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# The Influence of Industry 4.0 on the Lessons Learned Process in Project Management

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## Abstract

Knowledge management, particularly the lessons learned (LL) process, is crucial yet challenging within project-based organizations, often hindered by the temporary nature of projects and cultural or structural barriers. The rise of Industry 4.0 (I4.0) and digital transformation introduces new technological capabilities and operational dynamics, but its specific influence on the lessons learned process in project management lacks comprehensive investigation. This article addresses this gap through a systematic literature review aimed at understanding how I4.0 and digital transformation impact the LL process. Based on an analysis of 26 articles retrieved from Web of Science and Scopus databases, the study identifies nine primary influences of I4.0 on LL. These include enhanced data security and transparency (e.g., via Blockchain, cloud platforms), promotion of agile methods for continuous feedback (like retrospectives), the need for new project manager competencies (data analysis, decision-making skills), real-time project data management, advanced data analysis generating insights and decisions (using Big Data, BI, AI), improved data sharing and integration, integrated project management systems, and task automation. Twelve key enabling technologies supporting these influences were also identified. The findings indicate that data analysis/interpretation and real-time data management are the most frequently cited impacts. Despite these findings, the review confirms a significant research gap, with few studies specifically addressing the LL process within the I4.0 context. This research contributes by consolidating the main influences and technologies of I4.0 relevant to the LL process, offering practical insights for professionals and highlighting a novel area for theoretical development in project and knowledge management.

## Keywords
Industry 4.0, Lessons Learned, Project Management, Knowledge Management and Digital Transformation

## 1. Introduction
In the post-capitalist society, knowledge is the core resource for the economy. "The central wealth-creating activities will be neither the allocation of capital to productive uses nor ‘labour'. It is and will be knowledge.” (Drucker 1993). In other words, knowledge is one of the main competitive advantages for organizations, and managing it involves how knowledge is acquired, disseminated, and utilized to respond promptly to market changes (Chen and Mohamed 2008). The context of managing knowledge in project-based business structures needs to consider the temporary nature of projects, which tends to be a major obstacle to the retention and dissemination of the knowledge generated therein.

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Several studies have demonstrated the difficulty projects face in extracting, distributing, and applying learnings and knowledge due to their cultural and structural boundaries (Bosch-Sijtsema and Postma 2009; Prencipe and Tell 2001). At the intersection of knowledge management and project management lies the lessons learned process. Studies show that companies truly achieve organizational learning through the lessons learned process in projects (Prencipe and Tell 2001). The process of collecting and disseminating lessons learned in Project Management is fundamental for the continuous management of knowledge within organizations (Association of Project Management 2012). Lessons learned refer to the knowledge acquired during a project, which shows how project events were addressed or should be addressed in the future, to improve the performance of subsequent projects. In the PMBOK – Project Management Body of Knowledge – lessons learned are understood as assets that aid in project success (PMBOK 7th Ed., PMI 2021).

The lessons learned process can be established in various ways, but we will exemplify it according to Dowson et al. (2024), who state that knowledge is first understood and processed individually, then shared among individuals, and finally, transferred between projects and the organization with the objective that it can be utilized.

However, the capture, categorization, and, crucially, the application of lessons learned are still limited (McClory et al. 2017; Brady and Davies 2004). There are several reasons listed in the literature that justify this scarce utilization of these practices in projects: outdated knowledge management systems (Wijnhoven 2003), the dissociation of organizational learning from the lessons learned process and the limited time dedicated to post-project analysis (Hartmann and Dorée 2015), the absence of a series of elements such as: a learning-oriented culture, social activities, technology, process, and infrastructure (Duffield & Whitty 2015), the very temporary nature of projects, which causes team dispersion, leading to fragmented knowledge within the organization (Bartsch et al. 2013), or simply, according to Meredith and Mantel (2010), the non-utilization of final reports from previous projects (cited by McClory et al. 2017). A survey conducted by the University of Portsmouth, England, which interviewed project managers associated with APM or PMI, as well as those belonging to other groups like "The Project Manager Network," revealed that 42% of project managers do not have access to a system to consult lessons from other projects or that the existing system is not used (McClory et al. 2017).

Given the challenging context cited above, studies analyzing and proposing methods and approaches to facilitate the collection and dissemination of lessons learned are evaluated (Dowson et al. 2024; Gorkem et al. 2019); however, few are specifically focused on the Industry 4.0 context – the context we will focus on in this article. Studies contributing to the theme of lessons learned in Industry 4.0 do so, mostly, through the correlation of specific technologies with the general process of knowledge management or project information management (Alkhudary and Gardiner 2024; Nunes et al. 2022); however, none conduct a systematic literature review to obtain a complete view of the influence of these technologies on the lessons learned process in projects.

Industry 4.0 involves a structural change in the technological base of manufacturing, allowing flexibility in specifications, quality, design, volume, and production time. It is the result of an industrial revolution initiated in 2011, where "machine manufacturing," which was not fully integrated, transformed into "digital manufacturing," driven by information technology, which enabled the digitalization and automation of industrial processes (Habib et al. 2022). The Industry 4.0 revolution consists of creating a suitable environment where all data and information along the supply chain are captured in real-time, evaluated, filtered, driven, and transformed into valuable data that establish the basis for greater optimization (Hamdi et al. 2019). There are three principles of Industry 4.0: Digitalization, Control and Insights (enabled by real-time data), and Automation (Hamdi et al. 2019).

This context brings a series of technological, social, economic, and even political challenges. Some of these challenges are perceived in project management as: data retention and sharing difficulties, the shift in skills required for project management professionals, the pressure for agility and real-time information, the need to adapt rapidly to the market in a context of constant change, and the very lack of connection between data analysis and project study (Podgórska 2022; Daxbacher et al. 2023; Al Amri et al. 2021; Shen et al. 2024).

Thus, this article will seek, through a systematic literature review, to understand how Industry 4.0 or digital transformation influences the lessons learned process in project management. The analysis was conducted by searching for literature associating general project management practices with Industry 4.0, with a specific focus on

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the process of collecting, disseminating, and using lessons learned – which is, as far as could be confirmed, unprecedented in the literature and extremely relevant, given the challenging scenario previously mentioned.
This rationale is presented in Figure 1, which summarizes the motivations and arguments, as well as the study's aim and objectives.

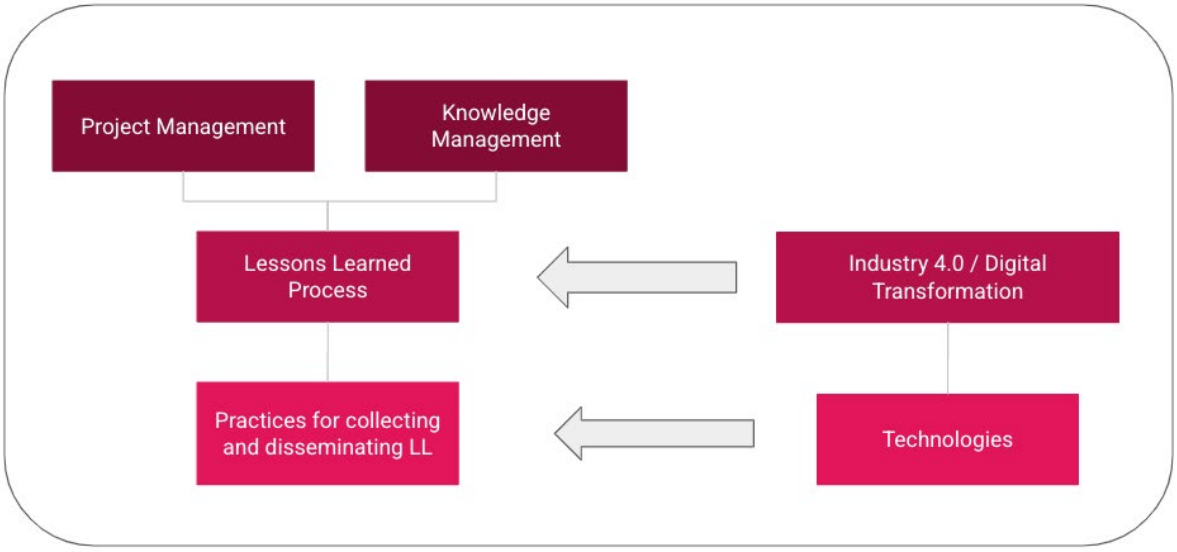


Figure 1. Research rationale based on the gap and motivation

### 1.1 Objectives

This article primarily aims to understand how Industry 4.0 and the broader digital transformation are influencing the established lessons learned process within the field of project management. Utilizing a systematic literature review as its core methodology, the study seeks to identify the specific impacts, challenges, and opportunities presented by Industry 4.0 technologies and principles on the practices of collecting, disseminating, and applying lessons learned from projects. A secondary objective is to uncover practical methods and approaches suggested by existing academic literature for enhancing the lessons learned cycle in the specific context shaped by Industry 4.0, thereby addressing an identified gap in research that specifically connects these two domains.
The research questions to be answered by the end of this article are:

- How have Industry 4.0 or digital transformation influenced the lessons learned process in project management?
- What practices for collecting and disseminating lessons learned are suggested by the literature in the context of Industry 4.0?

## 2. Literature Review

The method adopted to search for and answer the research questions was a systematic literature review. A framework was constructed and followed to help conduct this research (Figure 2). It helps us understand step-by-step what was done to identify the main influences of Industry 4.0 on the Lessons Learned Process in Project Management and possible practices cited in the literature.

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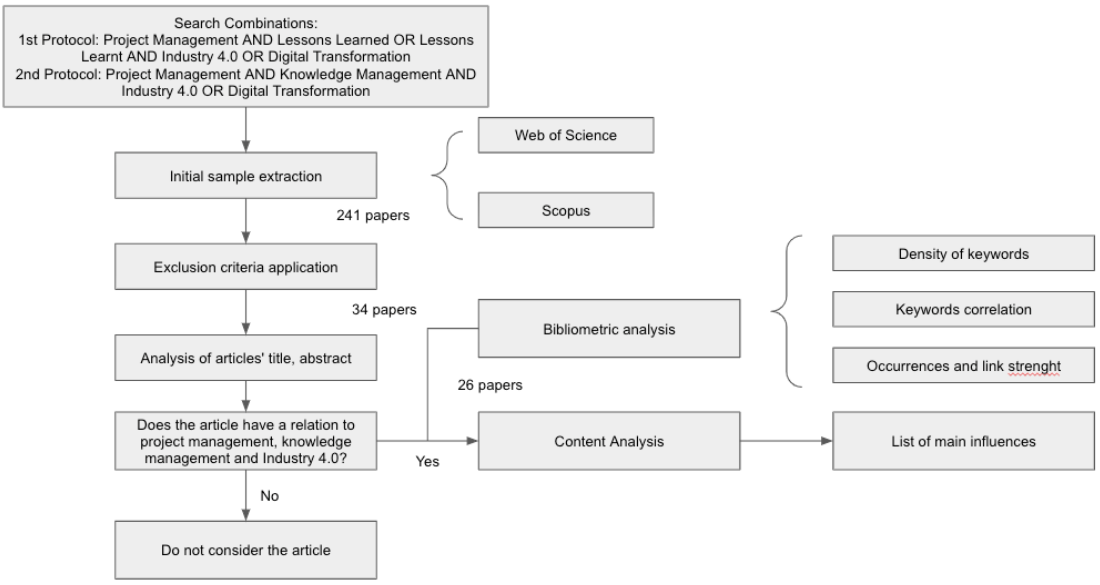


Figure 2. Research Method

The systematic literature review focused on two databases, **Web of Science** and **Scopus**, and followed the Prisma method to ensure transparency and replicability of the study, as exemplified in Figure 3. The final corpus of articles was analyzed using the **VOS Viewer** platform, which enabled bibliometric assessments of keyword density, as well as their occurrences.

The literature review followed the process proposed by (Tranfield et al. 2003), which consists of: planning, conducting, and disseminating. For the dissemination stage, we adopted the concept of the author-concept matrix, proposed by (Watson and Webster 2020).

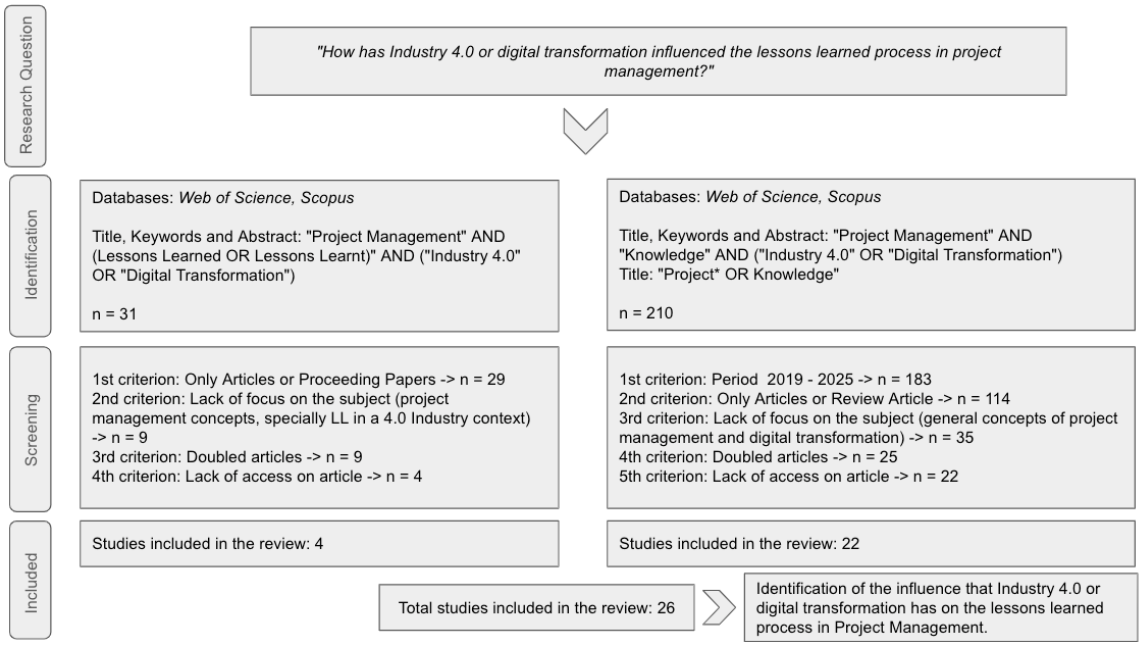


Figure 3. Research Protocol adapted from the Prisma Method

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## 2.1 Planning the Review

An initial search was conducted to find articles directly linking Industry 4.0 to the theme of Lessons Learned in Project Management. Being a specific topic, few articles were found in the database, and only 04 were selected for the systematic review. For this protocol, the keywords used were: Project Management AND (Lessons Learned OR Lessons Learnt) AND (Industry 4.0 OR Digital Transformation). The search was conducted considering the title, abstract, and keywords. To capture the reference to Industry 4.0, two keywords that may refer to this context in the literature were used: industry 4.0 and Digital Transformation.

Due to the low number of articles linking lessons learned specifically to the Industry 4.0 context, which already demonstrates a research gap, a second search was performed, seeking to correlate lessons learned with organizational knowledge management (a broader term, within which the project lessons learned process is contained). Thus, we replaced the keywords "Lessons Learned" and "Lessons Learnt" with "Knowledge Management". However, it became evident that the database was very broad, with 382 articles. It was noted during the analysis that those containing the word "Project" or "Knowledge" in the title were more connected to the study's theme.

By applying this new search with this new criterion, articles addressing topics related to the use of specific Industry 4.0 practices in diverse areas not connected with project management or knowledge management were excluded.

Finally, the second search used the keywords: "*Project Management*" AND "*Knowledge*" AND ("*Industry 4.0*" OR "*Digital Transformation*") considering their presence in the title, abstract, or keywords. Additionally, the words "*Project*" OR "*Knowledge*" were included in the title search. This search yielded 210 results, which then proceeded to the selection stage.

## 2.2 Conducting the Review

During the conducting stage, the criteria shown in Figure 1 [Note: Likely meant Figure 3] were applied. In the first search, 31 articles were found without applying any exclusion criteria. Subsequently, the criterion by document type was applied, selecting only articles and proceedings. Then, titles and abstracts were reviewed to assess affinity with project management (preferably the lessons learned process) and Industry 4.0. As expected, few articles remained in the database, even without considering a temporal criterion in the search. Finally, duplicate articles were evaluated and removed, keeping only those with open access, totaling 04 articles in the final corpus.

Due to the low number of articles found, the decision was made to broaden the search, and therefore, a new search was executed, where the terms "*Lessons Learned OR Lessons Learnt*" were replaced by the term "*Knowledge*", which is broader and could direct us to articles addressing knowledge management, in which the project lessons learned process is contained.

In the second search, 210 articles were found without applied exclusion criteria. Subsequently, a temporal criterion (2019-2025) and publication type were applied, considering only articles and review articles. These criteria were applied with the objective of capturing more complete and recent studies on the topic, obtaining a view of what has been discussed on the subject in recent years. Subsequently, the articles were analyzed (by title and abstract) and all those that did not have affinity with the theme (that did not directly address project management or knowledge management in projects and that did not consider the industry 4.0 context) were excluded. In this filter, an effort was made to exclude articles that, despite containing the keywords "*Project Management*", "*Knowledge*" and "*Industry 4.0 or Digital Transformation*", did not address Project Management from a methodological perspective, and treated the project, mainly digital or digitalization projects, as their object of study.

Finally, duplicate publications and those without open access were excluded. In this second search, the final corpus consisted of 22 articles, which, added to the 04 from the previous search, totals a final corpus of 26 articles. In the final analysis, articles in English and Portuguese were considered.

Figure 4 shows the density of keywords found in the file, after processing the database, where a clustering of keywords into broader clusters was performed, to enable understanding the interrelation between concepts (this is indicated in Table 1). From the density analysis, the presence of the keyword "*construction*" can be observed, indicating the strong incidence of studies in the civil construction area, as well as the "SECI" model by Nonaka (1994) and Nonaka and Takeuchi (1995), which uses the distinction between explicit and tacit knowledge to describe the creation of

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organizational knowledge and interorganizational knowledge. A relevant point is the absence of the keyword "*Lessons Learned*" in the articles of the final corpus, which shows that, although most articles relate "*project management*", "*knowledge*" and "*Industry 4.0*", few are specifically delving into the theme of the lessons learned process.

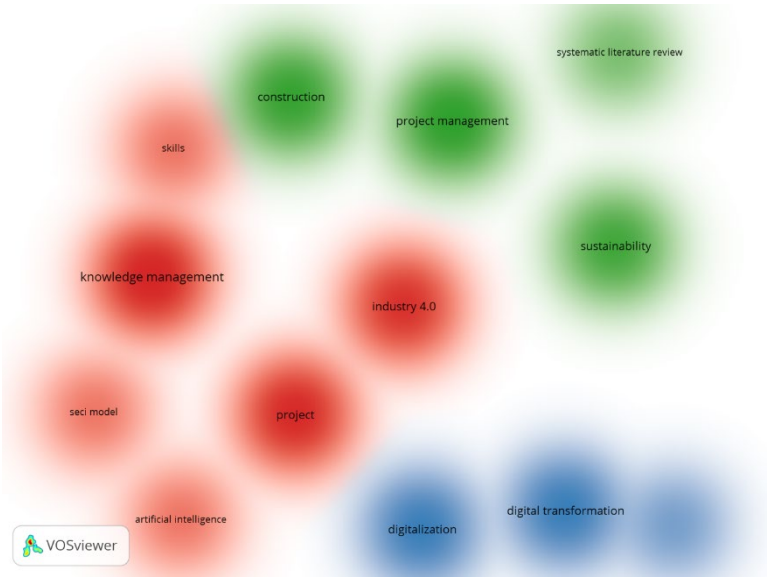


Figure 4. Keyword Density

Table 1. Keyword Grouping

| Label | Replace by | Label | Replace by |
|---|---|---|---|
| construction competitiveness | construction | project complexity | Project |
| construction education | construction | project data analytics | Project |
| construction industry | construction | project delivery performance | Project |
| construction management | construction | project governance | Project |
| construction projects | construction | project management (pm) | project management |
| digitalization project | digitalization | project management education | project management |
| fourth industrial revolution | industry 4.0 | project manager | project management |
| industry 4.0 (i4.0) | industry 4.0 | project network organization | Project |
| knowledge | knowledge management | project performance | Project |
| knowledge cooperation | knowledge management | project studies | Project |
| knowledge creation | knowledge management | project success | Project |
| knowledge management process | knowledge management | project team competencies | Project |
| knowledge workers | knowledge management | projects | Project |
| organizational digital transformation | digital transformation | seci | seci model |
| pm 4.0 | project management | sustainable development | sustainability |
| project complexities | Project | systematic review | systematic literature review |

Figure 5 shows the relationship between keywords divided by clusters. The minimum occurrence established was 02 and considered the base of 26 articles selected for the systematic review. It is curious to note that "*knowledge management*" stands out more than the other keywords. This happens because the articles end up dividing the citations between "*Project*" and "*Project Management*" and between "*Industry 4.0*", "*Digital Transformation*" and "*Digitalization*".

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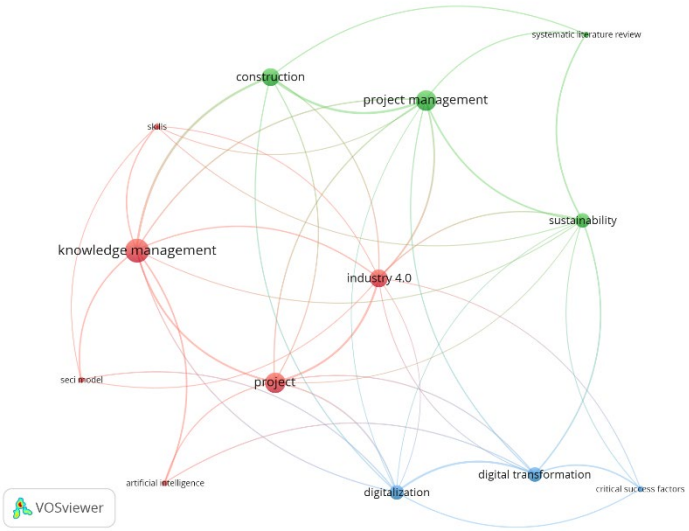


Figura 5. Palavras-chave por clusters

Table 2 shows the list of articles selected for the literature review, totaling 26 articles.

Table 2. List of articles selected for the literature review

| No | Authors | Article Title | Database | Source |
|---|---|---|---|---|
| 1 | Alkhudary and Gardiner (2024) | Utilizing blockchain to enhance project management information systems: insights into project portfolio success, knowledge management and learning capabilities | Web of Science | International Journal of Managing Projects in Business |
| 2 | Podgórska (2022) | Challenges and Perspectives in Innovative Projects Focused on Sustainable Industry 4.0—A Case Study on Polish Project Teams | Web of Science | Sustainability |
| 3 | Garcia et al (2023) | Creating and Sharing Interorganizational Knowledge Through a Supply Chain 4.0 Project: A Case Study | Web of Science | Journal of Global Information Management |
| 4 | Gibbin et al (2023) | Thematic evolution and trends linking sustainability and project management: Scientific mapping using SciMAT | Web of Science | Journal of Cleaner Production |
| 5 | Wei et al (2024) | Project management for sustainable development: Critical determinants of technological competency for project managers with smart technologies | Web of Science | Sustainable Development |
| 6 | Ginigaddara et al (2024) | Conceptualising project management capabilities for offsite construction | Web of Science | Engineering, Construction and Architectural Management |
| 7 | Ngereja et al | A Retrospective Analysis of the Role of Soft Factors in Digitalization Projects: Based on a Case | Web of Science | 2020 IEEE European Technology and |

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| | | | | |
|---|---|---|---|---|
| | | Study in a Public Health Organization in Trondheim-Norway | | Engineering Management Summit (e-tems 2020) |
| 8 | do Amaral Gonçalves et al (2020) | AGILE TRANSFORMATION PROCESS IN A BRAZILIAN TELECOM COMPANY | Web of Science | Revista de Gestão de Projetos |
| 9 | Nunes et al (2022) | Achieving Competitive Sustainable Advantages (CSAs) by Applying a Heuristic-Collaborative Risk Model | Web of Science | Sustainability |
| 10 | Khoa and Chinda (2023) | Assessment of Construction Competitiveness through Knowledge Management Process Implementation | Web of Science | Sustainability |
| 11 | Liu et al (2023) | Fostering Digitalization of Construction Projects through Integration: A Conceptual Project Governance Model | Web of Science | Buildings |
| 12 | Ngereja et al (2024) | A comparison of soft factors in the implementation and adoption of digitalization projects: a systematic literature review | Web of Science | IJISPM-International Journal Of Information Systems And Project Management |
| 13 | Daxbacher et al (2023) | Critical success factors in digital transformation projects in the brazilian automotive industry: a qualitative study | Web of Science | International Journal Of Innovation |
| 14 | Aliu et al (2023) | Towards a New Paradigm of Project Management: A Bibliometric Review | Web of Science | Sustainability |
| 15 | Zhu et al (2022) | Applications of Smart Technologies in Construction Project Management | Web of Science | Journal Of Construction Engineering And Management |
| 16 | Yap et al (2020) | Capitalising knowledge management (KM) for improving project delivery in construction | Web of Science | Ain Shams Engineering Journal |
| 17 | Al Amri et al (2021) | Towards Sustainable I4.0: Key Skill Areas for Project Managers in GCC Construction Industry | Web of Science | Sustainability |
| 18 | Russell et al (2023) | The construction-related project management evolution and its future research directions | Web of Science | Engineering Construction And Architectural Management |
| 19 | Shen et al (2024) | Data analytics for project delivery: unlocking the potential of an emerging field | Web of Science | INTERNATIONAL JOURNAL OF MANAGING PROJECTS IN BUSINESS |
| 20 | Anshari and Hamdan (2021) | Understanding knowledge management and upskilling in Fourth Industrial Revolution: transformational shift and SECI model | Web of Science | Vine Journal Of Information And Knowledge Management Systems |
| 21 | Manuti and Monachino (2020) | Managing knowledge at the time of artificial intelligence: An explorative study with knowledge workers; | Scopus | East European Journal of Psycholinguistics |
| 22 | Kanski and Pizon (2023) | The impact of selected components of industry 4.0 on project management | Web of Science | Journal Of Innovation & Knowledge |

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| | | | | |
|---|---|---|---|---|
| 23 | Zhang et al (2023) | Sustainability and Digital Transformation within the Project Management Area: A Science Mapping Approach | Web of Science | Buildings |
| 24 | Gomes et al (2024) | Digital technologies and knowledge management in project context: a systematic literature review | Web of Science | Knowledge Management Research & Practice |
| 25 | Liu and Zhang (2024) | The role of digital resilient agility: how digital capability incompatibility affects knowledge cooperation performance in project network organizations | Web of Science | Journal Of Knowledge Management |
| 26 | Frederico (2021) | Project Management for Supply Chains 4.0: A conceptual framework proposal based on PMBOK methodology | Web of Science | Operations Management Research |

### 2.3 Dissemination

After concluding the content analysis of the articles listed in Table 2, the main influences of digital transformation or Industry 4.0 on the lessons learned process could be extracted. Most of the cited influences were related to the broader context of project management and not specifically the lessons learned process itself. However, understanding the main objective of the lessons learned process and its relevance and applicability, it was possible to draw a parallel and connect these influences to the lessons learned process specifically. Table 3 summarizes the 09 main influences.

Table 3. Main influences of Industry 4.0 on the Lessons Learned Process

| No | Main influences of Industry 4.0 on the LL Process |
|---|---|
| 1 | Protection and security of data generated by the project |
| 2 | Information transparency and accessibility |
| 3 | Promotion of agile methodology - Collection, analysis, and application of Lessons Learned during the project via retrospectives |
| 4 | Development of new competencies, skills, and attitudes for Project Managers in the context of Digital Transformation |
| 5 | Real-time management of project data and information |
| 6 | Data analysis and interpretation that generate insights and decisions |
| 7 | Data (knowledge) sharing and integration |
| 8 | Integrated project management system |
| 9 | Task automation |

Table 4 categorizes the articles based on their contributions to analyzing the influence of digital transformation on the lessons learned process in project management. Again, it is important to emphasize that some listed contributions were not established directly for the lessons learned process, but rather for general project management. However, given the clear objective and process of lessons learned in projects, it was possible to establish a correlation between the cited contributions and this specific process. Based on the concept-centric matrix (Watson and Webster 2020), Table 4 was created, and it presents the main findings extracted from the literature review. Some listed articles do not contribute directly to the theme but were relevant for understanding the context and the importance of research in this thematic area. Tables 3 and 4, therefore, become relevant for answering our first research question: “How have Industry 4.0 or digital transformation influenced the lessons learned process in project management?”

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Table 4. Listo f Main Findings by article

| No | Authors | Article Title | Main Findings | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 1 | Alkhudary and Gardiner (2024) | Utilizing blockchain to enhance project management information systems: insights into project portfolio success, knowledge management and learning capabilities | x | x | | | | | | | |
| 2 | Podgórska (2022) | Challenges and Perspectives in Innovative Projects Focused on Sustainable Industry 4.0—A Case Study on Polish Project Teams | | | x | | | | | | |
| 3 | Garcia et al (2023) | Creating and Sharing Interorganizational Knowledge Through a Supply Chain 4.0 Project: A Case Study | x | x | | | | | | | |
| 4 | Gibbin et al (2023) | Thematic evolution and trends linking sustainability and project management: Scientific mapping using SciMAT | | | | | | | | | |
| 5 | Wei et al (2024) | Project management for sustainable development: Critical determinants of technological competency for project managers with smart technologies | | | | x | | | | | |
| 6 | Ginigaddara et al (2024) | Conceptualising project management capabilities for offsite construction | | | | | x | x | | | |
| 7 | Ngereja et al | A Retrospective Analysis of the Role of Soft Factors in Digitalization Projects: Based on a Case Study in a Public Health Organization in Trondheim-Norway | | | | | | | | | |
| 8 | do Amaral Gonçalves et al (2020) | AGILE TRANSFORMATION PROCESS IN A BRAZILIAN TELECOM COMPANY | | | x | | | | | | |
| 9 | Nunes et al (2022) | Achieving Competitive Sustainable Advantages (CSAs) by Applying a Heuristic-Collaborative Risk Model | | | | | | x | | | |
| 10 | Khoa and Chinda (2023) | Assessment of Construction Competitiveness through Knowledge Management Process Implementation | | | | | | x | x | | |
| 11 | Liu et al (2023) | Fostering Digitalization of Construction Projects through Integration: A Conceptual Project Governance Model | | | | | x | | | x | |
| 12 | Ngereja et al (2024) | A comparison of soft factors in the implementation and adoption of digitalization projects: a systematic literature review | | | | | | | | | |
| 13 | Daxbacher et al (2023) | Critical success factors in digital transformation projects in the brazilian automotive industry: a qualitative study | | | | | | | | | |
| 14 | Aliu et al (2023) | Towards a New Paradigm of Project Management: A Bibliometric Review | | | | | x | x | | | |

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| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | Zhu et al (2022) | Applications of Smart Technologies in Construction Project Management | | | | | x | x | | | x |
| 16 | Yap et al (2020) | Capitalising knowledge management (KM) for improving project delivery in construction | | | | | | | | | |
| 17 | Al Amri et al (2021) | Towards Sustainable I4.0: Key Skill Areas for Project Managers in GCC Construction Industry | | | x | | | | | | |
| 18 | Russell et al (2023) | The construction-related project management evolution and its future research directions | | | | | | | | | x |
| 19 | Shen et al (2024) | Data analytics for project delivery: unlocking the potential of an emerging field | | | | | | x | | x | |
| 20 | Anshari and Hamdan (2021) | Understanding knowledge management and upskilling in Fourth Industrial Revolution: transformational shift and SECI model | | | | | | | | | |
| 21 | Manuti and Monachino (2020) | Managing knowledge at the time of artificial intelligence: An explorative study with knowledge workers; | | | | x | | | | | |
| 22 | Kanski and Pizon (2023) | The impact of selected components of industry 4.0 on project management | | | | | x | | | | |
| 23 | Zhang et al (2023) | Sustainability and Digital Transformation within the Project Management Area: A Science Mapping Approach | | | | | | | x | | |
| 24 | Gomes et al (2024) | Digital technologies and knowledge management in project context: a systematic literature review | | | | | | | | | |
| 25 | Liu and Zhang (2024) | The role of digital resilient agility: how digital capability incompatibility affects knowledge cooperation performance in project network organizations | | | | | | x | x | | |
| 26 | Frederico (2021) | Project Management for Supply Chains 4.0: A conceptual framework proposal based on PMBOK methodology | | | | | | | | | |

## 3. Results and Discussion

We will describe below how each influence cited in Table 3 occurs in the lessons learned process in project management.

- **The protection and security of data generated by the project, which can be guaranteed through Blockchain technology** - technology that ensures data protection, making it transparent and traceable (Alkhudary and Gardiner 2024) – influences the lessons learned process as it guarantees that lessons generated within projects, which are duly collected and processed, are kept secure over time and safe from possible human errors when editing or deleting information.
- **Information transparency and accessibility, guaranteed through cloud computing, digital platforms, and Blockchain** (Alkhudary and Gardiner 2024), influence the lessons learned process as they facilitate access to information from different teams and facilitate the recording of the learned lesson at different times and locations. From digital platforms or cloud computing, information becomes available and accessible much faster and with a much wider reach, so that lessons generated by other teams can be easily accessed and applied in other projects, like the case presented by Garcia et al (2023), with the implementation of the supplier portal that allowed the exchange of information about projects in an agile and transparent way.

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- **The promotion of agile methodology (in the format of retrospectives)** is an influence of Industry 4.0 as the industry begins to demand a rapid and dynamic flow of information (Podgórska 2022), and agile methodology, specifically the Scrum methodology, proposes a faster way of collecting and applying lessons learned in projects through the Retrospective – a ceremony at the end of each sprint, i.e., recurringly, with the objective of evaluating what went well, what went wrong, and what the team can and should change for the next sprint.
- **The development of new competencies, skills, and attitudes for project managers** is one of the influences of digital transformation in the context of project management in general (Wei et al 2024). Connecting these competencies to the lessons learned process, project managers will need to develop analytical thinking to deal with the high volume of data generated in the context of digital transformation and a skill focused on problem-solving and decision-making to capture insights and learnings based on this data and apply them.
- **Real-time management of project data and information influenced by Industry 4.0** is one of the factors that can contribute to project success (Kanski and Pizon 2023) and, in the context of lessons learned, can allow lessons learned to be captured, analyzed, and applied (if necessary) immediately, reducing the amount of relevant information loss and increasing the speed of response of the project or the project portfolio as a whole, as soon as a lesson learned is detected. The technologies cited in this context are: 1. Big Data, which allows for the capture and storage of an immense amount of data, 2. the Internet of Things – which allows the exchange of data and information between different digital platforms, and 3. the digital platforms themselves, which allow the management of this information in a single location.
- **Data analysis and interpretation that generate insights and decisions** allow the lessons learned process to be more guided, specific, and effective, since conclusions start to be drawn from a large amount of data generated by the projects. Data analysis and interpretation are facilitated by technologies such as: Business Intelligence, Virtual Reality or Augmented Reality, Simulations, and Data Modeling. All of them allow the design and analysis of possible situations and solutions to be applied in projects, without compromising a large amount of time and resources. As suggested by Ginigaddara et al (2024), traditional programming methods should be replaced by data-driven programming based on simulation to reflect risks and uncertainties under the impact of existing constraints in projects. Furthermore, Nunes et al (2022) manage to make this influence tangible by testing a project risk analysis model based on lessons learned from previous projects using a database and BI to analyze and predict whether ongoing projects tend to fail or not.
- **Data sharing and integration** influence the lessons learned process as they allow lessons learned and other data generated in the project to be shared more quickly and broadly across various sectors, teams, and platforms, potentially generating relevant inputs for different areas and processes. Combined software and hardware technologies include robotics, digital platforms, and the Internet of Things for collecting and transmitting data between devices (Somohano-Rodriguez et al. 2022).
- **The integrated project management system** was cited in several articles, mainly focused on the construction industry. Here, the BIM system is the most cited in the articles (Liu et al 2023), (Russell et al 2023), and (Shen et al 2024), as it is the platform that allows the integration of information and management of the project's facts in a single location, accessible from anywhere and by any team member. Analyzing this system from the perspective of lessons learned, these integrated systems stimulate a holistic view of the project and can allow relevant insights regarding problems faced throughout the project, stimulating the process of collecting, analyzing, and disseminating lessons learned. It is obviously influenced by digital platforms, cloud computing, and Blockchain.
- **Task automation, enabled by technologies like artificial intelligence and automation,** can influence the lessons learned process as they can analyze and correlate a database and information from various projects to propose the main lessons or suggest structuring actions that can be taken in future projects. As suggested by Zhu et al (2022), it is possible to use AI to monitor project quality, assisting in the prediction of problems and identification of defects.

The data analysis also shows us the main (most cited) influences of Industry 4.0 on the Lessons Learned Process. We observe that data analysis and interpretation enabling insights and decisions is the most cited influence, and, combined with real-time project data and information management, they account for 42% of the most cited influences (Figure 6).

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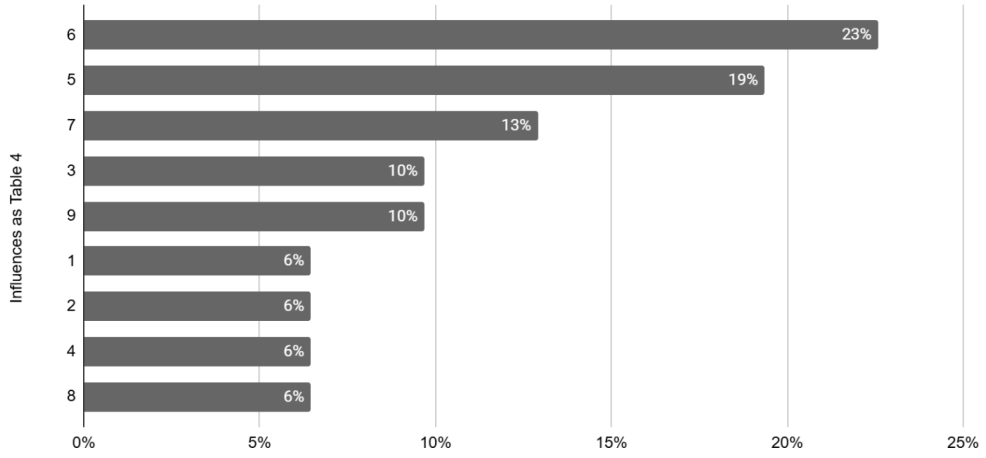


Figure 6. Most cited influences

Also based on the systematic literature review, it was possible to extract the 12 main technologies cited by the articles that somehow influence project management and, consequently, the lessons learned process. These technologies are found and summarized in Table 5.

Table 5. Main technologies promoted by Industry 4.0 that influence the Lessons Learned Process

| No | Main cited Technologies | Description |
|---|---|---|
| 1 | Automation | Automation is the use of technology to perform tasks with minimal or no human assistance. It involves the creation and application of technologies and processes that control and monitor the execution of repetitive, complex, or dangerous tasks, previously performed by people. |
| 2 | Simulation | Makes simulation of a complete production system possible and allows operators to test and optimize machine setups before making any changes in the real world. |
| 3 | Digital Modeling | Digital modeling is the process of creating virtual representations (models) of real-world objects, systems, processes, or concepts using software and computational tools. These models can be two-dimensional (2D) or three-dimensional (3D). |
| 4 | Blockchain | A blockchain is a distributed ledger that records digital assets after being validated securely, transparently, and immutably. |
| 5 | Robotics | System that uses industrial robots or robotic devices that are autonomous, flexible, and collaborative. |
| 6 | Internet of Things (IoT) | Represents a network that promotes communication between objects or devices, using sensors, which results in real-time actions. |
| 7 | Big Data | Represents the practice of revealing hidden information within a large amount of data, collected from various different devices, using advanced analytical techniques (statistics, data mining), which promotes real-time decision-making. |
| 8 | Business Intelligence (BI) | It is the process of collecting, organizing, analyzing, interpreting, and presenting business data to provide insights that help managers, executives, and other end-users make more informed and strategic decisions. |
| 9 | Cloud Computing | Service that promotes data storage, sharing, and access through various devices via the internet. |
| 10 | Virtual Reality (VR) | Information technology that promotes an indirect experience through the creation of a virtual space that interacts with humans through sensory systems. |

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| | | |
|---|---|---|
| 11 | Artificial Intelligence (AI) | Computer programs that consider perceptual learning, memory organization, and critical reasoning, tasks performed by humans that require high-level mental processes. |
| 12 | Digital Platforms | Systems that allow the storage and access of information by different companies, such as supplier portals. |

## 4. Conclusion

The systematic literature review yielded 26 selected articles for analysis, seeking to answer how Industry 4.0 or digital transformation have influenced the lessons learned process in project management. These articles revealed the main influences of Industry 4.0 on project management in general, as few specifically addressed the lessons learned process, thus demonstrating a research gap. Following the analysis of the articles, it was possible to correlate these influences specifically to the lessons learned process, as discussed in the previous section. We see that by promoting digitalization and creating a suitable environment for data generation along the supply chain, Industry 4.0 influences and stimulates processes such as data analysis and interpretation, which generate insights and decisions in projects, potentially oriented towards lessons learned for future projects. Additionally, digital platforms enable real-time data management, allowing the lessons learned process to be captured, analyzed, and applied immediately, reducing the loss of relevant information and increasing the project's response speed when facing errors.

Despite the results obtained, there is still a significant research gap in the area. It is possible to detect some isolated empirical studies that seek to apply specific digital technologies for collecting or disseminating lessons learned, but, as far as could be observed, there is little literature that consolidates these technologies and evaluates their impact on the lessons learned in project management.

### 4.1 Practical Implications

The practical implications are that the main influences and technologies presented in this article can help other researchers and professionals evaluate possible paths and ideas for the collection and dissemination of lessons learned within the industry 4.0 context.

### 4.2 Theoretical implications

The theoretical implications are relevant, given that no systematic literature review was found through the research conducted in the selected databases that specifically relates Industry 4.0 or digital transformation to the lessons learned process. Through the analysis that identifies the main influences of Industry 4.0 on the lessons learned process and the technologies related to each context, the article makes a novel contribution to research in the area of project and knowledge management.

## References

Al Amri, T., Khetani, K. P. and Marey-Perez, M. Towards sustainable I 4.0: Key skill areas for project managers in GCC construction industry. *Sustainability*, vol. 13, no. 15, 2021.

Aliu, J., Oke, A. E., Kineber, A. F., Ebekozien, A., Aigbavboa, C. O., Alaboud, N. S., & Daoud, A. O. Towards a New Paradigm of Project Management: A Bibliometric Review. *Sustainability*. vol. 15, no 13, 2023.

Alkhudary, R; and Gardiner, P. Utilizing blockchain to enhance project management information systems: insights into project portfolio success, knowledge management and learning capabilities. *International Journal of Managing Projects in Business*, vol. 17, no. 4/5, pp. 731-754, 2024.

Anshari, M., & Hamdan, M. Understanding knowledge management and upskilling in Fourth Industrial Revolution: transformational shift and SECI model. *VINE Journal of Information and Knowledge Management Systems*, vol. 52, no 3, pp. 373–393, 2022.

Association For Project Management. APM Body of Knowledge, 6th ed. Association for Project Management, Princes Risborough, UK, 2012.

Bartsch, V., Ebers, M. and Maurer, I. Learning in project-based organizations: The role of project teams' social capital for overcoming barriers to learning. *International Journal of Project Management*, vol. 31, no. 2, pp. 239-251, 2013.

Bosch-Sijtsema, P. M. and Postma, T. J. B. M. Cooperative innovation projects: Capabilities and governance mechanisms. *Journal of Product Innovation Management*, vol. 26, no. 1, pp. 58–70, 2009.

© IEOM Society International

Brady, T. and Davies, A. Building Project Capabilities: From Exploratory to Exploitative Learning. *Organization Studies*, vol. 25, no. 9, 2004.

Chen, L. and Mohamed, S. Impact of the internal business environment on knowledge management within construction organisations. *Construction Innovation*, vol. 8, no. 1, pp. 61–81, 2008.

Daxbacher. E., Meira, S. and Soares, S. Critical success factors in digital transformation projects in the Brazilian automotive industry: a qualitative study. *International Journal of Innovation*, vol. 12, no. 1, 2024.

Downson, C., Unterhitzenbergerb, C. and Bryde, D. Facilitating and improving learning in projects: Evidence from a lean approach. *International Journal of Project Management*, vol. 42, no 102559, 2024.

Drucker, P. F. *Post-Capitalist Society*, New York: Routledge, 2011.

Duffield, S., Whitty, S. Developing a systemic lessons learned knowledge model for organisational learning through projects. *International Journal of Project Management*, vol. 33, no. 2, pp. 311–324, 2015.

Eken, G., Bilgin, G., Dikmen, I. and Birgonul, T. A lessons-learned tool for organizational learning in construction. *Automation in Construction*, vol. 110, no 102977, 2020.

Frederico, G. F. Project Management for Supply Chains 4.0: A conceptual framework proposal based on PMBOK methodology. *Operations Management Research*, vol. 14, no 3–4, pp. 434–450, 2021.

Garcia, F., Grabot, B., & Paché, G. Creating and Sharing Interorganizational Knowledge Through a Supply Chain 4.0 Project: A Case Study. *Journal of Global Information Management,* vol. 31, no. 1, 2023.

Gibbin, R. V., Sigahi, T. F. A. C., Pinto, J. de S., Rampasso, I. S., & Anholon, R. Thematic evolution and trends linking sustainability and project management: Scientific mapping using SciMAT. *Journal of Cleaner Production*, vol. 414, 2023.

Ginigaddara, B., Ershadi, M., Jefferies, M., & Perera, S. Conceptualising project management capabilities for offsite construction. *Engineering, Construction and Architectural Management*. 2024

Gonçalves, M. L. do A., Da Silva, R. A. C., Silva, E. A. C., & Penha, R. Processo de transformação ágil em uma empresa brasileira de Telecom. *Revista de Gestão e Projetos*, vol. 12, no 1, pp. 70–94, 2021.

Habibi, F., Bnouachir, H., Chergui, M. and Ammoumou, A. Industry 4.0 concepts and implementation challenges: Literature Review. International Journal of Advanced Manufacturing Technology, vol. 113, no. 7-11, pp. 2395-2412, 2021.

Hamdi, S., Abouabdellah, A. and Oudani, M. Industry 4.0: Fundamentals and Main Challenges. *Proceedings of the 12th International Colloquium of Logistics and Supply Chain Management*, pp. 1-7, Paris, France, June 12-14, 2019.

Hartmann, A., Dorée, A. Learning between projects: More than sending messages in bottles. *International Journal of Project Management*. vol. 33, pp. 341–351, 2015.

José Lopes Gomes, R., Ferreira da Silva, L., Rezende da Costa, P., & Gonçalves de Oliveira, P. S. Digital technologies and knowledge management in project context: a systematic literature review. *Knowledge Management Research and Practice*, 2024.

Kanski, L., & Pizon, J. The impact of selected components of industry 4.0 on project management. *Journal of Innovation and Knowledge*, vol. 8, no 1, 2023.

Khoa, V. D., & Chinda, T. Assessment of Construction Competitiveness through Knowledge Management Process Implementation. *Sustainability*, vol. 15, no. 22, 2023.

Liu, F., & Zhang, L. The role of digital resilient agility: how digital capability incompatibility affects knowledge cooperation performance in project network organizations. *Journal of Knowledge Management,* 2024.

Liu, Z., Ding, R., Gong, Z., & Ejohwomu, O. Fostering Digitalization of Construction Projects through Integration: A Conceptual Project Governance Model. *Buildings*, vol. 13, no. 3, 2023.

Manuti, A., & Monachino, D. Managing knowledge at the time of artificial intelligence: An explorative study with knowledge workers. *East European Journal of Psycholinguistics*, vol. 7, no. 2, pp.179–190, 2020.

Mcclory S., Read M. and Labib A. Conceptualising the lessons-learned process in project management: Towards a triple-loop learning framework. *International Journal of Project Management,* vol. 35, no. 7, pp. 1322-1335, 2017.

Ngereja, B., Hussein, B., Hafseld, K. H. J., & Wolff, C. A Retrospective Analysis of the Role of Soft Factors in Digitalization Projects: Based on a Case Study in a Public Health Organization in Trondheim-Norway. *Proceedings from IEEE European Technology and Engineering Management Summit (E-TEMS)*, Dortmund, Germany, March 05-07, 2020.

Ngereja, B. J., Hussein, B., & Wolff, C. A comparison of soft factors in the implementation and adoption of digitalization projects: a systematic literature review. *International Journal of Information Systems and Project Management*, vol. 12, no 2, pp. 70–86, 2024.

© IEOM Society International

Nonaka, I. A dynamic theory of organizational knowledge creation. *Organization Science*, vol. 5, no. 1, pp. 14–37, 1994.

Nonaka, I. and Takeuchi, H. *The knowledge creating company: how Japanese companies create the dynamics of innovation*. Oxford University Press, 1995.

Nunes, M., Bagnjuk, J., Abreu, A., Saraiva, C., Nunes, E., & Viana, H. Achieving Competitive Sustainable Advantages (CSAs) by Applying a Heuristic-Collaborative Risk Model. *Sustainability*, vol. 14, no. 6, 2022.

Podgórska, M. Challenges and Perspectives in Innovative Projects Focused on Sustainable Industry 4.0—A Case Study on Polish Project Teams. *Sustainability*, vol. 14, no. 5334, 2022.

Prencipe, A. and Tell, F. Inter-project learning: Processes and outcomes of knowledge codification in project-based firms. *Research Policy*, vol. 30, pp. 1373–1394, 2001.

Project Management Institute. A Guide to the Project Management Body of Knowledge (PMBOK guide), 7th ed. Project Management Institute, Inc., Newtown Square, PA, 2021.

Russell, J. S., El-adaway, I., Khalef, R., Salih, F., & Ali, G. The construction-related project management evolution and its future research directions. *Engineering, Construction and Architectural Management*, 2024.

Shen, Y., Brookes, N., Flores, L. L. and Brettschneider, J. Data analytics for project delivery: unlocking the potential of an emerging field. *International Journal of Managing Projects in Business*, vol. 17, no. 2, pp. 302 – 337, 2024.

Tranfield, D., Denyer, D. and Smart, P. Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. *British Journal of Management*, vol. 14, no 3, pp. 207–222, 2003.

Watson, R. T. and Webster, J. Analysing the past to prepare for the future: Writing a literature review a roadmap for release 2.0. *Journal of Decision Systems*, vol. 29, no. 3, pp. 129–147, 2020.

Wei, F., Hwang, B. G., Zhu, H., & Ngo, J. Project management for sustainable development: Critical determinants of technological competency for project managers with smart technologies. *Sustainable Development*, vol. 32, no. 4, pp. 3654–3677, 2024.

Wijnhoven, F. Operational knowledge management: identification of knowledge objects, operation methods, and goals and means for the support function. *Journal of the Operational Research Society*, vol. 54, no. 2, pp. 194–203, 2003.

Yap, J. B. H., Lim, B. L., & Skitmore, M. Capitalising knowledge management (KM) for improving project delivery in construction. *Ain Shams Engineering Journal*, vol. 13, no. 6, 2022.

Zhang, L., Mohandes, S. R., Tong, Y., Cheung, C., Banihashemi, S., & Shan, M. Sustainability and Digital Transformation within the Project Management Area: A Science Mapping Approach. Buildings, vol. 13, no. 5, 2023.

Zhu, H., Hwang, B.-G., Ngo, J., & Pui San Tan, J. Applications of Smart Technologies in Construction Project Management. *Journal of Construction Engineering and Management*, vol. 148, no 4, 2022.

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