INSTITUTO POLITÉCNICO DE BRAGANÇA
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Effective STEM Project Management: A Research Study on Best Practices and Strategies

Arthur Rocha Firmino da Silva

Master thesis presented to the Superior School of Technology and Management of Bragança for obtaining a Master's Degree in Industrial Engineering.

Supervised by:
Prof. Ana I. Pereira
Prof. Luis Mesquita

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Abstract

Project management is a multifaceted subject that encompasses a multitude of areas of knowledge, gathered together to move towards accomplishing a goal. This work aims to identify good practices and strategies in project management that will be implemented and that have been achieving satisfactory results in a European Project funded by the Horizon Europe program at the Polytechnic Institute of Bragança (IPB), Portugal, which aims to enhance and increase IPB's capabilities within the STEM fields (Science, Technology, Mathematics and Engineering) together with EDI (Equality, Diversity and Inclusion). Through a series of surveys, assessments, measurement and comparison of internal key performance indicators this case study was made possible. Within this work, a data acquisition standard was defined and tailored for the particular project together with a risk assessment framework for monitoring, controlling and steering the project's activities according to its performance. A group of actions and strategies were developed in order to equip the team for future project iterations, based on the enhancements identified through the initial outcomes. In conclusion, this work shall serve as a useful source of enlightenment, benchmarking foundation for future projects with similar environments and final targets such as the ones here entailed.

Keywords: Project Management, STEM, European Project, Horizon Europe.

Contents

List of Tables

List of Figures

Chapter 1

Introduction

Project management is a multifaceted and demanding endeavour that requires precise planning, coordination, and implementation. With the swift evolution of a multitude of technological and innovative processes, the significance of effective STEM project management has become increasingly crucial. This thesis aims to enlighten the audience on the most successful approaches and techniques presented in a case study for achieving excellence in STEM project management.

This work will analyze and evaluate the efficacy of these approaches and techniques, providing an equitable comprehension of the indispensable components necessary for accomplishing projects successfully. By apprehending and executing the most favourable strategies and practices for STEM project management, the project manager can guarantee successful project delivery, satisfy stakeholder expectations, and accomplish project objectives.

The thesis report is organized as follows:

Chapter One presents a brief introduction to the work and its theme. Chapter Two highlights the status and comprehension of the STEM term and its details. Chapter Three has the objective to describe project management methodologies, different methods and frameworks. Chapter Four describes the case study for this thesis. Chapter Five enlists the result of the work carried out and discussions about it. Chapter Six are the conclusion and the suggestions for future work.

Chapter 2

Science, Technology, Engineering and Mathematics.

STEM (Science, Technology, Engineering, and Mathematics) is a commonly used acronym in the contemporary educational and job landscape. Introduced by north americans, its first appearance was given by the National Science Foundation (NSF-United States) to describe a group of disciplines that formed a specific curriculum [1]. But many times, a clear envisioning of what exactly is STEM is not achieved in debate. Some consider that STEM education is an interdisciplinary approach to learning where challenging academic concepts are combined with practical lessons as students apply science, technology, engineering, and math in contexts that make connections between the classroom, community, workplace, and global enterprise [2]. The absence of an explicit description of what is and what is not STEM-related contributes to a lot of disagreement on which approach should be taken and what outcomes are aimed to be expected. Therefore, other descriptions were given with the intent of better telling this definition, such as the one appointed by The American Congress, when it assumes that STEM education points to giving lessons and learning in the fields of science, technology, engineering, and mathematics. It normally includes educational activities across all grade levels— from pre-school to post-doctorate that could be in formal and informal configurations [3], [4]. This concept emerged as a way to promote the integration of these four disciplines in educational settings. It has emerged as an important educational focus in recent years due to its potential for preparing students for the challenges of an increasingly technical world [4], [5]. This approach is beneficial in developing a holistic perspective on problem-solving, an essential skill in various fields of study. Moreover, the term STEM has been adopted by numerous educational institutions to emphasize the importance of the four disciplines in the overall educational experience. This has been done through the implementation of integrated teaching methods and the formation of facilities wherein students can have direct experience with the disciplines. Furthermore, a STEM-based education has proven to be very effective in preparing students for further studies and professional careers [4], [6]. Also considered an educational framework based on the integration of those four disciplines, which seeks to close the gap between the classroom and the real-world scenario by giving and providing students with hands-on learning experiences, encouraging exploration and innovation. By doing that, students are able and allowed to develop enough skills to become successful in an increasingly technology-driven society [4], [6], [7].

With an emphasis on interdisciplinary learning, STEM education also makes sure that students have exposure to the whole spectrum of STEM-related fields, which can help them identify, acknowledge and pursue their own passions. Additionally, STEM education has the potential to help break down gender and socioeconomic barriers that may exist, by providing students with equal access to potential and highly lucrative career paths, making them highly well qualified for job positions of great impact and renown [5], [6], [8], [9].

STEM education also seeks to expose students to the current trends and advancements in the world of science and technology, preparing them for future careers in the STEM industry promoting integrated learning and connecting it to modern problems and their respective most advanced solutions [7].

2.1 STEM Jobs and Careers

STEM education can also help prepare students for the future by introducing them to the latest advancements in science and technology and the potential careers related to these fields [4]. Additionally, STEM education has the potential to help break down gender and socioeconomic disparities, as it provides students with equal access to potentially lucrative career paths [5].

By the market acknowledging and understanding that technological advancements are being made at a neck-breaking speed together with the fact that innovation is being sought and fostered in various sectors, the necessity for STEM career professionals has been growing exponentially. For the year 2019, there were 16.8 million individuals employed in STEM-related roles, which represents 7.5% of the total employment number in the EU. Despite this apparent expansion, there are worries about a shortage of competent and certified people in certain industries. Therefore, is also relevant to note that STEM-related positions have been growing at a faster rate than non-STEM jobs in Europe, with an average annual growth rate of 2.7% for the period between 2016 and 2018 [10], [11].

However, the lack of an explicit explanation of what falls within the STEM field and what does not contributes to significant disagreement regarding which professionals are truly qualified for STEM careers. As a consequence of that, alternative descriptions and definitions have been proposed in an effort to more accurately define the field. For example, the United States Department of Commerce (DOC) has suggested that specialized knowledge is a mandatory requisite for employment in STEM roles. Additionally, the DOC has divided STEM jobs into four distinct categories: Computation and Mathematics, Engineering and Surveying, Life and Physical Sciences, and STEM Management [1].

Yet about those careers, STEM jobs are becoming more and more relevant in contemporary society. Occupations in STEM are expected to increase by 8.9% between the years 2016 and 2026, which is more than the average for all jobs [12].

STEM workers tend to have lower unemployment rates too and are less affected by job losses due to automation and other technologies [12].

Even though the success of individuals within STEM moves towards more universalistic and meritocrat criteria due to its scientific character, there is a significant gender and racial gap in STEM [8]. According to the National Science Foundation in the USA, only 26% of workers in STEM fields are women, and only 13 % are Hispanic or black [13].

Efforts are being made to increase diversity in STEM fields. For example, programs that aim to increase the participation of underrepresented groups in these fields through targeted initiatives and support [14].

The European Commission warns that in 2020, there could be a shortage of as many as 900,000 STEM-related professionals, which could further intensify with the soaring demand for STEM experts [11].

Another worrisome fact is that the number of graduates in Europe has been decreasing in the last decades. Consequently, several European countries have introduced various initiatives to encourage students to pursue STEM careers and attract skilled professionals from overseas. For example, the Netherlands offers tax breaks to highly skilled migrants in STEM fields, while Germany has implemented measures to make it easier for international students to work and stay in the country after completing their studies [11], [15].

2.2 Activities and Discussions

The definition of STEM has been a source of debate, discussion and controversy in the educational environment. Hence, there is a lack of consensus on the definitions of STEM among academics and practitioners about the exact description of this subject. Several researchers defend that the incorporation of arts and humanities shall be necessary to foster a creative and better applied educational experience for the students and that the definition of STEM should be expanded to STEAM (Science, Technology, Engineering, Arts, and Mathematics) as a way of including a creativity perk into the learning practices and methods [16], [17].

The inclusion of the "Arts" group subject into STEM education can be essential in order to develop well-rounded learning methods which stimulates creativity and innovation, alongside problem-solving capabilities. To achieve this, several strategies are proposed, such as fostering collaboration between professors in different areas, designing and implementing arts-based activities that encompass scientific addressing of a particular discipline or subject task in a non-traditional way, engaging students in creative problem-solving tasks and helping them better visualize those concepts [18].

It also is a good practice for education to emphasise the importance of providing students with the opportunity to explore their creativity and to instigate that educators should strive to make the learning experience more engaging, humanized and meaningful to the students. Additionally is also suggested that educators ensure that the arts are integrated into the classroom in a worthy way, as opposed to simply being added on as an afterthought, in a careless manner. Hence, active steps need to be taken to certify that the integration of the arts into STEM education is indeed successful [16], [18], [19].

On the other hand, the other side of thinkers has argued that the definition of STEM should remain as it is and that its focus should be on the hard sciences and mathematical knowledge [20], [21].

Nevertheless, there is a significant lack of a definitive categorization of the individual areas of study that constitute STEM among various institutions, researchers, and organizations. A more pressing issue is the inconsistency in the definitions which either encompass or exclude extensive fields such as agriculture and health sciences [21]–[23].

As those approaches have put on their routine the use of phenomena to engage learners in arousing students' curiosity and fascination about the subjects, it is important to acknowledge and recognize that learning STEM is not simply memorizing facts and equations but also involves understanding how the concepts and principles of science and STEM interact with each other and can be applied to real problems [19], [23].

2.3 Educational Strategies and Good Practices

Strategies for quality improvement in STEM education are an important matter when it comes to the modern educational system. Hence, one of the most effective strategies for quality improvement and impact enhancement on STEM education is the professional development of professors. Providing professors with the necessary training, knowledge on best practices and supporting them to further understand and implement research-based instructional lessons that will have a greater and more profound outcome on students learning. Additionally, providing professors with enough access to proper resources to promote problem-based learning, which fosters critical thinking, and creativity and can also improve STEM education [16], [19], [24], [25]

Another suggestion is that schools should focus more on developing students' understanding of the "big ideas" in STEM, such as the relationships between technologies and fields of knowledge, the implementation of software and automation in tasks that would be done manually and so on. These strategies, if implemented effectively, can help to improve the quality of STEM education and, in turn, help to foster better learning outcomes for students and the educational scenario as a whole [25].

Other similar strategies can also be used to improve STEM education quality. These include increasing the use of technology within classes with educational purposes, incorporating real-world applications of concepts, and emphasizing learning by doing, with a hands-on approach [25], [26].

In this manner, technology can be used to facilitate, and speed-up learning by providing students with a sense of ownership of the knowledge they have learned as they develop their assignments in a more independent way, helping them better understand abstract terms that may seem otherwise hard to visualize at first. Incorporating real-world applications of this knowledge can give students a deeper understanding of the material provided, as it encourages them to think beyond the textbook. Therefore, emphasizing learning by doing helps students develop, as well as a better subject knowledge attainment [16], [26].

That illustrates that a successful STEM education requires more than just the basic and pure development of technical skills. The emphasis should stay on having the effective application of activities to increase the quality of STEM education as a whole, seeing to what extent the educational environment fosters and encourages critical thinking, provides opportunities for hands-on research and concept application, and develops the skills necessary to be successful in the field [27].

2.4 Differences in STEM Educational Approach

Depending on the region, there may be different approaches when it comes to STEM education due to a multitude of factors. These differences are primarily because of the emphasis of each particular educational system. In North America for example, the focus is more prone to individual achievement, and students are pushed to compete with each other, measuring their progress and achievements [28].

This goes in contrast with the European approach, which emphasizes the collective growth of all students. Hence, when it comes to Europe, the focus is on creating a more equally distributed path for learning, where all students are encouraged to work together towards success. Furthermore, the North American curricula are far more rigorously structured than the curricula in Europe, as it tends to be more focused on teaching a certain set of skills and information [29], [30].

On the other hand, European curricula tend to be much more open-ended, allowing students to explore and discover the course topics of their own choice and interest [29].

Furthermore, Europe has also been more proactive when it comes to fostering and implementing STEM-related initiatives and policies. It can also be noted that European countries have embraced a more holistic and problem-based approach to STEM education, while North American countries have been more inclined to apply a skills-based, isolated approach [31]–[33].

Another relevant indicator is that European countries tend to have higher levels of overall student attainment in STEM education, even though North America has seen the greatest increase in the number of STEM students in recent decades [31], [32].

In Europe, STEM education is more widely available and accessible to students from all backgrounds and economic levels while in North America, access is more restricted and often limited to those from higher socioeconomic backgrounds due to the higher price of universities in this region [30].

Chapter 3

Project Management

Project management has become a key factor for the success of any corporate endeavour. This is due to the fact that it determines and provides a traceable framework for the planning, implementation, and control of the activities that will be enrolled and involved within a project. Using those techniques allows management professionals to have a clearer and broader understanding of the project's scope, objectives, resources, and timeline. Furthermore, applying project management techniques ensures that the project is completed according to the schedule, delivering it on time and within the stipulated budget, alongside stakeholder satisfaction. So, project management can be defined as a combination of techniques, tools, methodologies and approaches that help and aids project managers handle their projects in a more effective manner [34], [35].

Also important to note that project management is not only about the implementation of a project but also about the management, drive, and manoeuvrability throughout its entire duration. This includes the identification of potential risks, managing stakeholder expectations, team management, resource management, monitoring progress, and ensuring that the project is completed on time and within budget [35].

It is an increasingly important skill set in the modern workplace and research shows that project management practices are linked to increased performance and efficiency, with better results and outcomes. This can be attributed to improved communication, coordination and planning between teams, as well as better use of resources and risk management, which directly implies higher lucrative outcomes [35].

Project management can also help to improve employee morale, as it allows greater collaboration and a clearer understanding of each other's role, together with the cultivation of the feeling of target accomplishment. Therefore, this makes it an invaluable tool for organizations of all sizes, as it is shown to improve performance and efficiency, better customer satisfaction, while also providing a better working environment by bringing the team together and moving toward a mutual goal [35]–[39].

Project management may be divided into three distinct phases: initiation, planning, and execution. The initiation phase is where the project ought to be defined, and the objectives and milestones are then established. The planning phase then involves the development of detailed execution tasks, drawing a timeline for the project as well as considering the necessary amount of time to complete these tasks, also identifying resources needed alongside [37]. The execution phase is when the project is indeed executed, lunging on the goal of meeting the objectives set during the initiation phase. Throughout the project, project managers must ensure that the team is working towards achieving the right targets, that resources are efficiently allocated, and that risks are managed appropriately [35].

3.1 Methodologies

There are two main types of project management methodologies: agile and traditional (waterfall). There is also a hybrid approach, which is the use of both of these methodologies tailored to fit together. Traditional project management is a more structured approach that is based on sequential and known processes. In this methodology, projects are managed in a more structured way with a well-defined plan [40]. The agile project management methodology is a more flexible approach when compared with the traditional waterfall, which is based on iterative and incremental development. It can be defined as a collaborative way of management that emphasizes communication and collaboration among the project team and the stakeholders. Finally, the hybrid approach is a combination of both previously cited. Hence, it is usually used to gain the advantages of both approaches and is typically used in complex, larger projects [40].

The following topics will better describe both of the cited methodologies for project management: Agile and Traditional (Waterfall).

3.1.1 Agile Methodology

The agile methodology has become increasingly popular especially in software development industries in the last decade due to the fact that it has been proven to offer some relevant and tangible advantages over other traditional approaches depending on the size of the project. Agile has been found to result in higher customer and stakeholder satisfaction as well as greater project transparency and flexibility. Furthermore, this methodology leads to faster development cycles, improved communication between teams and more accurate estimation of project completion times [41].

Additionally, this methodology is known to encourage collaboration and feedback from all stakeholders, encouraging collaboration between them, which may include engineers, customers, and other classes of team members. This helps and aids to ensure that everyone is indeed working towards the same goal and that the feedback is being taken into consideration throughout the process, leading to a more comprehensive, useful and user-friendly product at the end. Therefore, the agile methodology tends to be more efficient and cost-effective other than traditional methodologies depending on the type of project [40]–[42].

It is an increasingly popular way of managing projects in the modern era. Considered as a “lightweight process framework” that emphasizes continuous feedback and improvement iterations in order to quickly and efficiently deliver high-quality projects, that fit and please the client's demands/requirements [40].

An example of an agile management procedure can be seen in the Figure 3.1:

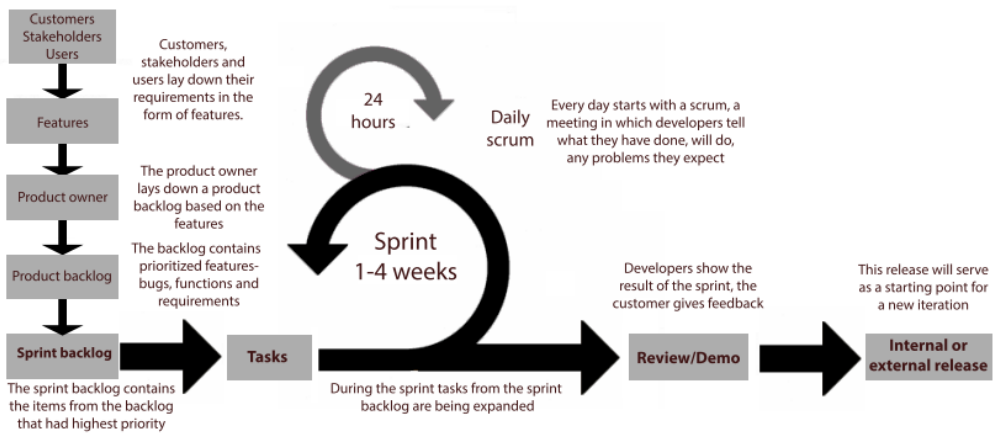


Figure 3.1: Example of an Agile methodology workflow [40].

The fact that it is based on the idea of gradual development, which means the process of breaking down large tasks into smaller and more manageable parts to seek constant client approval, and constantly getting in contact with the team, makes it interesting to be used in many project types. This allows teams to adjust quickly to changing requirements and conditions by allowing them to focus on the most important tasks first [43], [44].

This flexibility allows for more efficient development and reduces the risk of the project becoming unusable due to unforeseen changes [43].

It is also considered a popular methodology amongst organizations and teams who are looking to increase their productivity and simplify their processes. This type of methodology is highly beneficial as it allows teams to develop solutions quickly and efficiently, while also providing the flexibility to modify previously decided solutions as and when needed [44].

Summarizing, this approach has been adopted by many organizations, as it emphasizes flexibility and adaptability in the face of most recent changes in technology, customer needs, and market conditions [43].

3.1.2 Traditional Methodology (Waterfall)

The traditional waterfall methodology is a project management methodology that is linear and sequential. It emphasizes the importance of following a strict, pre-planned process that moves through several distinct phases [45]–[47].

The referred phases include requirements gathering, design, implementation, testing, and maintenance, which are based on the assumption that it is possible to accurately predict and plan all aspects of a project in advance, assuming that any changes to the plan must be carefully controlled, properly considered, and adequately managed to avoid disrupting the process as a whole. While it may be effective in certain situations, it has been criticized for being inflexible, slow to adapt to changing requirements, and too much bureaucratic, as it is overly focused on documentation and process rather than on delivering value to the end user, [45], [48].

An example of a traditional waterfall workflow can be seen in the Figure 3.2 as follows:

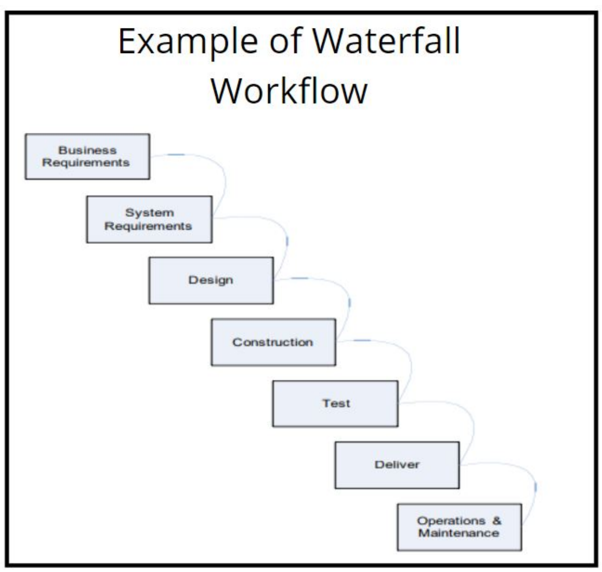


Figure 3.2: Example of Traditional Waterfall workflow [46].

The criticisms, the waterfall methodology remains a popular and widely used approach to software development in many organizations, particularly in industries such as finance and healthcare, where regulatory compliance and risk management are critical concerns [45], [46], [48].

3.1.3 Methodologies Comparison

Considering the previously cited, Table 3.1 briefly encompasses the pros and cons of each methodology presented.

Comparison between presented methodologies		
Methodology	**Pros**	**Cons**
Agile	Flexibility, customer involvement faster time to market	Lack of predictability, requires active participation,
	Enhanced transparency, quality focus	Resource-intensive, potential for scope creep, limited documentation.
Traditional (Waterfall)	Clear project structure, predictability, well-documented	Limited flexibility, limited customer involvement, late error
	Clear milestones, suitable for stable requirements.	Identification, risk of outdated requirements, lengthy feedback loops.

Table 3.1: Comparison between presented methodologies

3.2 Project Management Frameworks

Project management frameworks provide a structured approach to managing projects by offering a comprehensive set of tools and techniques that enable successful project delivery. By leveraging these frameworks, organizations can improve project success rates, optimize resource utilization, and achieve their strategic objectives.

Some of those frameworks will be presented below.

3.2.1 SCRUM

Scrum is a popular agile-type framework, most utilized in software development. It highlights the importance of collaboration, flexibility, and iterative progress [49]. It is an iterative and incremental approach that emphasizes collaboration, flexibility, and continuous improvement. Scrum is based on three pillars: transparency, inspection, and adaptation [49], [50].

Transparency refers to the idea that all stakeholders have a common understanding of the project's goals, progress, and challenges. The inspection involves regularly reviewing the product and the process to identify areas of improvement. Adaptation means that the team responds to feedback and changes course as necessary to achieve the desired outcome. During the brief daily stand-up meetings, team members share progress, discuss any impediments, and plan for the day ahead [49], [50].

At the end of each sprint, the sprint review is held to demonstrate the product increment to stakeholders and gather feedback, while the retrospective is conducted after the sprint review to reflect on the sprint and identify areas of improvement for the next one. Scrum is particularly useful in complex and dynamic projects, where requirements are likely to change, and collaboration and communication are crucial for success. By implementing Scrum, teams can efficiently and promptly deliver high-quality products while fostering a culture of continuous improvement and teamwork [49]–[51].

3.2.2 PMBOK

The Project Management Body of Knowledge (PMBOK) is a widely accepted, well-known and recognized framework used to manage projects and one of the most widely used project management approaches in the world [52]–[54].

It can also be considered a guideline for the management of projects and is anchored on the principles of project management. It consists of the sectioning of knowledge into a few areas of the managing process, which lists integration, scope, time, cost, quality, human resource, communication, risk, procurement and stakeholder management. Each of these knowledge areas contributes to the success of the project in different ways [52], [55].

Another definition for the Project Management Body of Knowledge PMBOK is a standardized framework for project management that provides guidelines, best practices, and processes for project management [52].

This framework is based on a collection of knowledge and lessons learned by experienced project managers from a broad spectrum of industries. With its comprehensive and descriptive way of project management, PMBOK helps project managers to manage all aspects of the project from initiation to closure. It is a process-oriented approach with a focus on defining the scope of the project, the planning, the execution, the monitoring, the control, and the closing of the project [52], [56].

PMBOK is based on five distinct process groups: initiating, planning, executing, monitoring and controlling, and closing. These processes are designed to help project managers achieve the project's goals and objectives, as well as to identify and address any risks or issues that might arise [52], [57].

In addition, PMBOK also defines nine knowledge areas that are specific to the project management profession, including scope, time, cost, quality, communication, risk, human resources, procurement, and stakeholder management. These knowledge areas are used to ensure that all elements of the project are properly managed and that the project is completed successfully [54], [58].

It is also considered a framework for creating and managing project plans. It is based on proven best practices and is thus highly respected in the project management industry. PMBOK is an approach to managing projects that emphasizes the importance of processes and procedures to optimize results [54], [57].

In 2021, a research survey with engineering and management professionals within the respective fields was made to assess the perceived effectiveness of the framework in managing projects. The results of the survey showed that the majority of participants had a positive opinion of the PMBOK guideline, with 91% reporting that they found it to be effective in helping to manage their projects, even when working into tight budget projects [54], [59].

PMBOK also emphasizes the need for an effective organizational structure and the need for clear role and responsibilities assignments. Additionally, it stresses the importance of applying the right techniques and tools in order to ensure successful project completion, which shall vary depending on the project's character. PMBOK guideline is also flexible and can be tailored to individual projects, enabling managers to make adjustments to the approach as needed. As a result, PMBOK is highly effective in ensuring successful project completion with minimal resources while ensuring that all stakeholders are satisfied with the end results [53], [60].

Ultimately, the PMBOK guideline is an effective tool for managing projects, as it can help ensure successful outcomes, improved communication and collaboration, and greater efficiency [61].

3.2.3 PRINCE2

PRINCE2, or PRojects IN Controlled Environments, is a structured method for managing projects developed by the United Kingdom government in 1989. It is a process-based approach to project management which is widely used both in the public and private sectors [62].

PRINCE2 is based on seven core principles, namely continued business justification, learning from experience, defining roles and responsibilities, managing by stages, managing by exception, focusing on products, and tailoring to suit the project environment and particular requirements [62], [63].

These principles are then further divided into components such as themes, processes, and techniques, which are used to plan, manage, and control projects [62].

Moreover, the PRINCE2 framework is based on the idea of dividing the project into manageable and controllable stages and processes. This approach allows for better control and visibility of the project's progress and also allows for improved risk management [62].

Additionally, PRINCE2 also provides templates, processes, and guidance which can be used to ensure that the project runs smoothly and is completed within a predetermined timeframe [62], [64].

PRINCE2 has revolutionized project management by providing a structure for project completion. It uses clear responsibilities and a focus on the best use of resources. PRINCE2 also offers a way to manage risks and address issues before they become major problems [65].

Its structure offers a simplified way to create a timeline and track progress, allowing project managers to ensure the project is completed on time. Additionally, PRINCE2 has a customer focus, meaning that the customer's needs are considered throughout the entirety of the project [64], [65].

PRINCE2 also encourages adaptation, enabling managers to adjust the project to accommodate changes that may occur or to be necessary. These features make PRINCE2 an ideal choice for project managers looking to make sure the project achieves success and customer satisfaction [65].

It also emphasizes collaboration and communication between team members and stakeholders, which helps to ensure that the project is delivered on time and within the desired budget [66].

Hence, PRINCE2 is shown to be highly flexible, adaptable, and scalable, making it a good fit for projects of any size or complexity level, which makes it adequate to be used in multiple industries and sectors, including construction, information technology, finance, marketing and the public sector. This makes it a relevant choice for organizations looking or searching for ways to streamline their project management processes [66], [67].

This makes it particularly suitable for large-scale projects where there are a large number of stakeholders, each with different needs and expectations upon the project [68].

Furthermore, PRINCE2 is designed to be a highly accessible framework, with its procedures being documented in a comprehensive and easy-to-understand manner which makes it easier for project managers to get the framework and apply it effectively. Furthermore, PRINCE2 provides a framework for documenting and tracking progress, ensuring that the project remains on track and any issues are identified and dealt with quickly, also being able to be implemented together with other existent methodologies and useful tools [64], [67], [68].

3.2.4 Lean Manufacture

Lean manufacturing is a system that consists of continuously seeking to maximize efficiency while minimising waste within an enterprise. When it comes to its application, this system has been used in a great variety of industrial scenarios, ranging from manufacturing to healthcare. It is based on the principles of the pioneer Toyota automotive manufacturing company which first adopted it in Japan in the early 1980s. Since it has proved to be a golden standard and has since been accepted as a good practice in a great number of other countries due to its astonishing results [69]–[72].

A study was made to assess the impact of Lean manufacture on the performance of a business organization and the implementation of Lean into the process had a positive effect on the organization's performance, as evidenced by increased efficiency, higher stakeholders' satisfaction, and improved product quality. Furthermore, the implementation of Lean manufacture was cost-effective, as it required fewer resources and had a shorter implementation time than traditional production systems [72].

When utilized in the field of organizational management, it emphasizes the importance of reducing waste and improving the efficiency of the production process by cutting out unnecessary steps and bureaucracy. The effects of the implementation of Lean manufacture in the automobile industry, for example, led to a decrease in the amount of time needed to complete production tasks, as well as a decrease in the amount of inventory waste [71], [73].

Additionally, the implementation of Lean manufacture significantly improved customer satisfaction due to the improved quality of the product, which showed a lesser number of defects[71], [73].

The first step for the implementation of Lean is to identify the value from the customer's perspective, which helps to ensure that the organization is working on the right things. The second step is to map the value stream, which involves looking for waste and non-value-added activities. The third step is to create flow, which includes eliminating bottlenecks and focusing on the flow of information and materials. The fourth step is to establish pull, which entails only producing products and services in response to demand signals from the customer. Finally, the fifth step is to pursue perfection, which involves continually striving to improve efficiency and effectiveness while also ensuring customer satisfaction [73], [74].

This is accomplished by reducing setup times, waiting times, and allowing for more flexible production processes. Lean manufacture also seeks to involve all employees in the production process, by allowing them to contribute with their ideas, experience and knowledge to the improvement of the production system. This increases employee morale and loyalty, as they will see their ideas being recognized and implemented. It is a system of working that should be incorporated into the culture of any institution or enterprise that wants to remain competitive and successful in the long run [73], [75], [76].

In 2009, a study about Lean manufacture took place within the field of operations management. The study found that the Lean manufacture is an effective strategy for operations management, as it is designed to reduce costs and improve customer service. Finally, the Lean manufacture is a viable approach for operations management and can be used to improve overall performance [73], [77].

Lean manufacture is a valuable tool for improving construction performance too. The approach involves identifying and eliminating any non-value-adding activities throughout the production line or project activities, thereby providing an efficient and effective way to improve the construction process [76].

This is done through the identification and elimination of inefficiencies, such as unnecessary processes and excess bureaucracy, which can significantly reduce construction costs and improve the quality of the output and also improve productivity and reduce time-to-market [76], [77].

3.2.5 CPM

The Critical Path Method (CPM) is an important tool for project management. First developed by DuPont Corporation in the 1950s, has since become a widely used tool for scheduling complex projects. CPM is a set of techniques used to plan, time-frame, and control projects. It can also be considered a mathematical algorithm utilized to indicate the earliest finishing time of a project or specific task. It is based on the idea that breaking down any project into a series of tasks to calculate the longest path of duration can determine the shortest amount of time needed to complete the project [78], [79].

CPM mainly consists of identifying the critical activities that must be completed in order for the project to be successful. CPM involves analyzing the interdependencies between activities and then calculating the shortest time in which the project can be completed. CPM also allows for the identification of potential risks and their impact on the project. In addition, CPM can be used to identify potential delays and their associated costs [79]–[81].

It also helps to identify which tasks to prioritize in order to optimize the project's efficiency. The CPM also helps to identify the shortest time required to complete the project and to identify potential delays that could impact the project. The referred path is the longest sequence of activities, meaning that if any of the tasks in this path is delayed, it will cause a delay in the entire project [80], [82], [83].

By allowing teams to identify the project's critical tasks, CPM can also help reduce the resources needed to in the process. Additionally, CPM can be used to identify and mitigate risks, identify potential problematic tasks, and help ensure that the project is completed on time and within budget [78], [84].

CPM utilizes a flow chart with a timeline that shows the start and finish dates of each task, as well as the dependencies between tasks. It also provides an analysis of potential risks within the activities, allowing project managers to plan alternative courses of action in the case of an unexpected event or delay. CPM is used extensively in the engineering and construction industries, as well as other industries where complex projects are undertaken. Furthermore, CPM can help project managers to anticipate potential problems and to make adjustments to the project timeline as needed [81], [85], [86].

The CPM also helps to identify potential sources of inefficiency in a project, which can be rectified by allocating additional resources or reordering tasks. This makes it a particularly useful tool for construction engineering project management, where delays can mean increased costs and missed deadlines which shall directly impact client's satisfaction [82], [87].

3.2.6 Frameworks Comparison

It is important to mention that there are interconnected features between the frameworks as they make part of the same craft. Therefore, they are not entirely unique in their characteristics.

However, after considering the frameworks presented, the Table 3.2 can help better describe their singularities, and better differentiate one from the others by highlighting their principal characteristic. The table is as follows:

Table 3.2: Comparison table between presented frameworks

Comparison table between presented frameworks			
Framework	Description	Focus	Key Principles
SCRUM	An Agile-based framework for managing projects	Flexibility and agility	Empirical process control, self-organization
PMBOK	A guide for project management practices and knowledge areas	Process-driven	Knowledge areas, process groups, best practices, lessons learned
PRINCE2	Structured project management guidelines for controlled environments	Control and scalability	Business justification, defined stages, project board
Lean Manufacture	A systematic approach for minimizing waste and optimize processes	Enhancing efficiency	Waste elimination, continuous improvement
CPM	Analyzing better and worst-case scenarios	Time and resource management	Identification of critical activities, project scheduling, resource allocation

Hence, this project will be carried out in a hybrid methodology and get inspiration from the PMBOK framework.

Chapter 4

Case Study

The case study takes place within the STEP project activities.

The STEP project is funded by the Horizon Europe program. The project's central goal is to enhance the STEM capability and drive excellence in the Polytechnic Institute of Bragança (IPB) together with Equality, Diversity and Inclusion (EDI), assessing its current status and implementing activities to improve its capabilities towards excellence.

Given the increasing complexity and interrelation of contemporary STEM educational scenarios, the STEP project recognizes the critical importance of disseminating and advancing current IPB practices to maximize their effectiveness and efficiency. This study will encompass analysis and evaluation of these IPB STEM-related practices and their management within the STEP project, pinpointing areas that could benefit from improvement in the goal of achieving success. The ultimate, practical, tangible and simplified objective is to elevate IPB's key performance indicators (KPIs), resulting in superior outcomes and more effective project management holistically.

The STEP project initiative aspires to elevate the research and impact capabilities and standing of Instituto Politecnico de Braganca (IPB) in Portugal, by striving for excellence in the domains of STEM together with EDI (Equality, Diversity, and Inclusion) values through mutual exchange. This is an issue of great significance to the academic community as a whole, as it can significantly aid in maintaining the quality of research methods within each institution and promote collaboration between areas that may otherwise seem distinct or disconnected. To accomplish this goal, IPB will work together and in collaboration with four globally recognized research-intensive partners, presented in Table 4.1

Table 4.1: IPB partners in the STEP project.

IPB STEP Partners	
Institution	**Country**
Sodetorn University - SH	Sweden
Complutense University of Madrid - UCM	Spain
Genova University - UNIGE	Italy
Reims Champagne-Ardenne University - URCA	France

4.1 Project Objectives

STEP's objective is to tackle the previously mentioned challenges by striving for excellence and enhancing research capabilities and the reputation of IPB, while also taking advantage of the exceptional expertise of the four EU partners in the consortium.

The project aims to improve the internationalization and project management abilities of IPB personnel, both at the academic and managerial levels, integrating and promoting EDI strategies and policies into STEM.

The aim of STEP is to encourage and maintain exceptional research in the STEM/EDI research field, such that their principles and approaches become an integral aspect of academic life.

The success of this endeavour will result in the bolstering of IPB's research capacity, reputation, and internationalization, even before the project's completion. This will have a strategic, ripple effect on the entire country, presenting the outcomes of STEP as a replicable model for other higher education institutions and research-performing organizations in Portugal. Achieving this ambitious goal will require networking, knowledge exchange, and concrete actions, including consistent and active involvement from all of the components of IPB. To attain the three sub-objectives (SOs) detailed below, indicators and target values have already been identified and will be constantly monitored throughout the project's implementation. These measurements will be taken against the values obtained from a self-assessment that IPB will perform at the beginning of the project, in collaboration with the partners.

Objective 1 aims to enhance the scientific and technological capacity of IPB, leading to an increased research profile and reputation, with a significant positive impact on EU partners. Achieving this objective will have several strategic outcomes, including opening up new approaches and research collaborations in the field of STEM and EDI, allowing EDI policies and strategies to be tested and implemented at IPB and then transferred to other institutions in Portugal and beyond. Additionally, the implementation of STEM research programs focused on EDI will tailor diversity and inclusion for staff and students of diverse backgrounds, creating an innovative research approach that will persist beyond the funding period. Finally, achieving Objective 1 will make IPB a reference point at a national and international level, enhancing excellent science practices.

Objective 2 aims to enhance internationalization and networking activities, leveraging the beneficial effects of the new research avenue on STEM and EDI activated at IPB and the effectiveness of STEP twinning mechanisms. This objective will contribute to a higher IPB presence in the international arena, increased networking with scientists, academics, and experts inside and outside Portugal, and enhanced open publication activity and open science practices for the entire partnership. These outcomes will serve as drivers for the growth of the promising, internationally oriented researchers.

Objective 3 aims to strengthen IPB's research management capacities and administrative skills, generating durable results with lasting effects on the institution and Portugal as a whole. Achieving Objective 3 will involve improving the R&I Management Unit at IPB, reinforcing the capacities and skills of the administrative and management staff through tailored training, and increasing IPB's overall ability to attract external funding and participate in international research and cooperation projects.

4.2 Key Performance Indicators - KPIs

STEP's key performance indicators have been designated to benchmark and used as a guide for actions taken within the project's activities. It will be the north for resource and effort allocation in regard to the expected end results of the project. If the indicator is out of alignment with the expected pace for the period of time, this should be addressed by the team with proper carefulness, making sure that it comes back on track or maintains it going well if there is no need for intervention.

All of these KPIs demonstrate the health and impacts of a HE institution, in this case, the Polytechnic Institute of Bragança (IPB). An initial scenario is required to be examined in order to push towards the goal of strengthening STEM research in IPB in conjunction with Equality, Diversity, and Inclusion (EDI) measures.

4.3 Management, Internal and Partners Teams

The project personnel has been divided into sections to better fit the workloads. The division was made according to the nature of the discussions involved and the layer of decision-making necessary to be accessed bearing in mind the non-trespassing or misalignment of documented obligations. These sections are the Management team, the Internal team and the Partners team.

The Management team comprises the IPB group that drives the project direction and keeps the activities well orchestrated, engaging with the other parts and offices, seeking aid and external advice when needed, identifying any possible threat or risk to the project's success, setting the ones responsible for a determined execution and coordinating the making and delivery of the deliverables.

The Internal team comprises the IPB members that are included in the STEP project, which includes professors and researchers of the three main Research Centres within the campus. The three centres related are the Research Center of Digitalization and Intelligent Robotics - CeDRI, the Mountain Research Center - CIMO, and the Research Group of Sustainable Construction - GICoS.

The Partners team comprises all the member institutions of the project, which includes all five institutions members of the project, namely IPB, Sodetorn University, Genova University, Reims Champagne-Ardenne University and the Complutense University of Madrid.

4.4 External Advisory Board and Coordination Group

The external advisory board is composed of notable personalities that will provide advice and consulting on the course and actions of the project. It consists of a group of six persons that will help with the achievement and counselling of the project.

The coordination group is responsible to give pace and attainment to the project's duties, and organizing the main events, actions and meetings. It is composed of IPB members since IPB is the coordinator partner institution.

4.5 Steering Committee

The steering committee comprises the committee that will monthly meet to entail the activities that are being executed, discuss points of improvement and share any difficulties being faced. This committee is made of representatives from each partner institution.

4.6 Project Management Method of Choice

The STEP project aligns with the model of development in which the means to achieve its targets can be many, and not clearly nor mandatory defined. Due to the fact that its end results to be reached are known and that there is no exact or unique path to follow, the Hybrid methodology is most suitable in this case due to the fact that the mixed approach better suits the project, knowing that it does have an initial plan pre-aimed at the project's proposal but its further development and activities will be done in an Agile way [40], [41], [44], [45], [49].

Hence a series of small iterations, it will allow the project to be kept on track, reaching its objectives accordingly and keeping stakeholders involved and informed about which and how the activities are being made.

This will let the project be driven in a more appropriate way, maintaining simplicity yet effectiveness, putting it in an easy and flexible way to execute but also efficient at the same time.

Chapter 5

Results and Discussion

Following a thorough investigation across all of IPB's main administrative offices, the following figures were discovered.

5.1 Project Monitoring

5.1.1 Data Acquisition Path

Bearing in mind that the KPIs encompassed in this thesis are aligned with the original KPIs encountered within the STEP Project's set of goals, they are the final target to be achieved by the end of the 36 months period of duration. The targets for these KPIs can be seen in the Table 5.1 as follows:

Table 5.1: Targets of increase for the selected KPIs

STEP Project KPIs - Increase target by the end of 36 month	
KPI	**Target**
1- Indexed Peer-reviewed publications	>5 Indexed International Publications
2- New IPB Fellowship Researcher's Profile	>30 New Profiles
3- Short Term Mobilities Concluded	>60 Mobilities
4- Staff Exchanges Concluded	>15 Exchanges
5- Projects Started	-
6- Projects Ongoing	-
7- Projects Submitted	>5 submitted
8- Training Courses/Events	>6 Courses regarding STEP's thematic
9- Non-National HE Agreements	>5 New Agreements

Considering that this data is widely spread through all IPB's working cells, such as its different administrative offices and research centres (RCs), a strategy for getting this information was needed. Acquiring data that is within a sparse, multi-location scenario requires adequate care and tailored-appropriate analysis. This type of data acquisition can be misleading when more than one source refers to different values for the same KPI. This may occur for multiple reasons, such as a lack of updates in information, human error, or acquiring it in a non-standardized manner. Therefore, in order to minimize those types of inconvenience, a data acquisition standard framework was developed for the STEP Project.

The objective here, other than avoiding the errors previously mentioned, is to locate and create a practical way of acquisition for this data in order to make it possible to be assessed at any time by the Management Team.

Hence, the techniques of data collection must be maintained throughout the project in order to prevent mistakes, duplication, or inadequate data from being used in future comparisons. The techniques for gathering KPIs will be described below and will lay the groundwork for comparisons in the near future.

Based on the institutional level of the KPI and its accessibility, the data is provided in two formats, as indicated in Table 5.2 below. Each KPI may be acquired either locally, by a designated Contact Point (CP) inside each of IPB's Research Centres or globally, acquired by independent administration offices that were contacted to provide those numbers and any additional information.

Table 5.2: Data classification types.

Data Classification	
Data Type	**Description**
A	Data acquired by the sum of the three IPB's STEM-related Research Centers' numbers.
B	Data acquired by an administration office, globally.

Therefore, for means of simplification, some data were defined to be acquired by the summation of the numbers given by the three main Research Centers within IPB'S campus, namely CeDRI, CIMO and GICoS. Some other data were better suited to be acquired by the adequate office regarding the KPI's nature, an office that already deals with those KPIs, directly or indirectly, inside its working competence and responsibility.

This method of data acquisition came out to be a better fit for traceability throughout the project and can be equally reassessed whenever necessary, according to the project's needs. Hence, it will ensure monitoring and control of the project performance as a whole, allowing the team to always align future actions with the determined goals.

The detailed acquisition paths are shown in the Table 5.3 and Table 5.4:

Table 5.3: KPIs classification

KPI	Type	Description
1- Peer reviewed publications	A, B	Bothly acquired by the sum of the RCs and by the SCOPUS database, check details further below
2- New IPB Researcher's Profile	A	Summation of the 3 RCs, information acquired with the contact points
3- Short Term Mobilities Concluded	B	Obtained by (GRI) Office
4- Staff Exchanges Concluded	B	Obtained by (GRI) Office
5- Projects Started	B	Obtained by Projects Office and President
6- Projects Ongoing	B	Obtained by Projects Office and President
7- Projects Submitted	B	Obtained by Projects Office and President
8- Training Courses/Events	A	Summation of the 3 RCs, information acquired with the contact points.
9- Non-National HE Agreements	B	Obtained by (GRI) Office

Table 5.4: Data acquisition path details

Project Data Acquisition Details	
KPI	**Acquisition Path Description**
1	The indicator will be the data provided by the RC centres, crossed with the Scopus database. A specific way of searching procedure was carried out on the Scopus website to verify the numbers in regard to institutions' publications. It consists of filtering by affiliation (IPB), then by year time frame, and then by a set of subject areas that were assumed and defined as STEM as per the literature review.
2	The indicator will be the sum of the data acquired by the CP in each centre. Nonetheless, the numbers of each RC will be tracked by their internal administration.
3	The indicator is directly given by the GRI Office. All IPB campus were considered, not only the STEM-related, and all the programs of mobility. It represents the sum of outgoing and incoming exchanges in total.
4	The indicator is directly given by the GRI Office. All IPB's campuses were considered, not only the STEM-related, and all the programs of mobility. It represents the sum of outgoing and incoming exchangesin total.
5	The indicator will be the data provided by the Projects Office and the President.
6	The indicator will be the data provided by the Projects Office and the President.
7	The indicator will be the data provided by the Projects Office and the President.
8	The indicator will be the sum of the data acquired by the CP in each centre. Nonetheless, the numbers of each RC will be tracked by their internal administration.
9	The indicator will be the data provided by the GRI Office, regarding new agreements with other universities, non-renewal, from STEM fields only.

By those means, the following numbers were assessed regarding the end of the year 2022, which implies the starting point of the STEP Project. The results can be seen in the Table 5.5 as follows:

Table 5.5: KPIs numbers for the year 2022, starting point of the STEP Project

Year of 2022	
KPI	**Number**
1- Indexed Peer-reviewed publications	491
2- New Fellowship Researcher's Profile	120
3- Short Term Mobilities Concluded*	130
4- Staff Exchanges Concluded*	400
5- Projects Started	39
6- Projects Ongoing	170
7- Projects Submitted	-
8- Training Courses/Events	25
9- Non-National HE Agreements	26

Regarding the asterisk in items 3 and 4, it is important to mention that they are comprehended and measured by the academic year instead of the civil year, which is comprised from September 2021 to July 2022.

Regarding the number of Projects Submitted in the previous table, the number could not be obtained for the year 2022 because it was not recorded or considered by the IPB offices.

Besides this particular indicator, the other ones inside this group were indeed assessed and can be used to better understand the actual spectrum of IPB's STEM capabilities.

CeDRi (Research Centre of Digitalization and Robotics) has its subjects of research related to robotics, optimization, data science and data processing.

CIMO (Mountain Research Centre) has its subjects of research related to biochemistry, chemical characterization of agro-products and chemical analysis as a whole.

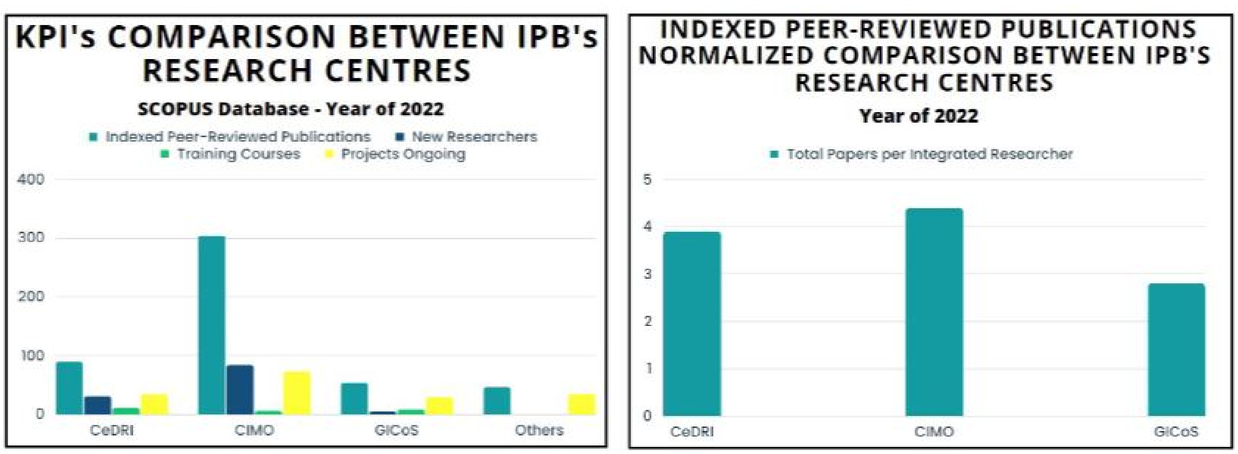
GICoS (Sustainable Construction Research Group) has its subjects of research related to the mechanical behaviours of materials in construction, aiming to develop sustainable and reliable solutions for the construction industry.

The dimension of the research centres can be comprised by the number of integrated PhD members, as seen in the following Table 5.6:

Table 5.6: Members in each research centre

Integrated PhD Members in IPB's Research Centres	
CeDRI	23
CIMO	69
GICoS*	19

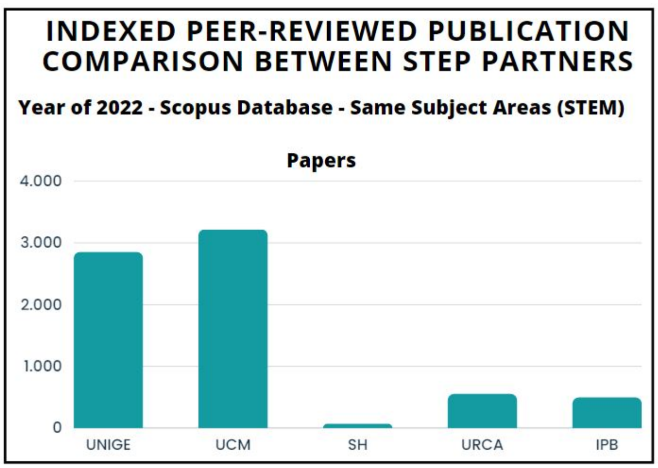
The asterisk in GICoS is due to the fact that GICoS is still a research centre in development and for this reason, its members can not be considered as integrated and shall be considered just regular members. Using these data, some comparisons were possible to be made as a way of broadly visualizing the actual context, as shown in the following graphs shown in Figure 5.1:



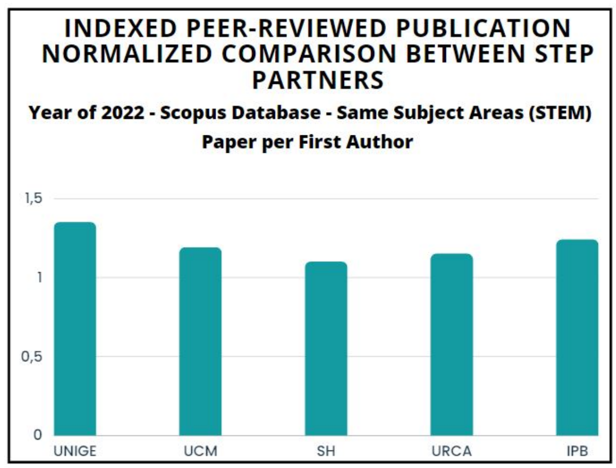
(a) (b)

Figure 5.1: (a) Total numbers of IPB's research centres. (b) Normalized comparison between IPB's research centres indexed peer-reviewed publications per integrated member.

Particularly regarding indexed peer-reviewed publications, it was also made possible to execute a comparison between the STEP partners over the number of publications achieved in the year 2022. It considers a search made into the SCOPUS database, for the year 2022, using the same set of subject areas (STEM-related) as filters. Foremost, for means of a deeper level of comprehension, the total number of publications was divided by the number of first authors of the respective institution. This number of authors was obtained by the function Export of the same previous research within the Scopus database, and removing the duplicates. These processes allowed to bring to sight the following graphs shown on Figure 5.2:



(a)



(b)

Figure 5.2: (a) Comparison between STEP Partners, STEM-related indexed peer-reviewed publications total number. (b) Normalized comparison between STEP Partners, STEM-related indexed peer-reviewed publications per first author.

The filtering for obtaining those values is as the following:

1. Locate the Affiliation of the respective institution
2. Filter for the specific year (2022 in this case)
3. Filter for the arbitrary-considered STEM-related subject areas

The subject areas selected can be seen in the following Table 5.7:

Table 5.7: Subject areas used in the filtering for acquiring the number of Indexed peer-reviewed publications in the Scopus database.

Subject Areas Used	
Engineering	Physics and Astronomy
Agricultural and Biological Sciences	Materials Science
Energy	Mathematics
Computer Science	Immunology and Microbiology
Chemistry	Earth and Planetary Sciences
Chemical Engineering	Decision Sciences
Biochemistry, Genetics and Molecular Biology	Environmental Sciences
Pharmacology, Toxicology and Pharmaceuticals	-

The previous Figure 5.2(b) shows that 3 out of the 4 partner institutions have a higher total production of scientific papers than IPB when it comes to the amount of indexed peer-reviewed publications in the Scopus database. This does not imply a better performance indicator for indexed peer-reviewed indicators however, it indeed shows that within the partner's group, there are different institutions, with different dimensions than IPB.

Nonetheless, when it comes to the normalized number of papers per first author, it demonstrates the positive scientific potential of IPB, which is the second better-performing partner in the group in this specific metric.

This confirms that the project's consortium as a whole has the necessary competence to succeed due to its institutions' size, experience, and influence, showing a promising path ahead for the STEP Project to succeed as a twinning programme.

With those comparisons made with regard to the initial point, the first project performance evaluation took place. Five months after the initial status assessment and also from the STEP project's commencement, a new assessment was carried out to monitor and control the ongoing situation and the project's health as a whole. The data were acquired by the exact same means as the first assessment and as previously described. Hence, the numbers found are shown in the Table 5.8 as follows:

Table 5.8: KPIs numbers for the period of 5/36 months, 2023.

Year 2023 - May (5/36 months)	
KPI	**Number**
1- Indexed Peer-reviewed Publications	211
2- New Fellowship Researcher's Profile	41
3- Short Term Mobilities Concluded*	318
4- Staff Exchanges Concluded*	360
5- Projects Started	10
6- Projects Ongoing	126
7- Projects Submitted	42
8- Training Courses/Events	18
9- Non-National HE Agreements	23

Some explanation needs to be addressed regarding the uptake of the numbers of Short Terms Mobilities Concluded and Staff Exchanges Concluded. As previously said those KPIs are measured by the academic year, and another fact to justify such a number increase is that in Short Term Mobilities Concluded, for the last measurement, only 1 semester existed as an initial phase for this particular protocol, being 2 semesters included in the actual period. Further explaining, for the first assessment, the time period comprised the academic year of September 2021 to July 2022. This second assessment comprised the period of September 2022 until May 2023 due to the date of submission of this thesis report.

Indicators other than those two can be normally compared.

It is possible to see some impacts of the STEP Project's endeavours in the majority of the indicators. Training Courses and Events are one of the most directly-positive increases by the projects' actions.

5.1.2 Decision-Making by Risk Assessment

In order to ensure the correct status of the STEP Project's course, which aims to increase IPB's KPIs throughout its duration, a framework was developed to monitor and provide countermeasures for deployment in case of an under-desired performance, setting a risk mitigation mechanism towards this non-satisfactory outcome that may occur on regard of one or more indicators. This Framework was inspired by works acknowledged by the Project Management Institute [88], [89]. Hence, a simplified method was designed for the project in question, which consists of measuring a percentage of how off-target a KPI is and the actions that should be taken to address the problem. It is described as follows:

$$T_s = \frac{T_g}{6} \tag{5.1}$$

$$R_s = 1 - \frac{S}{T_s} \tag{5.2}$$

Where:

T_s = Semester Target for the particular KPI
T_g = Global Target for the end of the project
R_s = Risk Score
S = Value acquired by the data acquisition path

Considering that S signifies the value acquired by the data acquisition path for a given KPI, the result is a percentage that can be either satisfactory or not, according to the amount achieved. If the KPI matches or surpasses the expected value for the semester, a Risk Score of zero is assigned. If it does not, it shall be included in one of the rankings within the framework for proper treatment and the executions of the accordingly countermeasures, depending on how much off-target it is.

Hence, the classification description can be seen in Table 5.9 as follows:

Table 5.9: Action plan regarding each rank.

Risk Assessment Framework - Ranking Action Plan		
Risk Score	**Ranking**	**Action Plan**
0%	No Risk	n/a
1-25%	Low Risk	Notify the internal team about it in the next monthly meeting.
26-50%	Medium Risk	Dedicate a moment of the monthly external meeting to brainstorm solutions.
>50%	High Risk	Convocate an extraordinary meeting with all the Partners within the Consortium for the execution of actions to tackle the particular KPI with higher effort and include the KPI in a monthly follow-up regime, where it will be monthly checked by the whole team.

Therefore, this ranking system intends to classify the actual KPI status and insert it into a priority action package bounded to improve performance and put it back into the desired levels. Each ranking status demands a certain amount of extra commitment from the team, depending on the size of the risk detected in the semester assessment in question.

With the ranks' definition in mind, the following workflow cycle, shown in Figure 5.3, can be considered:

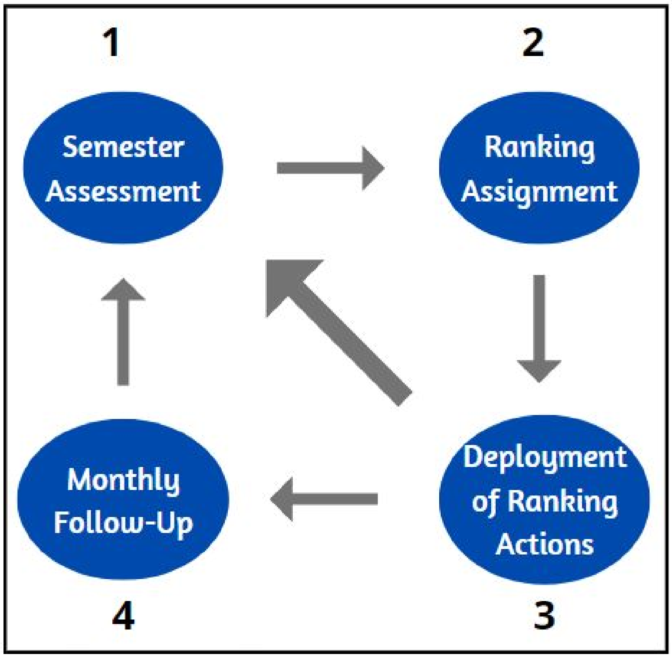


Figure 5.3: Risk assessment workflow cycle

Therefore, ranks other than High Risk consist of a pathway described as 1-2-3-1, as they do not require the inclusion of monthly follow-up assessments. For High Risk so, the workflow cycle should take the longer route, and its pathway is described as 1-2-3-4-1, as it indeed would require the inclusion of the particular KPI into a monthly follow-up regime.

In order to ensure that the STEP Project ends with all its objectives accomplished, all KPIs other than the ones that have achieved the target, regardless of their rank, should be included in a monthly follow-up regime in the last semester. This shall certify that no KPI go unattained by the end of the project.

Hence, it is possible to assign the ranks for the results obtained by Table 5.4 according to this ranking system. The target for the period has been calculated by taking the value assessed in 2022, dividing it by twelve months and multiplying it by five months (January to May 2023), then adding the proportional target for the 5 months period. The result of the comparison of target vs status is as follows:

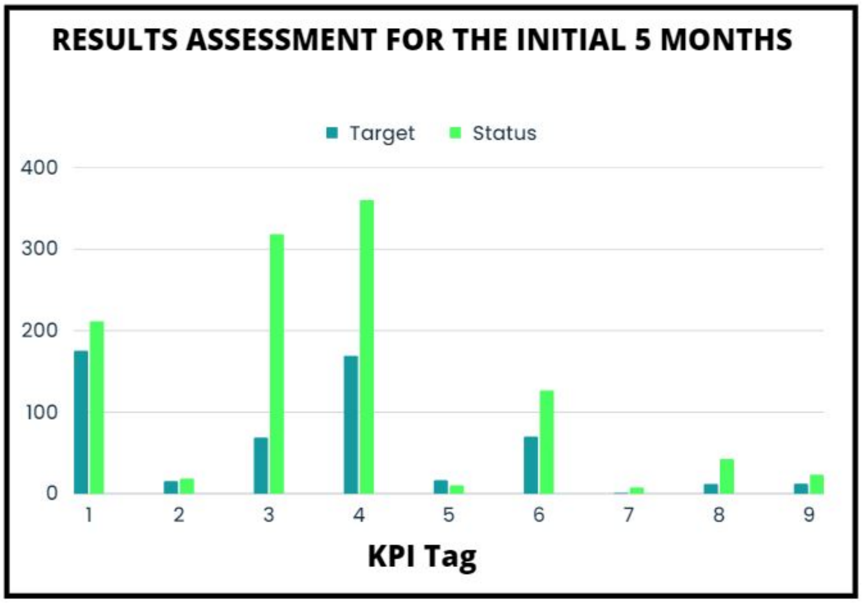


Figure 5.4: Target vs status evaluation.

All KPIs that have been achieved or surpassed are not required to be included in the risk assessment. Considering the status calculation description above, and that the number of projects does not have a defined number increase by the project's documentation, its proportional target for the period shall be at least the same number as for the same period in the previous year. Hence, it is running within planned expectations. Even though this particular KPI is not comprised in the original project description, a risk ranking can be assigned for it. Considering no increase target was set for this KPI, the theoretical target can be assumed as the same of the previous year for exemplification purposes. The 5 months fraction (16) of the whole year value (39), shall be compared with the value measured for the actual analysis (10). Hence, the value of S is 16, and the value for Ts is 10, obtaining a percentage of around 37%. Therefore, as seen in the previous table, the KPI Projects Started shall be included in the plan of action relative to the Medium Risk category.

5.1.3 Deliverables Handling

Besides general periodic record presentations, such as timesheets and reports, there are the project deliverables which are a set of specific documents that are mandatory to be posted into the Funding and Tenders portal according to priorly defined deadlines.

Those deliverables are part of the project's compulsory duty and their posting schedule needs to be rigorously followed, otherwise, it will cause negative evaluation from the stakeholders which includes, most importantly, the funding provider. Hence, a workflow has been developed to avoid misalignments and noise through the making of each of those deliverables, as well as attaining the entire team's opinions/feedback, ensuring that everybody is being included in the process, contributing with their expertise, and rowing to the same direction. It can be seen in the following Figure 5.5:

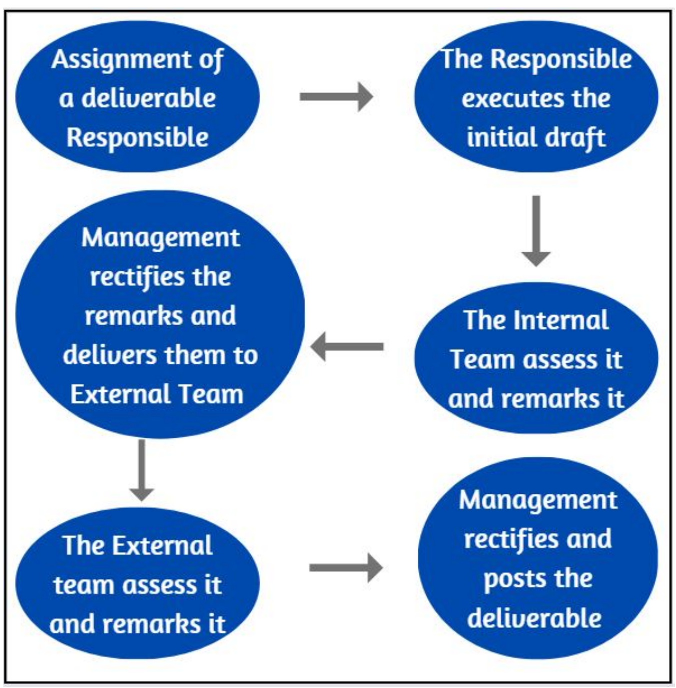


Figure 5.5: Deliverable processing workflow.

By this workflow method, project discordance can be cut out more easily, as every person gets to see and check the key points within the deliverables according to their expertise, providing a better alignment with the guidelines of the project and mitigating risk along the process.

5.2 Conference Ranking Awareness

Conference attendance and participation are a great part of the academic life. Via this kind of meetings, research jobs are published and gain visibility by being posted into recognised indexed databases, where they become available to the whole scientific community, either through the purchase of the paper or by its inclusion on open databases. But one important factor, often neglected, is the amount of credibility and the ranking that a particular conference has when in the process of submitting a piece of work for approval. This directly affects the impacts and the outreach of a research institution, being a significant path for attracting opportunities for further investments or funding to continue the work being done or to bring resources and partners to enable the commencement of new works. Also, submitting work and attending low-tier conferences may not compensate for their respective costs, such as the article/paper processing fees, transportation and accommodation costs. Perhaps, this cost can be spent on more prominent, higher-tier conferences, which will bring more visibility and renown to the institution's scientific board.

A survey was internally carried out into CeDRI (Research Centre in Digitalization and Intelligent Robotics) to better assess the understanding and awareness of its principal integrated researchers towards this subject. The survey consisted in asking the CeDRI researchers for providing conference names that they would classify as top-notch in their field of expertise and that they were considering attending or already attended recently. The following conferences were obtained by their response are comprised in the following list:

1. Advances in Information and Communication Technology

2. Annual Conference of the IEEE Industrial Electronics Society

3. Annual Conference of the International Speech Communication Association
4. CEUR Workshop Proceedings
5. Conference on Optimization
6. European Conference on e-Learning
7. European Conference on Innovation and Entrepreneurship
8. Flexible Automation and Intelligent Manufacturing International Conference
9. Iberian Conference on Information Systems and Technologies
10. Iberian Robotics
11. Iberoamerican Congress of Smart Cities
12. Workshop on Intelligent Manufacturing Systems
13. International Joint Conference On Biomedical, Engineering System and Technologies
14. International Computer Programming Education Conference
15. International Conference on Acoustics Speech and Signal Processing
16. International Conference on Autonomous Agents and Multiagent Systems
17. International Conference on Autonomous Robot Systems and Competitions
18. International Conference on Bio-Inspired Systems and Signal Processing
19. International Conference on Biomedical Electronics and Devices
20. International Conference on Climbing and Walking Robots and the Support Technologies for Mobile Ma-chines
21. International Conference on Computational Science and Its Applications

22. International Conference on Computer Science and Application Engineering
23. International Conference on Emerging Technologies and Factory Automation
24. International Conference on Health and Social Care Information Systems and Technologies
25. International Conference on Industrial Cyber-Physical Systems
26. International Conference on Industrial Engineering and Engineering Management
27. International Conference on Industrial Informatics
28. International Conference on Industrial Technology
29. International Conference on Operations Research and Enterprise Systems
30. International Conference on Optimization, Learning Algorithms and Applications
31. International Conference on Practical Applications of Agents and Multi-Agent Systems
32. International Conference on Robotics and Automation
33. International Conference on Simulation and Modeling Methodologies, Technologies and Applications
34. International Conference on the Design of Reliable Communication Networks
35. International Conference on Tourism Research
36. International Smart Cities Conference
37. International Symposium on Computers in Education
38. International Symposium on Industrial Electronics
39. International Workshop on Service Oriented, Holonic and Multi-Agent Manufacturing Systems for Industry of the Future
40. Learning and Intelligent Optimization Conference

41. Mediterranean Conference on Control and Automation

42. Optimization, Learning Algorithms and Applications

43. Symposium on Computer-Based Medical Systems

44. Tecnological Ecosystems for Enhancing Multiculturality

45. The International Conference of Numerical Analysis and Applied Mathematics

Therefore, utilizing Google, a search was made to find conference rankings online that could be used to assess the conferences given by CeDRI's researchers. Then, three online ranking websites were found, being they shown in the following Table 5.10:

Table 5.10: Conference ranking websites used.

Conference ranking websites	
Name	**Address**
Conference Rankings	http://www.conferenceranks.com/
CORE Conference Portal	http://portal.core.edu.au/conf-ranks/
Resurchify	https://www.resurchify.com/conference-ranking

With the name of the conferences and these websites, an analysis was made regarding their ranking of impact in the field. The result of this classification is shown in the graph Figure 5.6 as follows:

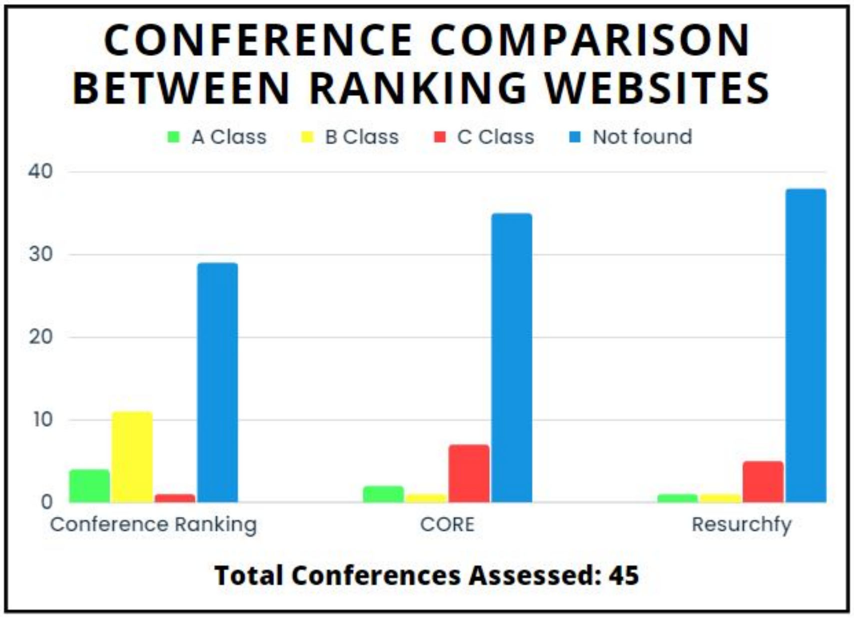


Figure 5.6: Website ranking assessment comparison.

Those websites were found to not consider many of the conferences included in the survey. The ranking classification of those initial websites had an average of 75% per cent of the conferences classified as "not found", with very few being considered top-notch conferences, and the rest being considered below the "A" class classification.

With this result in mind, another source of evaluation was sought to better equip this sorting method on which conference to seek participation. Hence, Scopus came out to be another option and a good fit through its conference classification indexes. The classification indexes namely are SNIP, CiteScore, SJR and H-Index.

The Table 5.11 below briefly describes the functioning of the respective indexes:

After the consideration of the Indexes cited above, some researchers were re-asked about why they were attending conferences that do not have relevant classifications or were not classified as the top tier of the classification ranks. Their answer was all in a similar sense, implying that they would go to conferences that they have always usually gone to, or that some of those medium or low-academic-tier conferences are good to promote networking

Table 5.11: Indexes description details

Indexes description details	
Index	**Description**
SNIP	Computed by dividing the number of citations given in the current year by articles published in the previous three years by the total number of publications published in the previous three years. A conference/journal with a SNIP of 1.0 has the median (rather than mean) amount of citations in that discipline [90]
SJR	Ranking made by quartiles across topic areas using the Scopus database and journal categorization scheme. SJR computation is an iterative procedure that distributes reputation ratings among conferences/journals until a stable solution is obtained, comparable to Google PageRankTM approach. The typical SJR value for all Scopus journals is 1.000 [90]
CiteScore	CiteScore is a Scopus statistic for determining conferences and journals impact. CiteScore for the current year is calculated by dividing the number of citations obtained by a journal in that year for documents published in the journal in the previous three years by the number of papers indexed in Scopus published in the three preceding years [91]
H-Index	A tool for assessing the cumulative influence of an author's academic work and performance; it compares publications to citations to determine quantity and quality. The H-index accounts for the excessive weight of articles with lots of citations as well as works that are yet to be mentioned [92]

and cultivating important connections.

This highlights the lack of awareness by the researchers about those excellence indicators and shows room for improvement, allowing higher and more profound impacts to be made if these rankings are taken into consideration. This allies with the possibility of increasing the prestige and outreach of their publications, bringing visibility to their job and attracting better opportunities for collaboration and further development.

Including these classification tools should be considered a good practice when it comes to which conference to apply to, and it shall be assumed as a way of increasing the STEM capabilities of the institution.

With that objective, a simple assessment path was created to aid this process of conference selection, which can be seen in the Figure 5.7 below:

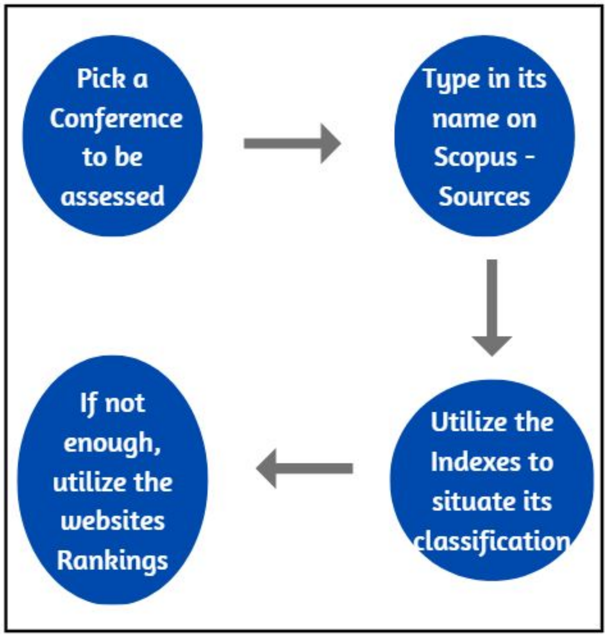


Figure 5.7: Conference assessment steps

For a better understanding, an instructional video was developed to be available at any time with a quick explanation of how to execute an assessment alike. The video can be accessed on the STEP project Youtube Channel through the link:
https://www.youtube.com/@STEPProjectIPB

5.3 Strategies and Action Plan

In order to kick-start the project, some activities were developed to initially crank the pace towards the project's goals in this first semester. Those activities will be described below and will be included in a set of actions for engaging in the efforts for driving excellence and enhancing the development of the IPB, as well as defining good practices that have been acquired by lessons learned throughout the course of this work and that can and shall be considered for similar twinning projects.

5.3.1 STEP Talks

The STEP Talks initiative is a group of lecture-type events that has the main objective of tackling strategic subjects within the project's needs. It is a way to call attention to a specific topic, to teach and highlight important fields that will directly affect the scientific excellence indicators and KPIs of the IPB as a whole. Therefore, the STEP Talks is a tool for creating, improving and polishing knowledge in the themes of the project. It is a form to bring specialists and key stakeholders to share their knowledge, know-how and points of view on strategic matters, according to STEP's objectives.

The first STEP Talk (STEP Talk 1) was conceived to call attention to the important nuances regarding the scientific databases and their practical way of functioning, which included the external Scopus and Web of Science databases, and the internal IPB's digital library. It also encompassed the necessity identified by the results of the Conference Ranking Awareness Assessment and the need to disseminate the knowledge and awareness of those rankings, the detailing of the conference ranking indicators, how they are calculated and how they should be considered.

The strategy behind this STEP Talk 1 was to equip IPB researchers with the necessary knowledge regarding those databases and therefore, increase the capability of IPB to generate visibility for its academic works. More precise information typing and specific ways for uploading scientific papers into these well-known databases, with small yet important points, were described.

Another important indicator of academic excellence also encompassed within the project's KPIs is the number of STEM projects that the institution is currently involved with. For increasing this particular number as well as the number of connections with other STEM players, nationally and internationally, STEP Talk 2 was conceived. It consisted in inviting the Portuguese National Innovation Agency (ANI) representatives to lecture about funding opportunities and programmes that could be a good fit according to IPB's and surrounding enterprises' technical capabilities.

The strategy behind this lecture is to bring to sight those opportunities as well as put within the same room companies, researchers, professors and students for discussion and networking. STEP Talk 2 addressed a multitude of opportunities and a pretty diverse range of possibilities tailored to the STEM fields of work that are within IPB capabilities. It also allowed the audience to connect and to get to know the actual best funding-related channels of information available.

The third STEP Talk is set to bring the IPB's Equality, Diversity and Inclusion Commission to encompass some relevant discussions to foster these increments allied with the development of the STEM fields.

Hence, the STEP Talks stay as a tool and a good practice model for tackling the desired topics and bringing awareness to them.

5.3.2 STEP Workshops

Similar to the STEP Talks, the STEP Workshops have the objective to create opportunities for the targeted audiences to get hands-on with a specific subject or task. They also follow the guidance of identified necessities and are organized to develop capabilities within the project's scope. In these events, viewers are incentivised to bring their laptops and execute the instructions together with the lecturer.

Two STEP Workshops were organized, the first was about the nuances of uploading scientific articles into IPB's internal library and the second was about the LaTeX application and its useful features for scientific writing. Further workshops will be developed throughout the project's duration according to the need in question.

5.3.3 Twinning Projects Benchmark

Benchmarking is a good practice when it comes to executing something for the first time. Through so, utilizing the European Commission website through the Funding and Tenders Portal, other Twinning-awarded institutions were located and contacted, and relevant information was acquired through a bilateral meeting to acknowledge the key challenges they faced during their project's duration. The institution that replied was the INESC-ID, the coordinator of the OLISSIPO twinning project, where it was obtained the following recommendations:

- Focus on effective project dissemination, as well as keeping a record of it to present to the funding provider.
- Use all media channels as catalysts for this dissemination, such as YouTube channels, Facebook, LinkedIn and similar social media.
- Always keep meetings, events and similar well documented and registered for further proof of work and example of organization.

Other meetings with other institutions are also being contacted for applying the same concept of consultation.

5.3.4 Mentoring Programmes

Mentoring and extra-curricular development are two tools that can be used to catalyze the results of any given individual walking towards an objective. Bearing this in mind, it has been identified as a good opportunity for the development and enhancement of the students, professors and researchers to enrol in a mentoring programme ministered by the International Mentoring Foundation For The Advancement Of Higher Education (IMFAHE), where worldwide executives from recognized companies mentor students from its partner universities and assist them in advancing their career goals.

IMFAHE is a renowned non-profit institution, recognized by the European Commission and mentioned in the Nature Biotechnology Journal [93], which is expected to serve as a booster for IPB's scientific capabilities of its researchers as a whole.

Connecting the IPB through a network of great international companies and universities will help promote its internationalization, bringing innovation and entrepreneurship closer to the students and researchers on a global spectrum. It also includes course modules about career development and scientific careers open to the students to enrol. Training programs are designed for professors too, which include peer mentoring groups that help to foster networking and collaboration between institutions.

Some worldwide-recognized organizations are encompassed within this programme's network, such as Google, Harvard University, Massachusetts Institute of Technology (MIT), Johns Hopkins University, Bank of America, Amazon Robotics and more, which highlights the relevance of inserting this type of mentoring as an action from the STEP Project for better outcomes.

5.3.5 EDI Promotion Activities

One of the project's targets is to enhance EDI (Equality, Diversity and Inclusion) within its campus. Towards this goal, few actions have taken place. Bilateral meetings with the partners to develop approaches for exploiting this topic, counselling with the advisory board and a STEP Talk directed at this subject have been organized. Those activities aim to ensure the increase of awareness for the EDI context and to familiarize the team with existing guidelines and good practices in this field. It also got the IPB's EDI commission involved and in a position to provide advice on this matter.

5.4 Dissemination and Exploitation Methodologies

5.4.1 Event Organization

An important part of the STEP project is to bring visibility to and disseminate IPB's STEM capabilities, making it open to further development and enhancements through collaboration with other institutions or organizations. Therefore, in regard to an event organization, proper announcement and dissemination should be done with attention to detail, aiming to spread the occurrence to the right target audience and to the maximum range possible. Hence, through a series of iterations and lessons learned from previous mistakes, an event organization checklist was developed to ensure a minimum satisfactory quality standard when organizing a general event. The checklist can be seen in the Figure 5.8 as follows:

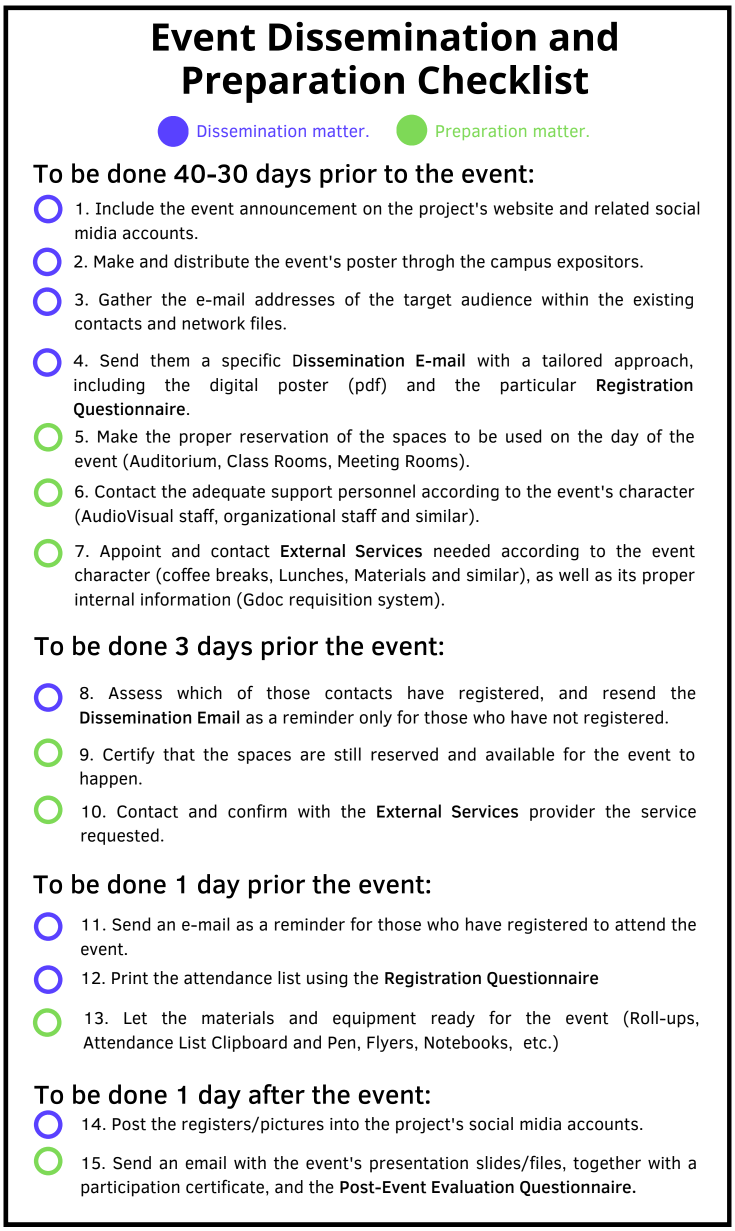


Figure 5.8: Event dissemination and preparation checklist.

The Registration Questionnaire cited in Item 4 and the Post-Event Evaluation Questionnaire, cited in Item 14 are both attached as annexes of this thesis.

The short and straightforward character of both questionnaires is crucial for their attainment by the public since this makes them more likely to be answered by the majority of those who will attend.

Further than event posters on Topic 2, roll-ups, folders and websites were produced and are available in a collaborative folder to be used by the entire project's team, making the dissemination of any event more effective.

5.4.2 Dissemination Awareness

Another concept that has been shown to be effective is the constant reminder of the need for project dissemination throughout normal routine events. This has been addressed in monthly meetings as a focal point for improvement, making regular activities noted and involved within the project's scope. At this point, there has been a total of thirty-seven (37) events disseminated by the project's website, together with thirty-six (36) opportunities for project calls and recruitment (fellowships and work positions) disseminated.

5.4.3 Events Documentation Record

Through the development of the STEP's website, the opportunity for keeping a record of the events and activities promoted within the scope of the project was identified. Therefore, this database keeps the disseminated events saved and registered, making it easier to access the number of events that were propagated by the STEP project and also to pinpoint eventual spots that can be improved. This helps when in need to provide accountability reports for the funding provider whenever necessary, being also considered a good practice to be made. All attendance lists, questionnaires and similar shall be kept in record for future assessments, reporting or similar.

At this point, the project's YouTube channel counts with a summation of thirty (30) views divided among four videos in the channel. This can be attributed due to the initial stage of the project and more outreach should be made through the events to increase the number of views.

Chapter 6

Conclusions and Future Work

In conclusion, this master thesis exemplifies actions, strategies, and to-avoid mistakes for a successful project such as the STEP, highlighting the significance of implementing effective practices that have been pushing it towards success. By those strategies and capitalizing on the collective expertise of the team, the project has surpassed initial obstacles, ultimately attaining its objectives within the designated timeframe.

Throughout the course of this research, a group of commendable practices have come to sight, deserving recognition. Foremost, the establishment of clear project goals and objectives has served as a compass, guiding focused efforts and providing a chart for accomplishment. The way of communication and collaboration among team members have fostered harmonious productivity, facilitating coordination and the dissemination of knowledge. Moreover, the adoption of agile project management methodologies has unveiled the power of adaptability in the face of challenging requirements, enabling assertive decision-making and resource allocation.

Furthermore, cultivating a culture of continuous improvement for team members will raise IPB's skills and expertise, enabling it to navigate through complexities with increased dexterity. Additionally, paying attention to stakeholders will provide new perspectives, facilitating the refinement of project processes and the journey of improvement.

Summarizing the works done, a data acquisition path for monitoring and control was settled, a risk management framework was developed, three STEP Talks and two workshops were conceived and executed according to the needs identified by the project, the project management working structure was set and an event organization checklist was developed based on the outcomes of these first events.

It is essential to acknowledge that, amidst the success, errors were made along the trajectory. These missteps, however, serve as invaluable lessons, guiding the way towards enlightenment. For example, inadequate time estimations or lack of detail attainment have resulted in unforeseen problems during certain phases. Similarly, inexperience may have hidden opportunities to incorporate good insights and feedback. Embracing these mistakes will serve as a catalyst for enhancements, paving the way for future and better endeavours. In conclusion, the successful kick-start of this project stands as a testament to the potency of implementing effective practices for STEM project management into the STEP Project, while also acknowledging the room for improvement and the bright nature of learning from past errors.

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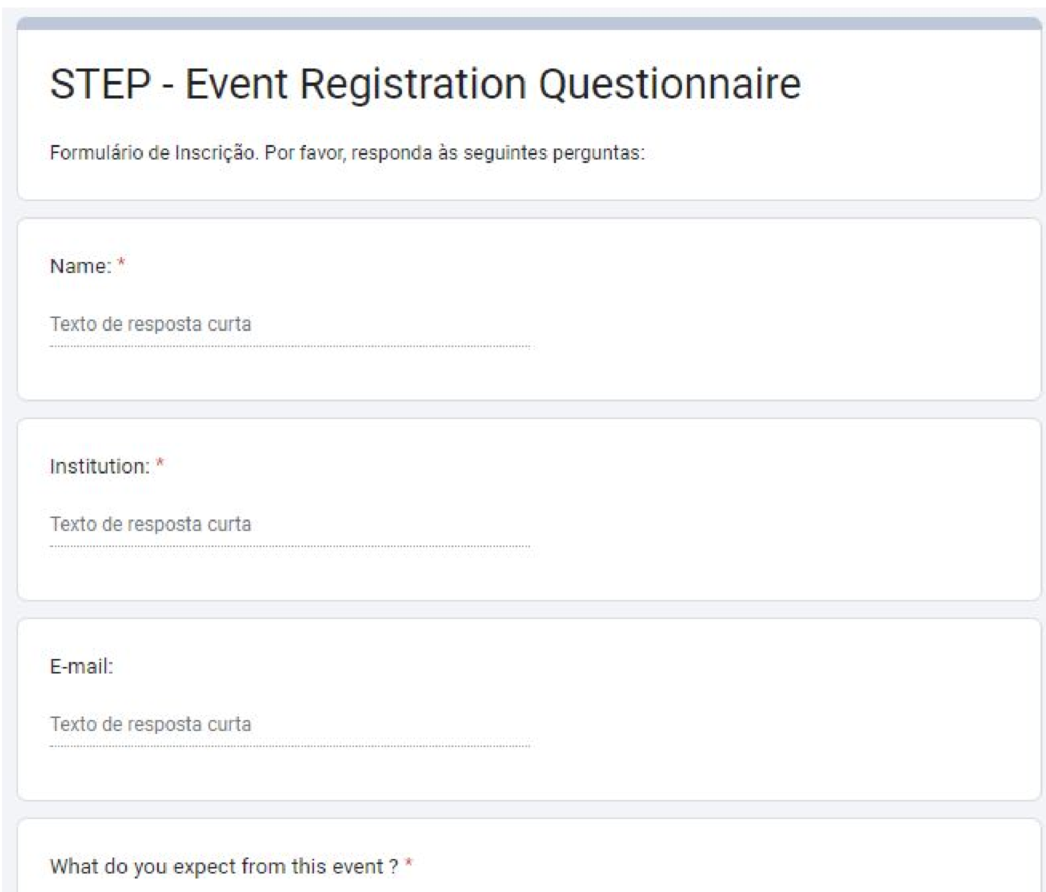
Appendix A

Annexes



STEP - Event Registration Questionnaire

Formulário de Inscrição. Por favor, responda às seguintes perguntas:

Name: *

Texto de resposta curta

Institution: *

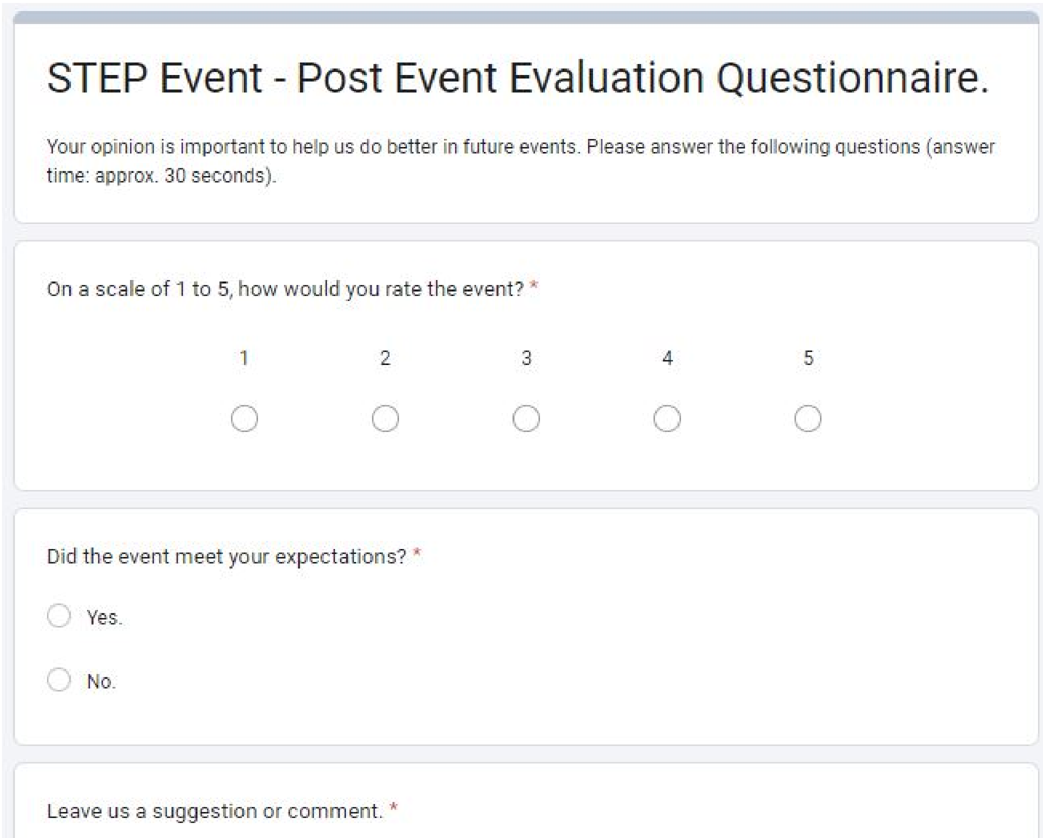
Texto de resposta curta

E-mail:

Texto de resposta curta

What do you expect from this event ? *

Figure A.1: Event registration questionnaire.



STEP Event - Post Event Evaluation Questionnaire.

Your opinion is important to help us do better in future events. Please answer the following questions (answer time: approx. 30 seconds).

On a scale of 1 to 5, how would you rate the event? *

1 2 3 4 5

Did the event meet your expectations? *

- Yes.
- No.

Leave us a suggestion or comment. *

Figure A.2: Post event evaluation questionnaire.