Magd (2014) studied a construction Project that was utilizing Artificial Intelligence programs which assisted the team during the planning, scheduling and controlling of construction Projects. The authors proposed a software named Smart Critical Path Method System or "SCPMS" that is based on features used in Critical Path Method and a multi-objective Genetic Algorithms whose purpose was to *"...(a) increase resource efficiency; (b) reduce construction time; (c) minimize construction total cost (direct cost plus indirect cost); and (d) measure and improve the quality of future mega construction Projects.*". To do so, the software was responsible for considering every relevant variable that affected decision making and that could have an impact in the time, cost and quality of the Project, through inputs that related to construction materials, number of crew members, crew overtime policy, machinery efficiency, among others. By running the inputs through different possible sets of solutions the program grants the user the best balance between time, cost and quality measures, which is usually considered an appropriate trade-off model for Projects.

To further investigate the application of AI in Project Resource Management, we must understand the available technologies to manage each aspect of resources and their effectiveness in Project Management. As stated, these resources are mainly divided into "Human Resources" and "Physical Resources", having different ways to be managed as well as different applications during the Project's development. Therefore, the following two sections of this dissertation will present more specific tools for each resource type, to further understand their usefulness.

2.4.1.1. Applied to Human Resource Management in Projects

Has studied in chapter 2.2.1., managing human resources is not as simple as one might think. Initially the Project Manager needs to plan and estimate the necessary work force needed to meet the Project requirements, which includes defining roles for each team member and creating schedules for the team. Then it is necessary to acquire the Team Members based on various parameters (availability, cost, ability, experience, knowledge, skills, attitude and international factors), making these stages of human resource management crucial to plan and commence Projects.

It is crucial to understand that recruiting and retaining the best talent is crucial for gaining a significant strategic benefit, since it provides a competitive advantage for the firm (Black, 2019 cited by van Esch & Black, 2019). The application of AI in e-Recruiting is

increasingly more significant and more frequent, easing the recruitment process for any role in modern companies (van Esch & Black, 2019), and machine learning algorithms are becoming more frequent since they process much more candidate information based on the desired parameters and specifications than a human recruiter (Tambe, Cappelli, & Yakubovich, 2019).

Designing schedules for Team Members is another challenging task that the Project Manager has to perform, since schedules need to be developed to identify the necessary resources for a given Project and rescheduling often occurs due to punctual flaws in task performance, lack of capacity to conclude a task within the scheduled timetable or being unable to perform certain tasks since they have a precedence relation, having to be concluded before others can be started (Myszkowski, Skowroński, Olech, & Oślizło, 2015).

Scheduling AI is gradually more frequent, with various scientific papers showing that it is an increasing trend to use this technology in Projects. Certain programs tackle this issue, such as in the paper presented by Ge & Xu (2016) where the authors utilize *"... a software Project scheduling/rescheduling framework which supports dynamic staffing and rescheduling."* where the user inputs detailed task and employee information, predicting task duration through simulations, and include management objectives and control actions. By providing this information, an optimal schedule for the Project is generated in the most efficient format by a digital agent, assigning task and employees to meet certain objectives, or use the precedent relation of tasks as a guideline to schedule all activities efficiently, as described in the paper developed by Myszkowski *et al*. (2015) where the authors present a Hybrid Ant Colony Optimization (HAntCO) AI whose purpose is to *"...find such task-to-resource assignments to make the final schedule feasible and as shortest as possible"*.

During the development of the Project, the Project Manager has to develop and manage the team, by developing their skills and competencies, maintain a productive work environment, apply leadership skills and emotional intelligence to motivate workers, ensure proper communication and colocation to ensure work progress, and provide proper compensation for the work performed.

Various forms of e-Learning technologies have been in place within companies for quite some time and are perceived as a time saving method that provides an online educational system that has a well performing degree of effectiveness and it can even respond to the learner's emotional response based on expressions to recognize the best way to educate the subject (Megahed & Mohammed, 2020). There can be some reservations about e-learning systems,

since these technologies can be isolating for trainees because they do not directly interact with a tutor (Choudhury & Pattnaik, 2020), although these technologies show a great deal of employee development and provide strong learning opportunities. A study conducted by Johnson, Hornik, & Salas (2008) shows that the social presence of the teacher/trainer plays an important role in the e-Learning effectiveness and they suggest that models of this technology should focus on *"developing mechanisms that encourage development of shared social learning environments to enhance e-learning effectiveness."*.

As the Team Members' skills develop and they become more familiar with their work functions, an AI agent is capable of assigning and reassigning tasks according to their skill set do promote the optimization of the Project's format. Myszkowski *et al.* (2015) estipulate that *"…the resource R is capable of performing the task T only if R disposes skill required by T at the same or higher level."* and the HAntCO AI developed in their research considers the costs as the wages per hour, which may increase or decrease depending on the associated skills, meaning that a skilled employee or team could perform a task in a shorter amount of time if they are appropriately assigned to the needed tasks, resulting in the reduction of costs associated with the Project.

Communication is yet another field that AI can provide assistance to users, since Natural Language Processing is allowing users to communicate directly with the AI and provide feedback of activities and resource usage, as well as facilitating communication among Team Members through different programs and applications. A study conducted in the healthcare management system focused on utilizing communication systems to provide trainees with the ability to rapidly communicate with e-Learning systems to be trained without having to consult their superiors, saving time (Butow & Hoque, 2020). The system also was able to analyse speech of patients to understand their necessities and analyse large amounts of audio data to gain more knowledge on how patients were being treated.

When it comes to rewarding Team Members for the effort they put into the Project, there are similar forms of e-Compensation programs to do so, allowing employees to receive their base salaries, commissions, overtime payments, bonusses or stock options. The American Payroll Association (as cited by Inc.com (2014)) reports that automated payroll systems reduce mistakes in compensation actions by 80% because the systems are designed to comply to stricter financial regulations for companies, saving and money. Systems such as Oracle's PeopleSoft eCompensation Manager Desktop (Oracle.com, 2019) grants managers with a easily available

online access to the total workforce compensation information, allowing them to automate payroll options, manage salary values and monitor compensation cycles.

These articles let us understand that managing and maintaining talent while properly allocating the different Team Members to the tasks they are more suitable to is crucial to have a proper human resource allocation system and lower both costs and completion time of the Project's activity. Applying the proper systems to supervise each parameter proposed by the PMI for Human Resource Management could indeed provide benefits for Projects in terms of cost reduction, time management and higher quality in all parameters.

But these systems might also affect the Project Manager's and Team Member's emotional well-being, team building opportunities, create communication and feedback problems, as well as generating burdens for the Project Manager if the AI systems are not properly developed and implemented by seasoned digital science professionals. The lack of knowledge to support and develop these systems in Portugal might also be a barrier to its full implementation.

2.4.1.2. Applied to Physical Resource Management in Projects

Proper management of physical resources is crucial for Project performance and success as mentioned in chapter 1.2.2.. The planning and estimation stage allow Project Managers to identify the different physical resource requirements needed for the Project's activities, therefore it is important to estimate the costs, attributes, schedules, properties and location for the necessary resources to ensure maximum efficiency.

The digital agent developed by Li, Tao, Chong, & Dong (2018), tackles an integrated problem closely related to construction Projects scheduling and physical resource allocation, where the main purpose of the proposed investigation is *"… to determine the start time of each activity and make a combined strategy of resource allocation in multiscale terms for minimizing two objectives, namely, (a) Project completion time and (b) expected total resource cost"*. To do so they established a tooled named Multiple Objective Particle Swarm Optimization with an interior point metaheuristic (MOPSO-Interior Point Metaheuristic) AI for establishing feasible solutions in regard to scheduling and resource allocation, while an internal layer determines the probabilities related to resource prices. While having certain limitations in relation to other factors such as contractual obligations or certain external events that affect the Project, this

model proved that it can indeed reduce the costs of resources and time needed to perform the Project, by promoting resource utilization efficiency.

Therefore, there already exists programs capable of making decisions in Physical Resource selection based on price fluctuation, activity costs, material availability and location. In fact, due to the dynamic environment that most Projects are subjected to, the demands for physical resources are nonstationary, this is, the demand for different materials are always changing from time to time.

Given the mentioned nonstationary nature of material necessity, uncertainty in inventory levels is constant, managers have to decide on *"... (1) how much inventory to keep, and 2) how to allocate the available material to on-going activities if shortages arise."* (Lu et al., 2018) affecting both scheduling and cost performance for Projects, making on-site and off-site supply logistics an important key aspect to optimize material allocations. A study conducted by Lu (*et al*., 2018) focused on limited material allocation among activities effectively in order to reduce the Project's duration and cost performance by utilizing a Genetic Algorithm (GA) simulation as a method so solve integrated inventory models and finding optimal inventory level according a specific allocation policies. The GA-based simulation optimization method calculates the most effective inventory level in order to reduce the cost as much as possible. They determined that an effective centralized material management system greatly increases the success of a large-scale Project, which in this specific study is a construction Project, while reducing costs and project duration.

It is also decisive to allocate the appropriate Physical Resources to the respective task exactly when and where they are needed. In the paper developed by Pinha & Ahluwalia (2019) the authors presented a software tool known as Short-term Resource Allocation and Management that is used to manage physical resources in near-real time by scheduling tasks that share a limited amount of physical resources between them, while handling *"... the resources across multiple capabilities and skill levels, multiple priority rules, and multiple calendars."*. The simulation that the tool performs presents the user with a set of optimal solutions and their impact on cost and schedule, relying on expert decision making to fully operate.

While investigating further into the Physical Resource allocation studies that were available, another reoccurring issue in most Projects kept appearing which is the materials

rehandling cost associated with physical resources when it is not appropriately distributed during the Project's development.

K. Li, Luo, & Skibniewski (2019) developed a method for inbound material component in limited construction site space in order to avoid inventory rehandling cost and increase Project efficiency, by using a Construction Components Storage Area Planning (CCSAP) that verified *"... (1) real-time components supply, (2) state identification of Areas of Interest from real-time data on-site, and (3) optimization using GA."* with a flexible arrangement that allows incoming materials to be placed on the dynamic storage spaces as they change throughout the construction site during the Project advancement in real-time, using imaging technology to track storage areas where construction site layouts are constantly changing and different schedules are constantly affecting the workflow. They applied the model in a case study, and it allowed the users to reduce the material rehandling costs by 21.9% and increase the construction efficiency by 19,4% when compared to conventional methods.

Managing physical resources throughout the Project requires constant corrective measures that include reallocating specific resources, rescheduling their availability and location according to the progress and activity necessity, as well as reacquiring certain resources if the activities require them, since the acquisition or procurement of physical resources is a repeating process for the duration of the Project.

In fact, the reviewed tools allow Project Managers and Team Members to monitor and execute physical resource management, but the utilization of this technology as other implications. For instance, the AI agent might execute a biased decision in allocating Physical Resources due to gender or ethnical discrimination (Y. Wang, 2020), or might miscalculate the amount of resources that is needed for a specific task, requiring an immediate readjustment of inventories to satisfy these necessities.

2.5. Critical Analysis of the Literature Review

After carefully reviewing the existing literature available on AI and its implementation in Project Management, as well a research that covered existent digital tools that can be used to further integrate AI into various levels of Project Resource Management, there clearly exists advantages to integrate these systems. As its development grows, AI systems are becoming more popularized and will inevitably become a part of our daily lives in various aspects, from professional AI tools to AI assistants in our houses.

In fact, in Project Management there already is a variety of available solutions provided by Artificial Intelligence agents that overcome various sets of challenges presented by Projects and provide aid to the Project Team without fully occupying their roles.

Through this literature review we are able to understand that there seems to be a lack of harmony between the existing tools utilized for Project Resource Management, as to say, there are indeed various AI machine learning models already applied in the Project Management area, but most are either tailored for a specific type of Project or have limited functions, and are mostly used to support decision-making, being mostly supportive as described by Magaña Martínez & Fernandez-Rodriguez (2015) and Bughin *et al.* (2019).

As mentioned by Prasad & Vijaya Saradhi, (2019) "*Many of the existing models of machine learning based Project management solutions were focusing on one or the set of Project management factors, but a holistic solution is missing in the process.*", as to say, there are indeed various AI machine learning models already applied in the Project Management area, but there is a lack of harmony within the different models in order to fully take advantage of this technology, which may represent as a struggle for the adoption of AI by companies and professionals. There is an absence of a managerial framework that helps users understand how and when they should apply Artificial Intelligence in the Project processes.

The effects of fully implementing these technologies in Project Resource Management is still not well known, and there seems to be a lack of research when it comes to understanding how it can affect Project Managers and Team Members, and if they are prepared and willing to accept this technology, even if there are proven positive effects, such as increases in revenues, reduction of costs and time spent on Projects, and an increase in Project overall quality.

The growing availability of capable and knowledgeable professionals in AI research and the development of infrastructures to support AI is allowing European countries to layout strategic plans to implement digital agents in various public and private sectors to facilitate the day-to-day lives of all citizens. A gap in understanding how it could affect Team Members and Project Managers in the Portuguese corporate environment is present and it would be useful for companies to understand the bottom-line impact of this technology in their business.

First off, there seems to be a lack of investment and qualified workforce in Portugal to actually build robust well-rounded AI systems and to support development across various public and private sectors that perform Projects either as a business or to improve their

structures. Although the number of professionals capable of building and handling AI systems are growing, the existent workforce is still not robust enough to accept these agents.

The cultural and educational standpoint of Portugal can also be a difficulty to fully implement AI tools in all levels of society as expected for the "*AI Portugal 2030"* strategic program, but the number of professionals that can fully implement and utilize this technology is growing, and it might facilitate its introduction in a corporate environment.

To the extent of the research conducted in this dissertation no study has been conducted to show how Project Managers and Team Members in the Portuguese corporate context would react to having an AI system making decisions regarding their task scheduling, supervising their communications, training, compensation/reward practices, allocate and distribute physical resources between tasks and Team Members.

Likewise, reduced supervision from a Project Manager due to the integration of an autonomous system which could affect the application leadership styles to manage the Project Team, perform team building exercises, deliver emotional intelligence to reassure the mental wellbeing of the team and guarantying a productive work environment could affect productivity. The existence of AI capable of procuring and negotiating prices for physical resources may bypass the interaction that Project Managers or Team Members should have with other parties, internal or external to the organization, and there is no research that shows the effects of this interaction and how it could affect corporate relationships between firms, suppliers or customers.

The following table is a result of the scientific investigation performed for this thesis that show the identified challenges in Project Resource Management, which were key to identify the research gaps, objectives and the questions that will be answered:

Table 2.1 - Summary Table of Literature Review Analysis (Source: The author, 2020)

Challenges in Project Resource Management and Artificial Intelligence detected in the Literature Review	**Authors**	**Research Questions**	**Research Objectives**
Recruiting appropriate Team Members is very time consuming and methodical task;	van Esch & Black, (2019);	What are the major difficulties that Project Managers and Team Members feel during Project Resource Management?	Identify the major challenges for Project during the planning, acquisition and management of Human and Physical Resources;
Scheduling activities to be performed in Projects;	Myszkowski *et al*., (2015);		
Monitoring and controlling activities during the Project;	Aljamee & Naeem, (2020);		
Acquiring physical resources in an efficient manner by selecting and procuring appropriate suppliers of material resources;	Araújo *et al.* (2017);	Do Project Team Members utilize AI tools to perform any activity in Project Resource Management?	Understand if it is a common practice to utilize Artificial Intelligence tools in Project Resource Management;
Project Managers are responsible for constantly managing material resource inventories;	Lu *et al*., (2018);		
Allocating, placing and storing material resources effectively to reduce costs and time expended in tasks;	K. Li *et al*. (2019);	Do Project Team Members perceive AI tools to be useful for their daily tasks?	
The author states that there are difficulties integrating AI into company structures and there is a lack of funding for the technology and ability to use it;	Bughin *et al.* (2019)		Understand if users would find useful having an AI agent supporting their daily tasks;
Adopting AI creates legal and ethical considerations that need to be regulated to ensure the proper use of this technology;	Cath, Wachter, Mittelstadt, Taddeo, & Floridi (2018)	In which tasks do Project Team Members feel that AI could provide support?	

3. Research Methodology

3.1. Research Context and Research Question

During the Literature Review it was possible to understand that there are existing gaps in information when it comes to the application of Artificial Intelligence in Project Resource Management, therefore, the aim of this research is to understand what are the current major difficulties that Project Managers have while performing Project Resource Management in companies and how can the current Artificial Intelligence programs can support decision making processes.

To reach this Research Objective, it is necessary to answer a Research Question cohesive with the research gap, which is: Can Artificial Intelligence provide support for Project Team Members in managing Human and Physical Resources?

The sub research questions must be integrated into the main Research Question, deconstructing it into simpler questions in order to obtain data relevant enough to answer the main questions.

3.2. Sub-Research Questions

Based on the table developed in the Critical Analysis and the Research Question, the Sub-Research Questions are:

Q1. **What are the major difficulties that Project Team Members feel during Project Resource Management?**

The literature review showed that Project Managers and Team Members have to perform a series of common tasks in all types of Projects that can present different sets of challenges. It would be practical to understand in which Process Group the Project Manager and the Team Members feel more difficulty both in Human Resource Management and Physical Resource Management, since there seems to be a gap in the available research material in understanding this issue. By understanding these difficulties, we will be able to understand which are in need of a new type of solution granted by AI and which ones do not urgently require the assistance of AI agents.

Q2.**Do Project Team Members utilize AI tools to perform Project Resource Management?**

It is apparent that the implementation of Artificial Intelligence in different industries and societies is still in the early stages of development, since there seems to be a lack of investment, knowledge and capable workforce to properly develop and maintain AI. Its utilization is continuously growing, but the literature did not reveal that it is a common or uncommon practice to utilize these technologies in Project Resource Management. Therefore, this sub-question will investigate whether users utilize Artificial Intelligence tools and whether they find usefulness in them or not.

Q3. **Do Project Team Members perceive AI agents to be useful for their daily tasks?**

To further comprehend if Project Team Members can utilize these tools, it is crucial to understand if they find usefulness in their day-to-day task in these tools, this is, if there is any sort of reluctance to use these agents or if Project Teams would welcome this technology. Some AI based tools may be crucial for certain Project Resource Management tasks, while others may not interest the users due to lack of usefulness for those tasks.

Q4.**In which tasks do Project Team Members feel that AI could provide a better support for Project Resource Management?**

After understanding which are the main difficulties that Project Resource Management presents and what are the tools that users find more useful, a study will be performed in order to match existing AI tools to the functions that are requiring a new approach in order to improve the overall performance in Project Resource Management.

3.3. Research Techniques

The study conducted in this dissertation will be based on a Quantitative approach to gather information.

A Quantitative approach in the form of a Survey Research will be deployed in order to obtain primary data that is relevant to answer Sub-Questions 1, 2 and 3. This Survey Research is used to collect numeric descriptive data of a population of a sample population that indicates the trends in behaviours and opinions (Creswell, 2014). It was developed in the format of a questionnaire constructed on *Google Forms* and it was shared online through several platforms, such as *Facebook* and *Linked In.*

The questionnaire was designed for this specific study and it is divided into 3 Sections to obtain specific data. Section 1 characterizes the demographic qualities of the sample population; Section 2 provides data on the most difficult Processes for the population; and Section 3 aims at collecting data to understand which of the studied tools identified in the Literature Review are the most useful for the users.

In Section 1 demographic data is collected to understand the stratification of the sample population of respondents. It aims at collecting independent variables that characterize the sample and it will provide a proper understanding on the answers provided in the latter sections. These variables are Age, Role in Projects, Industry in which they work, Years of Experience in Projects, Country of profession and Size of the Company, which are appropriate measures to stratify Project Teams according to Ekemen & Şeşen (2020) and Parker & Skitmore (2005). As it was also necessary to understand if the respondents had previous experience in Projects to validate their response and ask whether they managed Human and/or Physical Resources to understand if their response is based on experience or not.

Section 2 aims at understanding the major difficulties in the different Processes that compose Human Resource Management and Material Resource Management in Projects as described in 2.2.1 and 2.2.2 in the Literature Review. To do so, respondents were asked to rank the 3 Processes in each resource type from 1 (most difficult) to 3 (least difficult).

Finally, in Section 3 the respondents are asked if they have previously have had contact with AI agents, if they used AI agents in Projects, if they used AI agents to manage resources in Projects and if they would find useful having an AI agent supporting their daily tasks in Projects. This usefulness is based on the perception of their users, and the perceived ease of use of a certain technology will justify their intention to use said technology which acts as a moderator to actually considering a technology useful (Rejón-Guardia, Polo-Peña, & Maraver-Tarifa, 2020).

Therefore, first three questions in Section 3 act as control variables to understand if the decision whether AI could be useful for Projects is conditioned by their experience with AI. Perhaps a user that has used AI solutions for other areas may find useful the application of the technology for Project Resource Management, while a user that did not use this technology may have some reservations about using it.

Then, the respondents are asked to rank some of the reviewed AI tools in the Literature Review from 1 (most useful) to 6 or 7 (least useful) which are:

Human Resource Management Tools:

- e-Recruitment and Candidate Selection
- Scheduling Project Tasks
- Allocation to Project Tasks
- Project Task Monitorization
- e-Learning
- Communication
- Rewarding Team Members

Material Resource Management Tools:

- Cost Estimation for Resources
- Scheduling Resources for Project Tasks
- Allocating Resources to Project Tasks
- Resource Placement
- Inventory Management
- Monitoring Resource Availability

These last dependent variables will help pair the existent AI tools to the requirements based on difficulty that the respondents identified in previous section. The purpose of ranking these items is to understand which technologies the respondents consider more critical or more useful based on their previous experience in Project Resource Management.

Alternatively, if a Rating or a Likert Scale type question was imposed, it would be very likely that most technologies would be rated the same, since the users could consider AI agents useful and all technologies would be welcome, or the use of AI could not be considered important or useful, and the technologies would be disregarded. In this sense, the provided responses will impose which AI agents are the most useful for Project Management professionals.

This information and breakdown of the methodology allows for the creation of a table that summarizes the Research Methodology that will be used to collect the data:

Table 3.2 - Research Methodology Summary Table (Source: The Author, 2020)

Research Objectives	Research Questions	Scales	Variables
		Sociodemographic;	Independent Sample Variables;
Identify the major challenges for Project during the planning, acquisition and management of Human and Physical Resources;	What are the major difficulties that Project Team Members feel during Project Resource Management?	Ranking Project Resource Management Processes;	Dependent Variables;
Understand if it is a common practice to utilize Artificial Intelligence tools in Project Resource Management;	Do Project Team Members utilize AI tools to perform Project Resource Management?	Closed Yes/No/Don't Know Questions;	Dependent and Control Variables;
	Do Project Team Members perceive AI tools to be useful for their daily tasks?		
Understand if users would find useful having an AI agent supporting their daily tasks;	In which tasks do Project Team Members feel that AI could provide support?	Ranking Existing Artificial Intelligence Tools based on their perceived usefulness;	Dependent Variables;

3.3.1. Survey Pre-Test

To ensure the validity of the survey used in the primary data collection, a pre-test survey was conducted with 3 professionals that have worked with Projects, constituting a control group to validate the variables used, the clarity of the survey design and semantic design. This pre-test survey presents all the sections that would be used for the final survey, including a final section specifically designed for pre-testing in which the respondents filled up some questions that included:

- How they felt about the presentation of the survey (if it was simple, clear, adequate and if there where spelling errors);
- The relevance of the questions to the study;
- If the questions where adequate to the objectives;
- If the questions where clear;
- If the extent of the survey was adequate;

Most of the tested parameters for the survey where on point, aside a few spelling errors, and the participants gave the suggestion of including a "Other" answer option in Section 1 to the role that people played in Projects, and also expressed difficulty in understanding what an Artificial Intelligence agent was, which is on par to the lack of contact with these agents that was noted in the Literature Review.

To overcome this difficulty, a small example on what an AI agent is was placed on the final survey, which can be consulted in Appendix A. After viewing this example, the respondents to the Pre-Testing phase noted that they fully understood what an AI agent was and where capable of responding with ease to Section 3.

3.3.2. Sample Population

The target population for this research is mainly focused on respondents that have experience in Projects, not having to inevitably be a Project Manager, since the application of Artificial Intelligence must be aimed at supporting Project Teams and not necessarily just the Project Managers.

To reach this sample, a Multistage Sampling method was employed in which certain clusters (in this case companies and organizations operating in Portugal) where identified and then individuals within these companies, and the stratification is based on whether they had experience in Projects or not (Creswell, 2014). These respondents where contacted via *Linked In* and *Facebook*.

4. Data Analysis

The following section will analyse the collected data starting with a characterization of the sample population of respondents and followed by the statistical analysis of the variables, with the supporting comments on this analysis.

4.1. Sample Error

This study was aimed at a population of Project Team Members that have worked within the Portuguese context and according to Professor Leandro Pereira, former President of the Portugal Project Management Institute Chapter, this population includes about 100,000 individuals.

Therefore, with a sample of 127 valid responses and a Confidence Level of 95%, the expected Sample Error for this study would be 8.7%, which is the expected size of the sample that would not represent accurately the results expected from this population.

4.2. Sample Characterization

The survey sample was directed to professionals that performed Projects, not being restricted by the type of organization, sector, the size of their organization or job function within Projects, creating a wide pool of possible candidates.

To control the answers given and provide their validity, the respondents were asked if they had previous experience in Projects and whether they had experience managing Human and/or Physical Resources. The answers of those who answered “No” where not considered, since having no previous experience in Projects or managing Resources does not provide a liable answer for the pretended study.

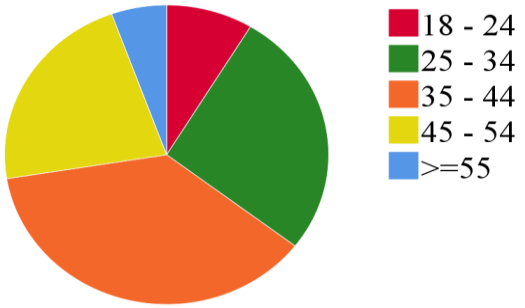
Out of the 142 respondents, 3 did not have any prior experience in Projects, 11 did not have experience managing Human and/or Physical Resources and 1 respondent had no experience in either one. Therefore, the sample that will be studied it composed of a total of 127 respondents that have experience in Projects and in managing Human and/or Physical Resources.

Starting with Age, out of the 127 respondents 37.0% (n=47) are in the age group of 35-44, 26.8% of respondents (n=34) are in the 25-34 group, 22,0% (n=28) are inserted into the 45-54 age group, while the 18-24 group corresponds to 8.7% (n=11) and the >=55 group has 5.5% (n=7) of the respondents. Therefore, the sample is mostly composed of respondents that are between being 25 and 44 years old.

Table 4.1 - Age Results (Source: The Author 2020)

Age

	Frequency	Percent
18 - 24	11	8,7
25 - 34	34	26,8
35 - 44	47	37,0
45 - 54	28	22,0
>=55	7	5,5
Total	127	100,0

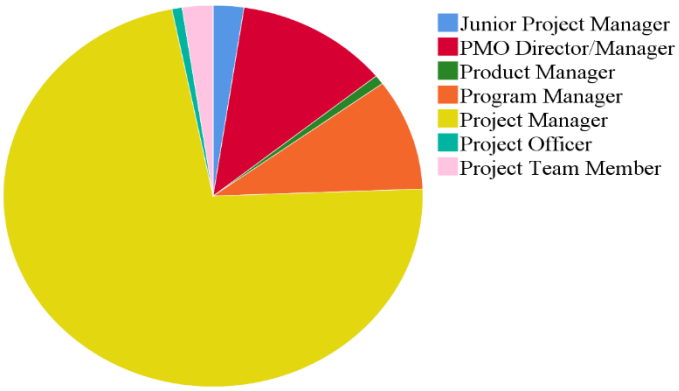


The statistics related to the Role respondents performed in Projects, 72.4% (n=92) where Project Managers, 11.8% (n=15) where PMO Directors/Managers, 9.4% (n=12) where Program Managers, 2.4% (n=3) are Junior Project Managers, 2.4% (n=3) are Project Team Members, and one respondent was a Product Manager (0.8%) and another one was a Project Officer (0.8%). With the roles performed by the respondents being mostly implemented in Project Management, with almost three-fourths of the sample being Project Managers, it is safe to assume that this sample has the necessary understanding to provide valuable and significate results for this study.

Table 4.2 - Role in Projects Results (Source: The Author, 2020)

Role in Projects

	Frequency	Percent
Junior Project Manager	3	2,4
PMO Director/Manager	15	11,8
Product Manager	1	,8
Program Manager	12	9,4
Project Manager	92	72,4
Project Officer	1	,8
Project Team Member	3	2,4
Total	127	100,0

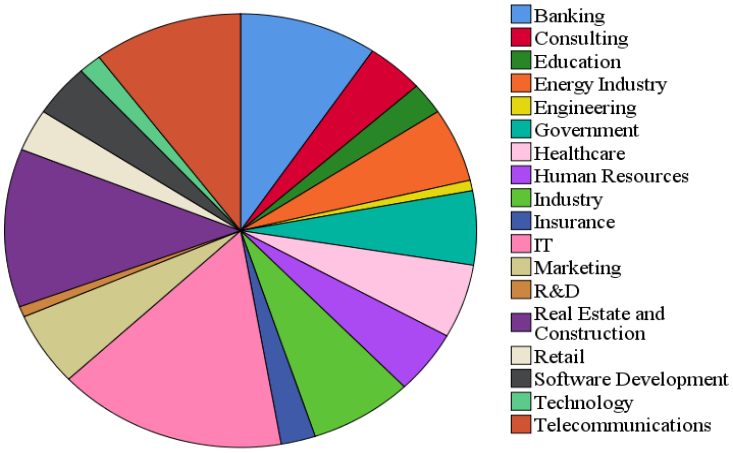


As for the Sectors in which the respondents work, there are many different sectors in which they perform Projects. In fact, there are 18 classes of different sectors, with the majority of the sample working in IT (15.7% and n=20), Real Estate and Construction (11.8% and n=15) and Telecommunications (10.2% and n=13). This large number of classes show that Projects are not limited to a specific sector but are diverse endeavours that are transversal to many professions.

Table 4.3 - Sector Results (Source: The Author, 2020

Sector

	Frequency	Percent
Banking	12	9,4
Consulting	5	3,9
Education	3	2,4
Energy Industry	7	5,5
Engineering	1	,8
Government	7	5,5
Healthcare	7	5,5
Human Resources	6	4,7
Industry	9	7,1
Insurance	3	2,4
IT	20	15,7
Marketing	7	5,5
R&D	1	,8
Real Estate and Construction	15	11,8
Retail	4	3,1
Software Development	5	3,9
Technology	2	1,6
Telecommunications	13	10,2
Total	127	100,0

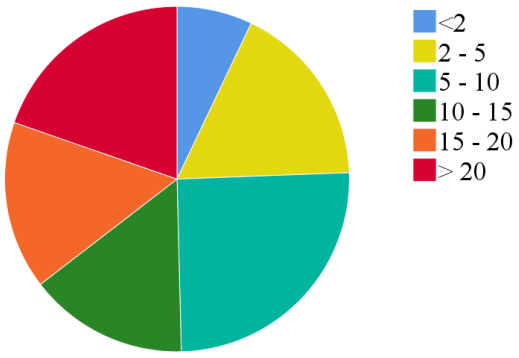


As for Years of Experience in Projects, the sample is composed by 25.2% (n=32) that has 5-10 years of experience, 19.7% has >20 years of experience, 17.3% (n=22) has 2-5 years, 15.7% (15-20) has 15-20 years of experience in Projects, 15.0% (n=19) has 10-15 years of experience and 7.1% (n=9) has <2 years of experience. Therefore, the sample collected is composed of respondents that have a good degree of experience, since only 24.4% (n=31) has the five or less years of experience.

Table 4.4 - Years of Experience Results (Source: The Author, 2020)

Years of Experience

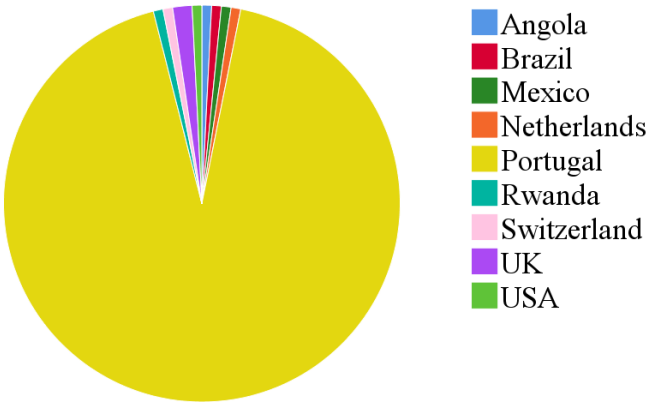
	Frequency	Percent
<2	9	7,1
2 - 5	22	17,3
5 - 10	32	25,2
10 - 15	19	15,0
15 - 20	20	15,7
> 20	25	19,7
Total	127	100,0



Has for Country, this variable tried to identify in which country the respondents where currently working in. 92.9% (n=118) worked in Portugal, 1.6% (n=2) worked in the United Kingdom, while Angola, Brazil, Mexico, Netherlands, Rwanda, Switzerland, and United States of America only represent 0.8% (n=1) of the sample. Therefore, a vast majority of the respondents operate in Portugal and this is justifiable by the fact that a great number of Portuguese Project Managers were asked to answer this survey.

Table 4.5 - Country Results (Source: The Author, 2020)

	Frequency	Percent
Angola	1	,8
Brazil	1	,8
Mexico	1	,8
Netherlands	1	,8
Portugal	118	92,9
Rwanda	1	,8
Switzerland	1	,8
UK	2	1,6
USA	1	,8
Total	127	100,0

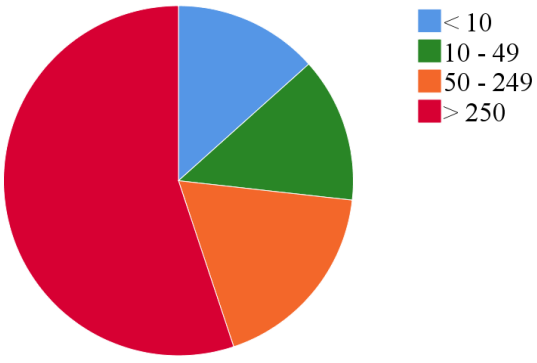


The survey also collected data reporting the Size of Companies in which the respondents worked in and the results show that 55.1% (n=70) worked in large companies, 18.1% (n=23) worked in medium sized companies, 13.4% (n=17) worked in small sized companies and 13.4% (n=17) work in micro companies. Therefore, more than half of the sample worked in large companies that have more than 250 employees.

Table 4.6 - Size of Company (Source: The Author, 2020)

Size of the Company

	Frequency	Percent
< 10	17	13,4
10 - 49	17	13,4
50 - 249	23	18,1
> 250	70	55,1
Total	127	100,0



4.3. Descriptive Analysis

The following sub chapter will be dedicated to the descriptive analysis of the dependent variables collected in the survey, the ranking of the Project Resource Management (PRM) Processes, the ranking of Artificial Intelligence Agents that support Project Resource Management tasks and the questions to test the users understanding and willingness to use AI agents in Project Management.

4.3.1. Project Resource Management Processes Ranking

First off, we will analyse the results obtained for the Ranking of PRM Processes. The respondents were asked to rank the three processes that compose PRM practices in order to understand what where the major difficulties that they felt when handling Human Resources and Physical Resources, by assigning a number from 1 to 3 to rank their position, being 1 the most difficult Process and 3 the least difficult process. To rank the processes in the pretended order, the Friedman Test was used in SPSS to rank the items according to their Mean Rank, which attributes them an overall position from 1 to 3.

For Human Resources, the overall most difficult process was Human Resource Management with the lowest mean (Mean Rank = 1.82), followed by Human Resource Acquisition (Mean Rank = 1.83) and as the least difficult was Human Resource Planning (Mean Rank = 2.35). It is note wordy that Human Resource Acquisition and Human Resource Management have a similar Mean Rank value, which indicates that the respondents find that both processes have a similar degree of difficulty. Therefore, Human Resource Acquisition and Human Resource Management are the equally difficulty for Project Teams when performing Projects.

4.7 - Human Resource Processes Ranks (Source: The Author, 2020)

Descriptive Statistics

	Mean	Std. Deviation	Minimum	Maximum
Human Resource Planing	2,35	,801	1	3
Human Resource Acquisition	1,83	,721	1	3
Human Resource Management	1,82	,821	1	3

Friedman Test Ranks

	Mean Rank
Human Resource Planning	2,35
Human Resource Acquisition	1,83
Human Resource Management	1,82

For Physical Resource Management Processes, Physical Resource Acquisition is ranked lowest with a Mean Rank = 1.76, followed by Physical Resource Management with a Mean Rank of 2.06 and ranked as the least difficult is Physical Resource Planning, with a Mean Rank of 2.17. These results show a clearer decision of which process is the most difficult out of the three, but Physical Resource Planning and Physical Resource Management show a similar difficulty degree in the respondents' perspective, since the Mean Rank only differs 0.11.

4.8 - Physical Resource Processes Ranks (Source: The Authors, 2020)

Descriptive Statistics

	Mean	Std. Deviation	Minimum	Maximum
Physical Resource Planning	2,17	,846	1	3
Physical Resource Acquisition	1,76	,718	1	3
Physical Resource Management	2,06	,833	1	3

Friedman Test Rank

	Mean Rank
Physical Resource Planning	2,17
Physical Resource Acquisition	1,76
Physical Resource Management	2,06

4.3.3. Artificial Intelligence Tools Ranking

The same method was applied for the AI tools used to support Project Resource Management, as to understand which tools provide greater assistance to specific tasks performed in each Process.

Each Process is composed of a set of tasks and during the literature review some AI technologies related to these tasks were identified. Therefore, these technologies can be assigned to specific Processes, as shown in the table below:

Table 4.9 - Human Resource Processes Tasks (Source: The Author, 2020)

Human Resource Processes	AI Human Resource Tool
Human Resource Planning	*Scheduling Project Tasks*
Human Resource Acquisition	*e-Recruitment and Candidate Selection*
Human Resource Management	*Scheduling Project Tasks*
	Allocation for Project Tasks
	Project Task Monitorization
	e-Learning
	Communication
	Rewarding Team Members

The Human Resource AI tools where ranked from 1 to 7, and the tool with the lowest Mean Rank is the one considered more useful by the respondents and the tool with the highest Mean Rank is the one considered least useful. The lowest Mean Rank corresponds to the Project Task Monitorization AI tool (Mean Rank=2.87), the tool placed in second place is Scheduling Project Tasks (Mean Rank = 2.94) and the one placed in third was Allocation to Project Tasks (Mean Rank = 3.48), which correspond to tasks from the Human Resource Management Process. The next ranked tasks were e-Recruitment and Candidate Selection (Mean Rank = 4.16). e-Learning (Mean Rank = 4.42), Communication (Mean Rank = 4.80) and finally Rewarding Team Members (Mean Rank = 5.33).

Table 4.10 - Human Resource AI Ranks (Source: The Author, 2020)

Descriptive Statistics			**Friedman Test Rank**	
	Mean	Std. Deviation		Mean Rank
e-Recruitment and Candidate Selection	4,16	1,986	e-Recruitment and Candidate Selection	4,16
Scheduling Project Tasks	2,94	1,692	Scheduling Project Tasks	2,94
Allocation to Project Tasks	3,48	1,685	Allocation to Project Tasks	3,48
Project Task Monitorization	2,87	1,743	Project Task Monitorization	2,87
e-Learning	4,42	1,801	e-Learning	4,42
Communication	4,80	1,873	Communication	4,80
Rewarding Team Members	5,33	1,860	Rewarding Team Members	5,33

For Physical Resources the same method was applied, and each task belongs to a specific Process as shown in the following table:

Table 4.11 - Physical Resources Processes Tasks (Source: The Author, 2020)

Physical Resource Processes	**AI Human Resource Tool**
Physical Resource Planning	*Cost Estimation for Resources*
	Scheduling Resources for Project Tasks
Physical Resource Acquisition	*Monitoring Resource Availability*
	Inventory Management
	Cost Estimation for Resources
Physical Resource Management	*Resource Placement*
	Allocating Resources to Project Tasks
	Inventory Management
	Monitoring Resource Availability

For the AI tools that support Physical Resource tasks, the respondents had to rank them from 1 to 6. The ranking shows that the most useful AI technology is the Cost Estimation for Resources (Mean Rank=3.02), followed by Monitoring Resource Availability (Mean Rank=3.31), Scheduling Resources for Project Tasks (Mean Rank=3.36), Inventory Management (Mean Rank=3.46), Allocating Resources to Project Tasks (Mean Rank=3.82) and ranked as the least useful is Resource Placement (Mean Rank=4.03).

The AI tool with the lowest Mean Rank is Cost Estimation for Resources which is included in the Acquisition of Physical Resources Process and was ranked as the least difficult Process in the management of Physical Resources. This is somewhat contradictive, since the Process was ranked as the least difficult. By looking at Table 10 it is possible to observe that the Mean Ranks are not very different from each other, indicating that the tools are perceived as having a similar usefulness.

Table 4.12 - Physical Resources AI Tasks (Source: The Author, 2020)

Descriptive Statistics			Friedman Test Rank	
	Mean	Std. Deviation		Mean Rank
Cost Estimation for Resources	3,02	1,813	Cost Estimation for Resources	3,02
Schedulling Resources for Project Tasks	3,36	1,636	Schedulling Resources for Project Tasks	3,36
Allocating Resources to Project Tasks	3,82	1,524	Allocating Resources to Project Tasks	3,82
Resource Placement	4,03	1,431	Resource Placement	4,03
Inventory Management	3,46	1,934	Inventory Management	3,46
Monitoring Resource Availability	3,31	1,698	Monitoring Resource Availability	3,31

4.3.3. Artificial Intelligence Usage

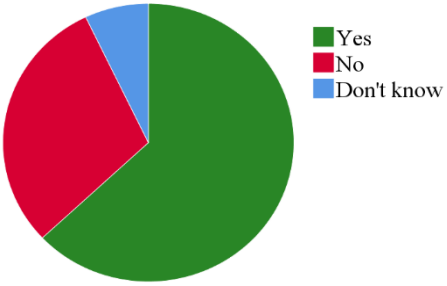
In this section, the survey tried to understand if the respondents have had any previous experience using AI, regardless if it was for personal use or for professional use. The results show that 63% (n=80) of the sample has used AI before, 29.9% (n=38) have never used AI in any previous situation and 7.1% (n=9) do not know if they have ever used AI before. The majority of the respondents have used AI agents previously, which is expected since the technology is being implemented in various aspects of our day-to-day. As for the respondents that have answered that they do not know if they used AI before, there could be two interpretations, either they do not understand the concept of an AI agent or they could be

unaware that they interacted with an AI agent, since these agents are usually discreet when operating in our daily lives.

Table 4.13 - Users that have used AI Results (Source: The Author, 2020)

Users that have used AI

		Frequency	Percent
Valid	Yes	80	63,0
	No	38	29,9
	Don't know	9	7,1
	Total	127	100,0

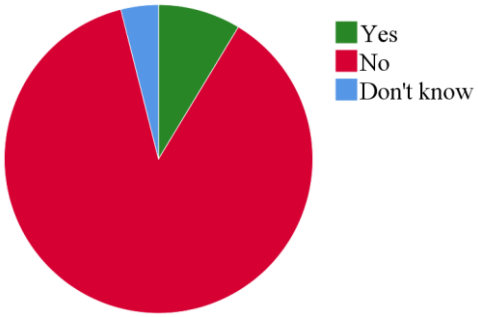


The following question identified if the respondents ever used AI in Project Management. Only 8.7% (n=11) have used AI in Project Management, 87.4% (n=111) have not used AI in Project Management and 3.9% (n=5) do not know if they used AI agents in Project Management. It is not surprising that the majority of respondents never used AI in Project Management, since most companies have not yet implemented the technology in their infrastructures, be it because of lack of funding, not enough qualified workforce to use the technology or maintain it, or because the functions do not require the use of such a sophisticated tool.

Table 4.14 - Users that have used AI in Project Management Results (Source: The Author, 2020)

Users that have used AI in Project Management

		Frequency	Percent
Valid	Yes	11	8,7
	No	111	87,4
	Don't know	5	3,9
	Total	127	100,0

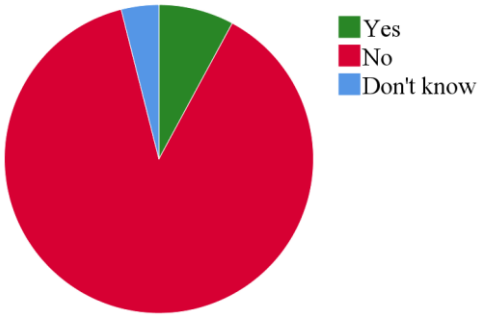


For Project Resource Management tasks, 7.9% (n=10) have used AI to support these tasks, 88.2% have not used AI in these tasks and 3.9% (n=5) do not know if they had these agents supporting their tasks. It would be expected that even less respondents would respond "Yes" to using AI agents in Project Resource Management, but only one respondent that used AI in Project Management did not use AI tools in Project Resource Management. It is noteworthy that 7.9% have used these agents while managing Human or Physical Resources in Projects, indicating that there are already some companies that are including AI in their operations.

Table 4.15 - Users that have used Ai in Project Resource Management (Source: The Author, 2020)

Users that have used AI in Project Resource Management

		Frequency	Percent
Valid	Yes	10	7,9
	No	112	88,2
	Don't know	5	3,9
	Total	127	100,0



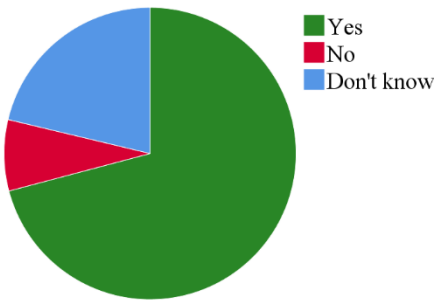
Finally, this section tried to understand if users found useful having an AI agent supporting their tasks in Project Resource Management. 70.9% (n=90) would find useful having these agents supporting their tasks, 7.9% (n=10) did not find useful having AI agents supporting their tasks in Project Resource Management and 21.3% (n=27) do not know if they would like to have AI agents supporting their daily tasks.

Despite a great percentage of respondents not having used AI in Project Management, the majority believe that AI could improve their daily professional routines and facilitate their tasks. This could be due to their previous contact with AI in their day-to-day personal routines or because of their perception and ease of use of AI agents act as a facilitator to wanting to use this technology. Users that answered "No" may have not used AI before or they could have had negative experiences using AI agents.

Table 4.16 - Users that would find useful having AI agents supporting Project Resource Management Tasks Results (Source: The Author, 2020)

Users that would find useful having AI agents supporting Project Resource Management Tasks

		Frequency	Percent
Valid	Yes	90	70,9
	No	10	7,9
	Don't know	27	21,3
	Total	127	100,0



4.4. Pearson's *r* Correlation Analysis

The following section will be dedicated to performing a Correlation Analysis between the Sample Variables, Processes Ranking Variables and the AI Technology Ranking Variables.

A correlation analysis aims at understanding the nature between two or more variables and to do so, a Pearson's *r* Correlation Coefficient was chosen to understand the relation between these variables, since it is a parametric correlation analysis that varies between +1 and -1, where +1 indicates a positive and proportionally direct relationship between variables and -1 represents a negative and proportionally inverted relationship between variables, while represents no relationship between variables at all (W. Kirch, 2008).

The values presented in a correlation analysis can indicate the strength of a relationship that exists between two variables based on the absolute value of the correlation coefficient from 0 to 1 (Pestana & Gageiro, 2014). The following table will help interpret the values that the correlation analysis performed on SPSS provided.

Table 4.17 - Correlation Coefficient Strength (Source: Pestana & Gageiro, 2014, adapted 2020)

Correlation Coefficient	Strength Classification
< 0.2	Very Weak
0.2 to 0.4	Weak
0.4 to 0.7	Moderated
0.7 to 0.9	Strong
> = 0.9	Very Strong

SPSS directly marks those correlations that are statistically significant based on the sample size and the confidence interval provided, which in this case is considered to be 95%. Correlations between the Sample Independent Variables "Age", "Role in Projects", "Years of Experience on Projects", "Size of the Company" will be performed on pair with three distinctive Dependent Variable sets, Human Resources, Physical Resources and Artificial Intelligence.

Due to the categorical nature of the Sample Data answers, these needed to be converted into ordinal variable sets so that a correlation between values could be interpreted in SPSS. These sample values are represented in the following table:

Table 4.18 - Survey Sample Variable Values (Source: The Author, 2020)

Age	Role in Projects	Years of Experience	Size of the Company
18 to 24 = 0	Junior Project Manager = 0	< 2 = 0	Less than 10 = 0
25 to 34 = 1	Project Team Member = 1	2 - 5 = 1	10 to 49 = 1
35 to 44 = 2	Program Manager = 2	5 - 10 = 2	50 to 249 = 2
45 to 54 = 3	Project Officer = 2	10 to 15 = 3	More than 250= 3
More than 55 = 4	Product Manager = 2	15 to 20 = 4	
	Project Manager = 2	More than 20 = 5	
	PMO Director/Manager = 3		

Starting with correlations (r) between Sample Variables, SPSS detected a weak positive correlation between Age and Role in Projects (r = 0.361) and a strong positive correlation between Age and Years of Experience in Projects (r = 0.803) as it can be observed in Table 4.19. These values are expected, since progression in any professional area requires years of experience to achieve and this also relates to the age of the respondents.

In the Human Resources correlation analysis both the Process rankings and HR AI Technology Rankings. First comes the relationship between the Sample Variables and the Processes' Variables, and in this case, SPSS flagged relevant correlations between a few of them. From Age and Years of Experience weak positive values emerged from Human Resource Planning (r = 0.260 and r = 0.204 respectively), which indicates that respondents with a higher Age and Years of Experience find that Planning Human Resources is the least difficult process for Human Resources.

Another relationship that was flagged was the relationship between Age/Years of Experience and Human Resource Management, presenting a negative weak correlation (r = -0.250 and r = -0.258 respectively), which might indicate that as Project Managers progress, develop their functions throughout the year and gain more experience, they understand that Managing Human Resources is a difficult process. In fact, this was the process that was ranked as the most difficult in the survey.

The relationships among the Processes themselves present moderated negative correlations, as it can be observed in Table 4.19 which is expected, since when one Process is placed at a higher point the others are placed in a lower position and vice-versa.

Relating the Sample Variables with the AI Technology Variables for Human Resources, there was only detected correlations between the Size of the Company and Allocation to Project Tasks AI, which presented a negative weak correlation (r = -0.206), and Size of the Company with Rewarding Team Members, which presented a positive weak correlation (r = 0.224). These

relationships could indicate that as Companies get bigger, they require a technology that can allocate personnel to tasks to reduce costs and time taken required for these tasks and they find that there is no need for a technology that can reward Team Members.

Between most technologies the correlations where flagged as being weak to moderately and negatively related, which is expected in a ranking study. But there were some technologies that ranked positively which where Scheduling Project Tasks and Allocation to Project Tasks ($r = 0.458$, Moderate) and between Allocation to Project Tasks and Project Task Monitorization ($r = 0.227$, Weak), which could have two interpretations for both relationships. Either the respondents that rank Scheduling Project Tasks as a very useful tool may also find that Allocation to Project tasks is very important, or they could find both technologies as being less useful than the rest.

Finally, the relationships between Human Resource Processes and the respective Human Resource AI technologies is observed. For Human Resource Planning there were two correlations flagged, a weak negative correlation with Project Task Monitorization ($r = -0.217$) and a weak positive relation with Rewarding Team Members ($r = 0.210$). This could mean that people that consider Human Resource Planning as more difficult Process find less usefulness in Project Task Monitorization, or they could find Human Resource Planning a simple process and consider Project Task Monitorization a useful tool. Also, respondents that consider Planning Human Resource a difficult Process find that a technology that Rewards Team Members useful tool or the opposite.

Table 4.19 - Human Resource Correlation Results (Source: The Author, 2020)

Correlation Matrix for Human Resources

	Age	Role in Projects	Years of Experience in Projects	Size of the Company	Human Resource Planing	Human Resource Acquisition	Human Resource Management	e-Recruitment and Candidate Selection	Schedulling Project Tasks	Allocation to Project Tasks	Project Task Monitorization	e-Learning	Communication	Rewarding Team Members
Age	1	,361**	,803**	,156	,260**	-,003	-,250**	-,046	-,058	-,043	,032	-,001	-,011	,123
Role in Projects	,361**	1	,348**	-,132	,060	,068	-,118	-,041	,051	,059	-,021	-,050	-,051	,062
Years of Experience on Projects	,803**	,348**	1	,160	,204*	,067	-,258**	-,129	,006	-,003	,083	-,048	-,061	,165
Size of the Company	,156	-,132	,160	1	,166	-,039	-,128	,098	-,158	-,206*	-,027	-,016	,041	,224*
Human Resource Planing	,260**	,060	,204*	,166	1	-,422**	-,604**	,140	-,138	-,066	-,217*	-,035	,062	,210*
Human Resource Acquisition	-,003	,068	,067	-,039	-,422**	1	-,467**	,007	,051	,046	,052	,011	-,165	,012
Human Resource Management	-,250**	-,118	-,258**	-,128	-,604**	-,467**	1	-,143	,090	,023	,166	,025	,085	-,215*
e-Recruitment and Candidate Selection	-,046	-,041	-,129	,098	,140	,007	-,143	1	-,250**	-,246**	-,372**	-,136	-,186*	,050
Schedulling Project Tasks	-,058	,051	,006	-,158	-,138	,051	,090	-,250**	1	,458**	,181*	-,406**	-,417**	-,413**
Allocation to Project Tasks	-,043	,059	-,003	-,206*	-,066	,046	,023	-,246**	,458**	1	,227*	-,467**	-,337**	-,481**
Project Task Monitorization	,032	-,021	,083	-,027	-,217*	,052	,166	-,372**	,181*	,227*	1	-,253**	-,297**	-,366**
e-Learning	-,001	-,050	-,048	-,016	-,035	,011	,025	-,136	-,406**	-,467**	-,253**	1	,130	,075
Communication	-,011	-,051	-,061	,041	,062	-,165	,085	-,186*	-,417**	-,337**	-,297**	,130	1	,028
Rewarding Team Members	,123	,062	,165	,224*	,210*	,012	-,215*	,050	-,413**	-,481**	-,366**	,075	,028	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

For Physical Resources, the same process was applied as it can be observed in Appendix C. For the correlation between Sample Variables and Process Variables, only a negative very weak correlation between Physical Resource Management and Years of Experience in Projects ($r = -0.193$). This relationship is very weak and indicated that respondents with more years of experience find that Managing Physical Resources is a difficult process, or the other way around.

As for correlations between Sample Variables and Physical Resource AI Technologies, no correlations where flagged, indicating that these variables have no statistically significant relationships.

Correlations between Processes and PR Artificial Intelligence Technologies also seem to be non-existent, since SPSS did not flag any and the highest relationship between variables $r = 0.147$.

As observed in the correlations between the rankings of the Human Resource Processes, all correlations between the different Physical Resource Processes are moderate and negative, indicating that they grow in an inverted linear relation.

Finally, the correlations between the different AI Technologies for Physical Resource tasks also present a great number of significant correlations, with the majority being negative due the ranking scaling applied in the survey. But once again there are a few weak positive relationships between these variables, which are Cost Estimation for Resources with Scheduling Resources for Project Tasks ($r = 0.217$), Scheduling Resources for Project Tasks and Allocating Resources to Project Tasks ($r = 0.208$) and Inventory Management with Monitoring Resource Availability ($r = 0.236$). Once again, this could either mean that respondents find the pairs of technologies useful or they find them useless.

Table 4.20 - Physical Resource Correlation Results (Source: The Author, 2020)

Correlation Matrix for Physical Resources

	Age	Role in Projects	Years of Experience in Projects	Size of the Company	Physical Resource Planning	Physical Resource Acquisition	Physical Resource Management	Cost Estimation for Resources	Schedulling Resources for Project Tasks	Allocating Resources to Project Tasks	Resource Placement	Inventory Management	Monitoring Resource Availability
Age	1	,361**	,803**	,156	,114	,029	-,140	,027	-,142	-,160	,067	,130	,047
Role in Projects	,361**	1	,348**	-,132	-,001	-,059	,051	,017	,038	-,074	,169	-,023	-,105
Years of Experience on Projects	,803**	,348**	1	,160	,088	,121	-,193*	-,021	-,096	-,026	,085	,055	,004
Size of the Company	,156	-,132	,160	1	,083	-,015	-,071	-,069	,001	,002	,108	,016	-,038
Physical Resource Planning	,114	-,001	,088	,083	1	-,442**	-,635**	-,043	,063	,006	-,050	-,039	,067
Physical Resource Acquisition	,029	-,059	,121	-,015	-,442**	1	-,413**	,076	,040	-,068	-,024	,095	-,147
Physical Resource Management	-,140	,051	-,193*	-,071	-,635**	-,413**	1	-,022	-,098	,053	,072	-,043	,059
Cost Estimation for Resources	,027	,017	-,021	-,069	-,043	,076	-,022	1	,217*	-,183*	-,404**	-,280**	-,453**
Schedulling Resources for Project Tasks	-,142	,038	-,096	,001	,063	,040	-,098	,217*	1	,208*	-,334**	-,529**	-,498**
Allocating Resources to Project Tasks	-,160	-,074	-,026	,002	,006	-,068	,053	-,183*	,208*	1	,043	-,588**	-,269**
Resource Placement	,067	,169	,085	,108	-,050	-,024	,072	-,404**	-,334**	,043	1	-,045	-,076
Inventory Management	,130	-,023	,055	,016	-,039	,095	-,043	-,280**	-,529**	-,588**	-,045	1	,236**
Monitoring Resource Availability	,047	-,105	,004	-,038	,067	-,147	,059	-,453**	-,498**	-,269**	-,076	,236**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

For last we have the correlation between the Sample Variables and the AI answers provided by the respondents. The classification given to the closed answer variables was “Yes = 0”, “Don’t Know = 1” and “No = 2”. The gathered results only showed that there was a weak negative relationship between the Size of the Company and Users that have Used AI (r = -0.196), which show that users in big companies are more likely to have used AI in their daily lives and a very weak positive relationship between “Role in Projects” and “Users that would find useful having AI agents supporting Project Resource Management Tasks” (r = 0.177), which could state that the willingness to use is greater among users that have a “lower” role in Projects, such as Junior Project Managers.

As for the correlations between the results from the questions related to AI usefulness, some relationships where flagged. Between “Users that used AI” and “Users that have used AI in Project Management” there is a positive weak correlation (r = 0.210), which may indicate that users that used AI are more likely to use the technology in Project Management.

The correlation between “Users that used AI” and “Users that have used AI in Project Resource Management” is positive and very weak (r = 0.197) which may indicate that respondents who have used AI before may also use AI in Project Resource Management.

Finally, a correlation between “Users that have used AI in Project Management” and “Users that have used AI in Project Resource Management” is positive and moderate (r = 0.569) which could mean that respondents who have used AI in Project Management may have also used AI in Project Resource Management.

Table 4.21 - Artificial Intelligence Correlation Results (Source: The Author, 2020)

Correlation Matrix for Artificial Intelligence

	Age	Role in Projects	Years of Experience in Projects	Size of the Company	Users that have used AI	Users that have used AI in PM	Users that have used AI in PRM	Users that would find useful having AI agents supporting PRM Tasks
Age	1	,361**	,803**	,156	-,065	,066	,003	-,035
Role in Projects	,361**	1	,348**	-,132	-,054	-,048	,034	,177*
Years of Experience on Projects	,803**	,348**	1	,160	-,110	,043	,031	,050
Size of the Company	,156	-,132	,160	1	-,196*	-,098	,061	,000
Users that have used AI	-,065	-,054	-,110	-,196*	1	,210*	,197*	-,006
Users that have used AI in PM	,066	-,048	,043	-,098	,210*	1	,569**	-,022
Users that have used AI in PRM	,003	,034	,031	,061	,197*	,569**	1	,051
Users that would find useful having AI agents supporting PRM Tasks	-,035	,177*	,050	,000	-,006	-,022	,051	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

5. Discussion and Findings

By collecting relevant data that met the objectives of the research context it is now possible to answer to the research sub-questions placed in Chapter 6.2.

Q1: What are the major difficulties that Project Team Members feel during Project Resource Management?

To understand these difficulties the Processes that encompasses the tasks of Project Resource Management according to the literatures were presented in detail to the respondents and these where asked to rank from the most difficult to the least difficult. In Human Resource Management they were ranked in the following order:

1º Human Resource Management (Mean Rank = 1.82);
2º Human Resource Acquisition (Mean Rank = 1.83);
3º Human Resource Planning (Mean Rank = 2.35);

It is observable, HR Management and Acquisition are close to a tie in scores, indicating that there is a similar difficulty to conduct these tasks, while HR Planning seems to be a task that Project Team Members have less difficulty in performing. In fact, the correlation coefficients show a weak negative correlation between Age/Years of Experience and HR Management (r = -0.250 and r = -0.258 respectively), which indicates that as Project Team Members age and gain more experience they tend to notice that these tasks are increasingly more complex, requiring some support to develop the tasks related to this Process. This could also be an influence of increasing Project complexity due to career progression.

For Physical Resource Management, the Processes where ranked in the following order:

1º Physical Resource Acquisition (Mean Rank = 1.76);
2º Physical Resource Management (Mean Rank = 2.06);
3º Physical Resource Planning (Mean Rank = 2.17);

These results show that there is clearly a greater difficulty in performing PR Acquisition tasks, while Managing and Planning for Physical Resources seems to be less difficult for Project Team Members. For these variables the correlation analysis only showed a relationship between “Years of Experience” and “Physical Resource Management” (r = -0.193) which is a very weak negative correlation between the variables and could indicate that as Project Team Members gain more experience and receive increasingly difficult Projects, they detect that there is a

greater complexity in the tasks that compose PR Management, although this correlation value does not allow us to conclude this hypothesis.

Therefore, the most difficult Processes in Project Resource Management are Human Resource Management and Physical Resource Acquisition.

Q2: Do Project Team Members utilize AI tools to perform Project Resource Management?

According to the data gathered in the survey, 87.4% of the respondents do not use Artificial Intelligence in Project Management and 88.2% do not use AI in Project Resource Management, even though 63% have used AI in other situations in their lives. Nonetheless, 8.7% have used AI in Project Management and 7.9% have used it in Project Resource Management, which shows that some professionals or companies are already using this technology in their work structure.

In the correlation analysis, a very weak and negative correlation between the "Size of Companies" and "Users that have Used AI" was detected ($r = -0.196$), which translates to companies that have bigger dimensions are more likely to have users that have had contact and operated AI before, even if it was not related with Project Management.

Other three correlations detected were between "Users that have Used AI" and "Users that have used AI in Project Management" ($r = 0.210$), "Users that have Used AI" and "Users that have used AI in Project Resource Management" ($r = 0.197$), and "Users that have Used AI in Project Management" and "Users that have used AI in Project Resource Management" ($r = 0.569$).

The first are expected, since if the respondents have used AI in Project Management or Project Resource Management it would be expect that they would say that they have used AI before. But the moderate positive latter correlation shows that most users who have used AI in Project Management, used it to manage Human and/or Physical Resources in Projects.

Similarly to the AI tools observed in the Literature Review capable of performing different tasks such as managing Physical Resources (Lu et al., 2018) or recruiting Project Team Members (van Esch & Black, 2019), the available technologies are being incorporated in Project Management practices and with the efforts being made on behalf of companies and governments (Steels & De Mantaras, 2018), the widespread advancement of AI could enable

Project Managers to be more efficient and take on more tasks or Projects. In sum, these technologies are still emergent and are beginning to be introduced into Project Management.

Q3: Do Project Team Members perceive AI tools to be useful for their daily tasks?

Understanding the willingness to use a given tool is important in order to adapt this tool to the users' needs. When asked if they found useful having an AI agent supporting Project Resource Management tasks in their day-to-day operations, 70.9% of the respondents said that they would like having these AI agents supporting their daily tasks, while 7.9% said that they would not like to have the technologies supporting their tasks and 21.3% do not know if they would like to have the support of these agents.

The only correlation flagged by SPSS between this variable and the independent variables was with "Role in Projects" ($r = 0.177$) with a very weak positive correlation. It could be stated that the lower the role performed by Project Team Members, the more receptive they would be towards AI agents supporting their daily tasks, but this relationship is far too weak to draw any sort of conclusion between these two variables, so the willingness to use AI agents in Project Resource Management Tasks is not influenced by the socio-economic variables tested in this research.

Therefore, the majority of the population of Project Managers in Portugal would be willing to use this technology to perform their daily tasks, according to the responses and this result is useful to justify that the efforts being performed by the European Parliament (European Comission, 2019) and the *"AI Portugal 2030"* program developed by the Portuguese Government and INCoDe.2030 (Coordination Office of INCoDe.2030 Initiative, 2019).

Q4: In which tasks do Project Team Members feel that AI could provide support?

In order to understand which tasks needed a greater support from AI agents, a set of tasks identified in the literature as being crucial to Project Resource Management and that are already being perform by AI agents was presented to the respondents and they were asked to rank these technologies. Starting with Human Resource Management, the ranking scores are as follows:

1º Project Task Monitorization (Mean Rank = 2.87);
2º Scheduling Project Tasks (Mean Rank = 2.94);
3º Allocation to Project Tasks (Mean Rank = 3.48);

4º e-Recruitment and Candidate Selection (Mean Rank = 4.16);

5º e-Learning (Mean Rank = 4.42);

6º Communication (Mean Rank = 4.80);

7º Rewarding Team Members (Mean Rank = 5.33);

The three highest ranking technologies (Project Task Monitorization, Scheduling Project Tasks and Allocation to Project Tasks) correspond to tasks from the Human Resource Management Process, which was considered the most difficult Process in the ranking of Human Resource Processes. In fact, there are positive correlations between these technologies (Project Task Monitorization with Allocation to Project Tasks, r = 0.277, and Allocation to Project Tasks and Scheduling Project Tasks, r = 0.458), which shows that these technologies go hand in hand with each other.

These are the Human Resource Tasks for Projects that require a greater support from AI agents, and they correspond to Human Resource Management tasks, indicating that the population of Project Managers need support in this area.

Correlations between these technologies and the Sample Variables were flagged in SPSS. Between Size of the Company and Allocation to Project Tasks (r = -0.206) and which could indicate that has companies get bigger in terms of hired personnel, they will require some sort of technology that can allocate their employees in a more efficient manner within their Projects.

Between Size of the Company and Rewarding Team Members there was also a correlation (r = 0.224), which could indicate that as companies grow in staff size, they will require less need of a tool that Rewards their employees, although it is difficult to apply any sort of hypothesis for this correlation.

As for Physical Resources, the ranking of the available AI technologies to support the tasks responsible for handling these resources are as follows:

1º Cost Estimation for Resources (Mean Rank = 3.02);

2º Monitoring Resource Availability (Mean Rank = 3.31);

3º Scheduling Resources for Project Tasks (Mean Rank = 3.36);

4º Inventory Management (Mean Rank = 3.46);

5º Allocating Resources to Project Tasks (Mean Rank = 3.82);

6º Resource Placement (Mean Rank = 4.03);

As it is observable, a cost prediction AI agent was selected as the most useful technology to be incorporated into the management of Physical Resources for Projects followed by the Monitoring Resource Availability AI, which are both included into the Physical Resource Acquisition Process, which was voted as the most difficult Physical Resource Process, indicating that there is a real need for this technology to be incorporated into Project development.

In fact, the remainder of the tasks where ranked in an order in which there was no correlation established between the Processes and the PR AI technologies. Therefore, the ranking of these technologies was mostly based on the difficulty that the respondents felt on specific tasks and not related to various tasks in the same processes.

Once again there are a few weak positive relationships between the variables correspondent to the ranking of technologies, which are Cost Estimation for Resources with Scheduling Resources for Project Tasks (r = 0.217), Scheduling Resources for Project Tasks and Allocating Resources to Project Tasks (r = 0.208) and Inventory Management with Monitoring Resource Availability (r = 0.236). The first and last correlations correspond to technologies that perform tasks within the same Process, indicating that if the respondents feel a certain degree of difficulty in a given Process, it is possible that they will rank both technologies higher or lower but on pair with each other.

In conclusion, the functions that are requiring a new approach to aid in the performance in managing Human Resources (if we consider the top 3 ranked tasks) are the Project Task Monitorization, Scheduling Project Tasks and Allocation to Project tasks. For these tasks the solutions presented by Aljamee & Naeem (2020), Ge & Xu (2016) and Myszkowski *et al.*(2015) respectively are a functional answer that correspond to these needs

As for the functions requiring a new approach in managing Physical Resources, the top 3 ranked tasks were considered, specifically Cost Estimation for Resources, Monitoring Resource Availability and Scheduling Resources for Project Tasks. These tasks also have already existent solutions that can meet the requirements for managing Physical Resources, such as the tools presented by Q. Li *et al.* (2018), Lu *et al.* (2018)and Aziz *et al.* (2014) respectively.

6. Conclusion

After performing the Literature Review, developing a Methodology to collect data and Discussing the results obtained it is possible to develop a Conclusion framework that relates all the findings with the Research Objectives and answers the Research Question.

6.1. Key Findings

The first objective was identifying the major challenges for Projects during the planning, acquisition and management of Human and Physical Resources. The results showed that the majority of Project Managers have a greater degree of difficulty in Managing Human Resources and Acquiring Physical Resources. The results also found that the age and years of experience of professionals in Projects has an influence in the difficulties felt while managing Projects.

These findings were also related with the need for an AI that performs Project Task Monitorization, Schedules Project Tasks and Allocates Team Members to Project Tasks for Human Resources and Cost Estimation for Resources and Monitoring Resource Availability for Physical Resources, which shows that there is a real need for these AI technologies to be incorporated into Project Management.

The second objective was to understand if it was common practice for Project Managers to use AI in Projects and the results showed that it is not yet a common practice for most professional to use this technology. Nonetheless, there are a few numbers of individuals that have used AI for Project Management and Project Resource Management, which shows that these AI agents are starting to make their way into job structures within Projects.

The third and final objective was to understand if the respondents felt like this technology would be useful for their day to day tasks and the results showed that a great percentage of individuals felt that Artificial Intelligence would in fact be useful for their professions. By extrapolating this result to the population of Project Managers in Portugal, it is possible to state that the majority of Project Managers would find useful having an AI agent supporting their daily tasks.

Therefore, to answer the main research question "Can Artificial Intelligence provide support for Project Team Members in managing Human and Physical Resources?" it is certain that this technology could indeed provide a significant support in the Project Resource Management Knowledge Area, since there are already AI solutions in place to aid in these

specific tasks. Also, the acceptance of this technology by the majority of professionals in the area could represent a significantly low barrier of entry for AI, where users would be willing to learn how to use this technology and harvest its potential.

6.2. Theoretical and Practical Contributions

It is possible to grasp the concept that the development and popularization of AI will inevitably make it a part of our daily lives and in some ways it already is. This trend will also translate to the incorporation of AI in many professional areas and Project Management will become continuously aligned with this trend.

By understanding how these technologies affect Projects and demonstrating that professionals feel the need and are willing to accept this technology to support their routines, this research has created a theoretical foothold for future studies in the Project Management/ Artificial Intelligence architype.

Has shown, not all areas within Project Resource Management have the same degree of difficulty, where some Processes are considered more difficult than others and it is most likely that the same will translate to other Areas of Knowledge in Project Management. Researchers and companies may come to understand that creating different AI solutions to tackle the major difficulties felt in Project Management, they can improve overall performance in Projects, reducing time and costs.

The further development and implementation of AI in Project Management also requires a holistic solution, as noted by Prasad & Vijaya Saradhi (2019), an agent capable of handling different responsibilities, such as scheduling tasks and estimating cost for resources, and harmonize the whole process, not only the management of Human and Physical Resources in Projects, but rather across all Project and in all Industries.

It should also be noted that due to the development of legal and ethical guidelines for the utilization of AI in company structures (Cath et al., 2018), companies need to maintain the effect of AI as a supporting tool during operations and require approval from the Project Manager, since the social impact of AI in companies has already been noted in previous researches, showing that AI can mimic certain human patterns that are legally and ethically considered discriminatory (Y. Wang, 2020).

Thus, companies and researchers who want to develop AI agents to fully integrate them into Project Management should keep in mind the legal, ethical and practical implications that this technology holds, with all of its benefits and disadvantages, and keep as supportive tools to Human agents, maintaining control over their autonomy.

6.3. Future Research Proposals

As it is expected, the implications of studying a system that is capable of autonomous learning cannot be tackle in a single study, further research proposals have been identified during the elaboration of this study.

First off, further studies should be conducted to understand which socio-economic variables affect the willingness of users to use AI agents in Project Management and which are the major barriers to use these technologies., since the ones utilized in this research did not seem to affect the willingness to use this technology in Project Management and Project Resource Management.

Secondly, a study should be conducted understand how the experience using AI tools actually affects the user's willingness to use the technology and how the perceived usefulness of AI will affect their willingness to use this technology, since 29.9% did not use AI before, 87.4% never used AI in Project Management and 88.2% never used AI in Project Resource Management, but still 70.9% of the respondents said that they would like to have this technology supporting their daily tasks in Project Resource Management, indicating that some users may have not used or do not know if they used AI before but are still willing to use these agents.

A study that shows the social implications of using an AI agents in Projects should also be conducted to understand exactly how Project Team Members would react by having a technology telling them which actions should be taken to meet the Project requirements and observe how this affects their work performance, dedication and mental wellbeing.

Also, the sample populous should is not broad enough to analyse the paradigm in the complete European scheme and perhaps a study that includes more nationalities in a significant proportion would help researchers understand how different geopolitical communities would respond to this technology.

7. Study Limitations

As stated before, this study was aimed at a population of Project Team Members that worked within the Portuguese context which includes about 100,000 individuals. With a sample size of 127 valid responses and a Confidence Level of 95%, the expected Sample Error for this study would be 8.7%.

This study was limited by usage of only a Pearson's *r* Correlation between the different variables which cannot clarify the linear associations of the variables used in this study due to its social nature (Pestana & Gageiro, 2014), and the available data and its nature did not meet the necessary requirements to develop a Linear Regression Model that would explain how the variables relate to each other.

Also, the lack of previous studies conducted on the willingness of Project Team Members to use AI in Project Management and Project Resource Management represented a barrier to define appropriate scales to measure the variables analysed in this study, which forced the creation of new scaling methods.

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9. Appendixes

9.1. Appendix A - Survey

Ricardo Miguel Silva Nobre, MSc in Business Administration at ISCTE Business School

Contacts: 914781285 | rmsn95@gmail.com

The following survey was developed in the context of acquiring relevant data for a Master's Dissertation Thesis in Business Administration at ISCTE Business School. This dissertation aims to study the application of Artificial Intelligence in Project Management, more specifically in Project Resource Managements, to understand its possible impacts in the development of Projects.

Welcome Page

Dear Participant,

My name is Ricardo Nobre and I would like to invite you to participate in a survey to **understand what the major challenges in Project Resource Management and how Artificial Intelligence are can better support your daily tasks.**

Please be aware that no expertise on Artificial Intelligence is needed to participate in this survey.

Should you have any doubts or concerns regarding the survey please contact me at: rmsne@iscte-iul.pt

Thank you for taking an interest in helping me obtain data for my dissertation for the qualification of the MSc in Business Administration at ISCTE Business School in Lisbon.

Section 1 – Sample Characterisation

This section will characterize the sample for this survey. The details provided will only be used for academic purposes and anonymity of the respondents will be kept, avoiding breaching their privacy.

1) Do you work or have you worked in Project Management or in Projects previously?

2) Age:
   a) 18-24
   b) 25-34
   c) 35-44
   d) 45-54
   e) > = 55

3) What is your role in Project Teams?
   a) PMO Director/Manager
   b) Project Manager
   c) Program Manager
   d) Project Officer
   e) Junior Project Manager
   f) Team Member
   g) Other (which one)

4) In which industry do you have more experience in Projects?

5) How many Years of Experience do you have in Projects?
   a) >2
   b) 2-5
   c) 5-10
   d) 10-15
   e) 15-20
   f) >20

6) In which Country are you currently working in?

7) Size of the company in which you work:
   a) < 10
   b) 10 – 49
   c) 50 – 249
   d) > 250

8) Have you ever had experience managing Human and/or Physical Resources?

Section 2 – Project Human Resource Management Processes

The following section will refer to the processes that elements of the Project Team perform when managing Human and Physical Resources during Projects. **Please rank the tasks based on Difficulty of Realization, placing at 1st the most difficult process and at 6th the least difficult.** Please consider the definitions provided for each process and the tasks that comprise the process:

1) Human Resource Management:
   a) Human Resource Planning
   b) Human Resource Acquisition
   c) Human Resource Management

2) Physical Resource Management:
   a) Physical Resource Planning
   b) Physical Resource Acquisition
   c) Physical Resource Management

Section 3 – Application of Artificial Intelligence in Project Resource Management

In this section Artificial Intelligence Agents dedicated to performing Project Resource Management tasks will be presented in order to understand if they could be useful for Project Management practices. These tools are already existent methods that analyse data bases and are capable of supporting decision making for various tasks in Project Resource Management, learning from past experiences and finding the best path to optimize processes. Therefore, in the interest of understanding if the different AI tools would be useful, please consider carefully the following questions:

1) Have you ever used AI tools?
    a) Yes
    b) No
    c) Don’t know

2) Have you ever used AI tools in Project Management?
    a) Yes
    b) No
    c) Don’t know

3) Have you ever used AI tools in Project Resource Management?
    a) Yes
    b) No
    c) Don’t know

4) Would you find useful having an AI agent supporting your tasks in PRM?
    a) Yes
    b) No
    c) Don’t Know

5) Please rank from 1st (Most Useful) to 7th (Least Useful) the following AI agents capable of supporting **Project Human Resource Management** tasks:
   a) e-Recruitment and Candidate Selection
   b) Scheduling Tasks
   c) Allocation to Tasks
   d) Task Monitorization
   e) e-Learning
   f) Communication
   g) Rewarding

6) Please rank from 1st (Most Useful) to 7th (Least Useful) the following AI agents capable of supporting **Project Physical Resource Management** tasks:
   a) Cost Estimations
   b) Scheduling Resources for Tasks
   c) Allocation to Tasks
   d) Resource Placement
   e) Inventory Management
   f) Monitoring Resource Availability

Conclusion Page

Thank you for taking your time to fill out this survey!

I truly appreciate the effort and I hope that you enjoyed filling out this quick survey to help me complete my study.

Once again, you have any doubts or concerns please contact me at: rmsne@iscte-iul.pt

Thank you and have a nice day!