Proposition of a Method for Project Management in Industry 4.0

Thais Albertos[1][0000-0002-0192-5887] and Pedro Ribeiro[2][0000-0003-3538-9282]

[1] Department of Production and Systems, School of Engineering, University of Minho, Guimarães, Portugal
[2] Department of Information Systems, Algoritmi Research Center, School of Engineering, University of Minho, Guimarães, Portugal

Abstract. The Fourth Industrial Revolution – Industry 4.0 – brings new concepts to the daily lives of the companies, allowing the emergence of new business models. Industry 4.0 impacts not only the production line, but all areas of the organizations, forcing them to seek new methods that help the project management process. To improve the project management process, those new methods need to bring more agility with sustainable actions and with more assertive data-driven decision making. Therefore, the changes that Industry 4.0 brings stimulate the search for new factors that influence the success of projects. This paper presents a review and analysis of the project management literature from the perspective of Industry 4.0. Articles were listed in the scientific databases considering the critical success factors of projects in Industry 4.0. Based on the critical analysis of the literature, a proposal for a method for project management in Industry 4.0 was made.

Keywords: Project Management, Industry 4.0, Method.

1 Introduction

Industry 4.0 symbolizes the Fourth Industrial Revolution that comes to meet the demand arising from constant changes in society due to technological advances. Such advances change patterns of consumption, production, services and business models. Therefore, it is necessary for organizations to adapt their processes in order to survive in this environment, which is increasingly competitive. With this, the role of project management has become essential to support this process of change, being a crucial factor for organizations to be able to transition to this new industrial paradigm [1][2][3].

This concept – Industry 4.0 or I4.0 – first appears in Germany, in 2011, in Hannover, as a strategic initiative that aims to create intelligent factories in which manufacturing technologies are updated and transformed by cyber-physical systems (CPS), Internet of Things (IoT) and cloud computing. Since then, this initiative has introduced a new revolution in the way factories operate. [4][5].

The speed, range and impact that Industry 4.0 brings, with the new technological age, will fundamentally transform production value chains and business models, making decision-making more decentralized, and processes more efficient, autonomous and

customizable. This means a new period in the industrial context, transforming different sectors of the market. However, these changes do not only occur in the industry, other segments also needed to adapt to this new era, as is the case of project management, with this in mind, it is important that organizations carry out better project management practices [6]

As a new concept, Industry 4.0 has deficiencies in terms of information, standards, and concept. What makes it necessary for good guidance as well as use and management guidelines [7]. Schwab [6] points out that new technologies will drastically change the nature of work in all sectors and occupations. Therefore, by its nature, it requires an adaptation of the form of management and the development of a whole new set of methods to manage projects in Industry 4.0.

Hence, the research problem of this paper is based on the elaboration of a proposal for a project management method in Industry 4.0. To this end, the Critical Success Factors are used to assist in the development of the method, as they represent the essential agents for the success of a program or technique [8] and are responsible for characterizing the actions and processes necessary for the company's objectives to be achieved [9].

2 Literature Review

2.1 Industry 4.0

The industry has gone through countless transformations until reaching Industry 4.0 or I4.0, known as the Fourth Industrial Revolution. The First Industrial Revolution, in the 18th century, provoked the construction of railways, the invention of steam engines, and the beginning of the appearance of the first factories, making the industry reach a new level with mechanical production. The Second Industrial Revolution began at the end of the 19th century and entered the 20th century with the emergence of electricity and the assembly line, making mass production possible. The Third Industrial Revolution began in the 1960s, also known as the digital or computer revolution, as it was driven by the development of semiconductors, mainframe computing, personal computing, and the internet. The Fourth Industrial Revolution, known as Industry 4.0, then appears for the first time in Germany, in 2011, at the Hannover Fair, which brings to discussion how new technologies will revolutionize the organization of global value chains [6].

The Fourth Industrial Revolution is just beginning to take shape. Therefore, it will take some time for a full appreciation of the main patterns to emerge. Despite this revolution, emerging technologies and pervasive innovations are diffused much faster, and more widely than in previous revolutions and determining an adequate definition will be elusive for some time [10].

The I4.0 initiative enables industries to have key characteristics that enhance their success, namely: meeting the customer's individual requirements; Flexibility; Opti-

mized decision making; Productivity and resource efficiency; Creation of value opportunities through new services; Respond to demographic changes in the workplace; Professional versus personal balance; A high-wage economy that is still competitive [5].

According to the Boston Consulting Group [11], Industry 4.0 affects all manufacturing domains and comprises advanced manufacturing technologies that capture, optimize, and deploy data. Simply, Industry 4.0 makes factories “smart”. Technologies like the Internet of Things, artificial intelligence, and cyber-physical systems interact seamlessly, communicating with each other, and continually adjusting. Companies that fully understand and capture the value of these advantages will be better positioned to meet the challenges ahead.

Also, according to the Boston Consulting Group [11], Industry 4.0 is supported by nine pillars: autonomous robots; Internet of Things; Simulation; Augmented Reality; Cybersecurity; Systems integration; Cloud computing; Additive manufacturing; Big data, and data analytics.

2.2 Project Management

Project management has existed since the beginning of civilization; however, it was only around the 20th century that the need to better monitor and analyze projects emerged, a need that has been growing in recent years. One of the first scholars to take a project management perspective was Frederick Winslow Taylor, who notes that the work could be improved if its parts were studied in isolation. Also, at this time, Henry Laurence Gantt gave rise to the famous task and goal chart, the Gantt Chart, which was applied in the military area during the First World War. The great contribution of this graphic to the art of decision was to relate facts with time. The concepts brought by Taylor and Gantt were essential for the characterization and conceptualization of project management [12]

Before understanding the concept of project management, it is necessary to understand what a project is, and for that, there are several definitions present in the literature. According to PMI [13], a project is a temporary effort undertaken to create a unique product, service, or result. It is temporary because it has a beginning and an end defined in time, and therefore a predetermined scope and resources. And it is unique in the sense that they are mainly characterized by having no routine, but a specific set of operations designed to fulfill a single objective. ISO 10006 [14] defines a project as "a single process, consisting of a group of coordinated and controlled activities with start and end dates, undertaken to achieve an objective according to specific requirements, including time limitations, cost, and resources” [14].

Projects must be managed with the objective of delivering the expected results within the stipulated time, within the intended budget, with the learning and integration that companies need. Project management, therefore, is the application of knowledge, skills, tools, and techniques to project activities to meet project requirements. At first, this management was done informally, but, over the years, it became a profession, and guides were created to provide foundation and support [13]. ISO 10006 [14] claims that “project management includes planning, organizing, monitoring, and controlling all aspects of the project in an ongoing process to achieve its goals”.

For Meredith & Mantel [15], project management provides companies with the support of powerful tools, the ability to plan, implement and control their activities, as well as the best ways to use people and resources. Thus, project management has stood out because of characteristics that contemporary society has demanded in the development of new management methods. Three parameters involve this growth: the exponential expansion of human knowledge; the growing demand for a wide range of complex, sophisticated, and customized products and services; and, finally, the evolution of world competitiveness.

Also, according to Meredith & Mantel [15] the entire project has three direct objectives: scope, time, and cost. Better known as "Triple Constraint". And there is still a fourth dimension, which is customer expectations.

According to Carvalho & Rabechini Jr. [16] companies have gone through a constant process of transformation, in such a way that they need to organize themselves to provide ever more agile and efficient responses to the problems that arise in this process. These responses comprise a set of actions or activities that reflect the competence to seize opportunities and the ability to act quickly, respecting time, cost, and scope limitations. Therefore, companies are increasingly investing in the adoption of project management techniques and tools to accompany this constant process of transformation.

To support project management, agile methods emerge, which were strongly influenced by the Lean philosophy, which seeks to eliminate waste, which includes unnecessary work, both concerning documentation and about doubtful functionalities. The Manifesto for Agile Software Development or Agile Manifesto can be considered the apogee of agile methods, on which it brings a series of principles on which agile methods that were developed from 2001 to 2010 are based. These principles call for teams to be self-organized with face-to-face interaction with the customer and must make available software that can be used in small intervals of time, always with a focus on adding value to the business [17].

The agile methodology claims that customer satisfaction can be achieved through continuous delivery of valuable software and constant communication with both the customer and team members. As opposed to previous practices, the agile methodology is not limited by the full definition of the entire project, or by a complete analysis or by the definition of all requirements, but rather by a dynamic interaction, which allows a constant delivery [17].

In the search for greater efficiency and effectiveness in conducting project management, the offer of models proposed by academics and professional associations has increased. Among these models, the following stand out: the Project Management Body of Knowledge – PMBOK guide proposed by the Project Management Institute [13]; the IPMA Project Excellence Baseline – PEB guide by the International Project Management Association [18] and the Project Management Methodology – PM² guide proposed by the European Commission [19]. According to Rabechini JR. & Carvalho [16], professionals who train and are certified in these normative models tend to practice in their entirety in a regulated manner in companies that work without considering customization to the reality of their projects.

3 Research Methodology

The research methodology used in this article will be based on Design Science Research (DSR), which consists of using analytical techniques to study, research, investigate the artificial and its behavior, whether from an academic point of view, or a business point of view [20].

According to Vaishnavi et al. [20] the knowledge resulting from DSR can be presented in the form of artifacts, frameworks, architectures, methods, instantiations, design theories, or design principles. This result can bring several types of contribution switching on two criteria: (1) maturity of the problem domain and (2) maturity of the solution domain. The types of contribution that DSR-guided knowledge brings are: invention (inventing new solutions/knowledge for new problems); improvements (developing new solutions/knowledge for known problems); adaptation (non-trivial or innovative adaptation of known solutions/knowledge to new problems); and routine (application of known solutions/knowledge to known problems). A single research project can bring more than one type of knowledge contribution [20].

Therefore, the knowledge contribution expected from this article, taking into account the framework and the research problem established in the introduction, is characterized by a high maturity in the domain of solutions, since existing solutions will be adapted to new problems. Furthermore, this study can be described as theoretical-conceptual, specifically dedicated to research and literature review on project management in Industry 4.0. Therefore, we seek to relate the Critical Success Factors to project management in Industry 4.0.

4 Method Guidelines

To support this article, the Systematic Search Flow (SSF) method proposed by Ferenhof & Fernandes [21] was used in the online scientific databases Scopus and Web of Science, as they are multidisciplinary electronic search platforms, which present qualified articles and peer-reviewed [21].The search was limited to results from the periods 2000 to 2021 and also to results in Portuguese or English. The main objective of this section is to initially identify works that can help in the development of this research.

Initially, the descriptors applied to the scientific bases were: (“Project Management”) AND (“method” OR “framework” OR “model” OR “approach”) AND (“Industry 4.0”) AND (“critical success factor”). Still in this design phase, no inclusion and exclusion criteria were applied in order not to restrict the results. As a result, the Scopus database resulted in seven works, but only four related to the theme are available for download. In the Web of Science database, five works, three of which were found in Scopus, and the other two also related to the subject. Then, the search was performed again, updating the query to ("Project Management") AND ("Industry 4.0") AND ("critical success factor") from the exclusion of the query ("model" or "framework" or "method ” or “approach”), obtaining one more result related to the theme in the Scopus database and four more articles in the Web of Science database, but this time only one related to the scope of this research project. It is observed then that the research field

lacks studies that address this issue. Thus, in order to further complement the research, a new query was created in order to find more articles that are related to the theme of this project. Thus, from the search of the descriptors ("Project Management") AND ("Industry 4.0"), the presence of about 300 works was observed. In order to refine the search, filters were selected, in which the two descriptors appeared in the keywords of the works and that were available for download. Thus, the list was reduced to 115 works. Of these, only two are related to the proposed theme and are available for download. By joining the three queries, a total of 10 articles were selected that will serve as a basis for selecting the Critical Success Factors for Project Management in Industry 4.0. Table 1 brings the selection of Critical Success Factors gathered into five groups: factors related to the organization; factors related to strategy and business; factors related to leadership and project team; factors related to technology and innovation; factors related to the project. Figure 1 summarizes these works.

Fig. 1. Critical Success Factors

Critical Success Factors		References									
		[22]	[23]	[24]	[25]	[26]	[27]	[28]	[29]	[30]	[31]
1. Factors related to the organization	Top management support	x	x	x	x	x	x	x	x	x	x
	Clarity in roles and responsibilities		x	x	x	x				x	x
	Clarity on mission and objectives		x			x	x			x	x
	Stakeholders involvement		x								
	Financial capacity	x						x	x		
	Culture	x			x		x	x		x	
2. Factors related to strategy and business	Sustainability				x				x		
	Volatility				x						
	Mindset aligned with management	x	x		x						
	Internal and external collaboration	x	x					x		x	x
	Incentives and subsidies with local government	x		x						x	x
	Competitiveness			x	x	x	x			x	
3. Factors related to leadership and project team	Trainings			x	x	x	x	x	x	x	
	Previous study of the project		x			x		x	x		
	PM leadership with knowledge of *core business* of the company		x						x	x	x
	Real time communication	x	x	x		x		x	x	x	x
	Defined roles and tasks for the team		x						x		x
	Project team with necessary skills	x	x				x		x		
4. Factors related to technology and innovation	Tool of Industry 4.0			x	x	x	x	x		x	
	Data management and integration system			x	x	x	x	x		x	x
	Simulation			x		x	x				
	Innovation	x		x	x	x		x		x	
	Technological incentives by the local government	x		x							
	Performance control			x		x		x		x	
	Cybersecurity				x		x			x	x
5. Factors related to the project	Flexibility		x	x	x				x	x	x
	Risk Plan		x								x
	Roadmap	x	x				x	x	x	x	x
	Size, value and uniqueness				x						
	Standardized methods	x						x		x	x
	Use lessons learned from previous projects		x			x		x			

5 Project management method proposal for industry 4.0

Proposing a project management method for Industry 4.0 is a significant challenge since each project is unique and has unique specificities. It was decided to adopt the timeline of a project life cycle as a basis by adding a phase before the initiation phase called the preparation phase, followed by the planning phase, which will act in parallel with the added simulation phase and the phase of project execution. Then there will be the project closing phase and an evaluation phase will be added, which will compute the lessons learned for the next projects.

The life cycle of a project encompasses the main phases that a project goes through. In addition to delimiting the phases, it facilitates project management, as it allows a more globalized view of the project as a whole, helping the manager to understand where the focus of attention should be at any given time.

In Industry 4.0, a project can start and finish quickly, and often a project branches into new projects. Thus, the project evaluation phase becomes essential, as it is there that the lessons learned will be documented and that will serve as input in the preparation phase of new projects that may arise.

Aiming to encompass the characteristics of a project in Industry 4.0 beyond the 10 knowledge areas suggested by PMI's PMBOK, a set of knowledge areas is suggested: data management, sustainability management, benefits management, and agility management.

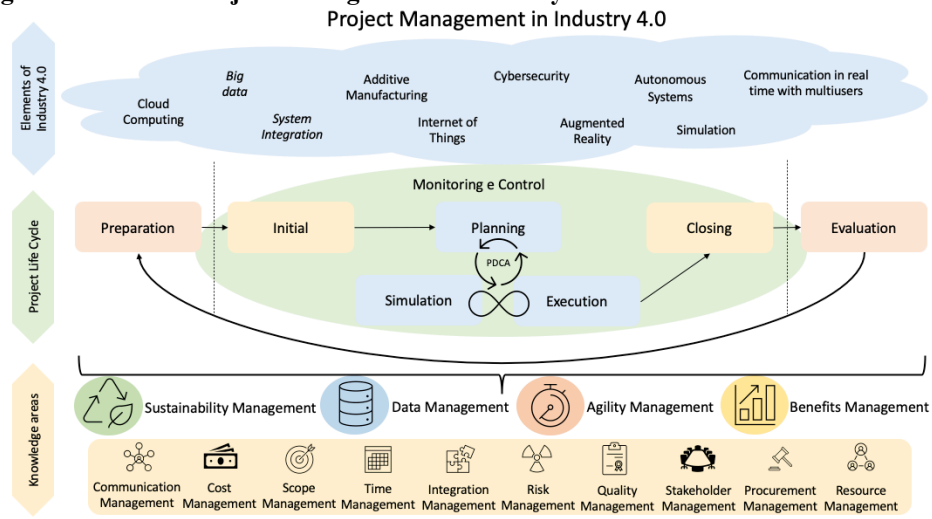
With Industry 4.0, project management models need to be rethought. In this sense, a proposal was made for a method that encompasses the differentials of Industry 4.0, enabling companies to operate their projects with greater speed and agility.

The project life cycle was rethought along the lines of Industry 4.0 and new areas of knowledge were suggested to support project management. Furthermore, with the elements of Industry 4.0, projects start to become more flexible, together with the high standard of quality, real-time optimized, and self-organized. Thus, in the method, the elements of Industry 4.0 are available throughout the project. Thus, the proposed method of project management in Industry 4.0 aims to unite the traditional models with the agile mentality, making it a hybrid method.

Project management in Industry 4.0 has become increasingly necessary. The greater the preparation of companies to carry out this management in an integrated manner and using Industry 4.0 tools, the better the final results of the project will be over time.

Figure 2 presents the method of project management in Industry 4.0.

Fig. 2. Method for Project Management in Industry 4.0



In Industry 4.0, data management is essential as all decision-making revolves around the information extracted from the data. It will be necessary to deal with a constant and massive volume of data throughout the project lifecycle, so data management is necessary to support decision-making and make it more assertive, from different perspectives and at various levels of detail. In addition, it makes it possible to analyze more complex business trends and comparisons.

Data management requires an agile mindset, that is, a break in paradigms, it is necessary to learn and relearn, have a flexible mindset and find creative solutions. Therefore, together with data management, it is essential to have agile management in projects.

What's more, projects in Industry 4.0 are increasingly volatile, which means that they can change objectives quickly, can be transformed into other projects, or simply close. Therefore, management of benefits comes to meet this demand.

Industry 4.0 has increasingly valued sustainable paths. Therefore, in projects it is also necessary to monitor the social, environmental, and economic impact, making it necessary to have sustainability management in the management of projects in Industry 4.0.

The life cycle of projects in Industry 4.0 is agile, in which processes, people, and technology are constantly involved and integrated. Thus, communication networks in an Industry 4.0 project need to be reliable, comprehensive, and of high quality. With this connectivity, tasks can be assigned faster and more assertively. Also, at the same time, it integrates the project team with interested parties, the exchange of information being increasingly transparent.

With the Industry 4.0 project management method begins the beginning of a project management mindset in Industry 4.0, i.e. a set of behaviors and attitudes that support the project team in the successful execution of the project in Industry 4.0.

Thus, in addition to the emerging operational models, the culture and mindset also need to be rethought, according to the new moment in the industry. Data in Industry 4.0 becomes more essential for decision making and operating models, but also for the mindset of the people who are involved, i.e. the company culture in Industry 4.0 needs to be data driven. This means having a solid foundation with information gleaned from data rather than guesswork. This applies to projects in which decision-making becomes more assertive and based on collected, processed, and analyzed data. The data is accompanied by the need to have an agile mindset, and for the projects, it is extremely important to foster learning.

In Industry 4.0, speed, reach and impacts stand out with the technologies, and the same happens in projects where more and more agility in processes and flexibility in decision-making are expected. It is essential to take advantage of technologies and always look for innovation, anticipate errors, and manage increasingly personalized projects quickly, with the objective of reducing costs. It is important to know how to read and interpret data and have a good relationship with all sectors of the industry. It is necessary to use data and technology in favor of the healthy, agile, and sustainable development of a project. Thus, the ability to interpret data will be part of the day-to-day projects in Industry 4.0.

Projects are increasingly volatile, as they can start and close very quickly or completely change the initially proposed objective, due to the dynamism of the market, company, or team. Increasingly, more globality and adaptability are required in projects. Learning and relearning are critical.

Collaboration in real-time, making knowledge sharing constant. Therefore, you must always be willing to learn. Top management also plays an important role in Industry 4.0 projects. Therefore, the more involved, the more success guarantee the project will have. Understanding Industry 4.0 technologies, knowing how to apply them and optimizing them according to each project and, more than that, using creativity will be differentials in Industry 4.0 projects.

Industry 4.0 projects need to be involved in sustainable actions, as companies are increasingly required to consider the economic, social, and environmental impact on the environment in which they operate. In addition, it must be kept in mind, throughout the project, the search for continuous improvement and small changes can have big effects on a project.

6 Conclusion

The main objective of this paper was to make a proposition of a method for project management in Industry 4.0 based on the review of related literature and on the Critical Success Factors for project management within Industry 4.0.

Industry 4.0 promotes major changes in the way companies operate, as it brings new trends and integrated technologies, in which information and data exchange become paramount, brings concepts such as cyber-physical systems, Internet of Things, cloud computing, and big data. The Fourth Industrial Revolution brings disruption to the business world, promoting the improvement of process efficiency and productivity. With

the changes arising from Industry 4.0, project management needs to be reassessed, as such changes impact project management processes.

The proposal of the method had a set of methodological steps considering theoretical elements. The proposed method brings as a result a knowledge guide that can be applied in a project in Industry 4.0 with the objective of bringing successful results to the companies that adopt it. The project lifecycle needs to be more agile to keep up with Industry 4.0 trends, so three new phases have been added to address these needs: project preparation, simulation, and evaluation. In which the assessment phase complements the preparation phase since a project can generate new projects, resulting in a cycle of improvement. The simulation phase becomes necessary since for some projects it is possible to prototype and simulate them before putting them into execution. In this sense, it is also emphasized that project management in Industry 4.0 requires a demand for the formation of new areas of knowledge, in addition to the 10 traditional areas of project management. In Industry 4.0, projects tend to be increasingly sustainable, volatile, dynamic, requiring more agile and data-oriented processes, as they are fundamental for decision making. Thus, four new areas were suggested to add to the existing ones: data management, sustainability management, benefits management, and agility management.

Regarding the limits of this article, it is noteworthy that the discussion on the role of the project manager as well as their necessary skills and the 4.0 manager mentality were not deepened during this research, given the extension of the topic and its complexity. Independent and more specific research, devoted exclusively to these questions, would justify itself; even more, it would bring considerable wealth to the debate on the knowledge built on the subject. This statement is supported even by the fact that, after analyzing the project management in Industry 4.0, it became clear that, despite the different existing difficulties, the biggest obstacle is the skills and culture that varies from company to company. they do not allow universal rules for their transformation to be established.

It should be noted, as a final conclusion, that, with the limitations inherent to the theoretical-conceptual approach, it was not possible to prove the propositions of the project management method in Industry 4.0, requiring confirmation and empirical tests that allow proving such propositions and the relationship of project management with Industry 4.0 conceptually established. However, according to the information collected, there is evidence that the proposed method reduces the gaps in the conceptual framework of project management in Industry 4.0.

Acknowledgements

This work has been supported by FCT – Fundação para a Ciência e Tecnologia within the R&D Units Project Scope: UIDB/00319/2020.

References

1. Da, L., Xu, E. L., & Li, L.: *Industry 4 . 0 : state of the art and future trends*. *56*(8), 2941–2962 (2020).
2. Hecklau, F., Galeitzke, M., Flachs, S., & Kohl, H.: Holistic Approach for Human Resource Management in Industry 4.0. *Procedia CIRP*, *54*, 1–6 (2016)
3. Keller, M., Rosenberg, M., Brettel, M., & Friederichsen, N.: How Virtualization, Decentrazliation and Network Building Change the Manufacturing Landscape: An Industry 4.0 Perspective. *International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering*, *8*(1), 37–44 (2014)
4. Dopico, M., Gomez, A., De la Fuente, D., García, N., Rosillo, R., & Puche, J.: A vision of industry 4.0 from an artificial intelligence point of view. *Proceedings of the 2016 International Conference on Artificial Intelligence, ICAI 2016 - WORLDCOMP 2016*, 407–413 (2016).
5. Kagermann, Wahlster, W., & Helbig, J.: Recommendations for implementing the strategic initiative Industrie 4.0. *Final Report of the Industrie 4.0 WG*, *April* (2013).
6. Schwab, K.: *A Quarta Revolução Industrial*. 1th edn. Edipro, São Paulo (2016).
7. Schepman, A., Rodway, P., Beattie, C., & Lambert, J.: An observational study of undergraduate students' adoption of (mobile) note-taking software. *Computers in Human Behavior*, *28*, 308–317 (2012).
8. Rockart, J. F.: *Chief executives define their own data needs*. 2nd edn. Harvard business review (1979).
9. Brotherton, B., & Shaw, J.: Towards an identification and classification of critical success factors in UK hotels Plc. *International Journal of Hospitality Management*, *15*(2), 113–135 (1996).
10. CNI.: Desafios para indústria 4.0 no Brasil. *Confederação Nacional Da Indústria*, *Industria 4.0*, 34 (2016).
11. Boston Consulting Group, https://www.bcg.com/en-pt/ 2021/09/21.
12. Valle, A. B., Soares, C. A. P., Finocchio Jr., J., & Silva, L. de S. F.: *Fundamentos do Gerenciamento de Projetos*. 2nd edn. FGV Editora, São Paulo (2010).
13. PMI.: A Guide to the Project Management Body of Knowledge (PMBOK Guide). In *Project Management Journal.* 6th edn. v32 (3) (2017).
14. Internacional Standard Organization: *ISO 10006: Quality management - Guideline to quality in project management* (1997).
15. Meredith, J. R., & Mantel, S. J. *Project Management: a managerial approach*. 8th edn. Wiley, Delhi (2013).
16. Rabechini JR., R., & Carvalho, M. M. Gestão de projetos inovadores em uma perspectiva contingencial: análise teórico-conceitual e proposição de um modelo. *Rai. Revista de administração e inovação*, *6*(3), 63–78 (2009).
17. Agile Manifesto. *Manifesto for agile software development*. (2001).
18. IPMA. Project Excellence Baseline. In *Ipma*. (2016).

19. European Commission. The PM2 Project Management Methodology Guide 3.0. In *Project Management Methodology*. 3th edn. European Commission, DIGIT Centre of Excellence in Project Management (CoEPM2) (2018).
20. Vaishnavi, V., Kuechler, B., & Petter, S.: *Design Science Research In Information Systems*. (2004).
21. Ferenhof, H. A., & Fernandes, R. F.: Desmistificando a revisão de literatura como base para redação científica: método SSF. *Revista ACB: Biblioteconomia Em Santa Catarina*, *21*(3), 550–563 (2016).
22. Menkhoff, T., & Surianarayanan, G.: Outcomes of an expert survey: Are Singapore's manufacturing small and medium enterprises ready to embrace industry 4.0. *Research Collection Lee Kong Chian School Of Business*. (2020).
23. Hussein, B.: The influence of project characteristics on project success factors. Insights from 21 real life project cases from Norway. *Procedia Computer Science*, *164*, 350–357 (2019).
24. Subramanian, G., Patil, B. T., & Gardas, B. B.: Evaluation of enablers of cloud technology to boost industry 4.0 adoption in the manufacturing micro, small and medium enterprises. *Journal of Modelling in Management* (2021).
25. Sony, M., & Naik, S.: Critical factors for the successful implementation of Industry 4.0: a review and future research direction. *Production Planning and Control*, *0*(0), 1–17 (2019).
26. Moeuf, A., Lamouri, S., Pellerin, R., Tamayo-Giraldo, S., Tobon-Valencia, E., & Eburdy, R.: Identification of critical success factors, risks and opportunities of Industry 4.0 in SMEs. *International Journal of Production Research*, *0*(0), 1–17 (2019).
27. Pozzi, R., Rossi, T., & Secchi, R.: Industry 4.0 technologies: critical success factors for implementation and improvements in manufacturing companies. *Production Planning and Control*, *0*(0), 1–21 (2021).
28. Lai, N. Y. G., Jayasekara, D., Wong, K. H., Yu, L. J., Kang, H. S., Pawar, K., & Zhu, Y.: Advanced Automation and Robotics for High Volume Labour-Intensive Manufacturing. *HORA 2020 - 2nd International Congress on Human-Computer Interaction, Optimization and Robotic Applications, Proceedings*, *L*. (2020).
29. Vrchota, J., Řehoř, P., Maříková, M., & Pech, M.: Critical success factors of the project management in relation to industry 4.0 for sustainability of projects. *Sustainability (Switzerland)*, *13*(1), 1–19 (2021).
30. Shinohara, A. C., Da Silva, E. H. D. R., De Lima, E. P., Deschamps, F., & Da Costa, S. E. G.: Critical success factors for digital manufacturing implementation in the context of industry 4.0. *67th Annual Conference and Expo of the Institute of Industrial Engineers 2017*, 199–204 (2017).
31. Yin, Y., & Qin, S. F.: A smart performance measurement approach for collaborative design in Industry 4.0. *Advances in Mechanical Engineering*, *11*(1), 1–15 (2019).