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RESEARCH ARTICLE

A framework for managing projects that integrate 4IR technologies

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Abstract

The Fourth Industrial Revolution (4IR) signifies a new phase in project management. The swift progression of 4IR technologies requires a reassessment of current methods to address the complexities of contemporary project management adequately. The ability of project managers to rapidly adjust to emerging technology and evolving standards is crucial in determining the successful outcome of projects. It is imperative for proficient project managers to recognise the significance of their capacity to predict and respond effectively to these changes, as well as their subsequent effects on ongoing and forthcoming projects, to achieve success in their professional domain. The objective of this study was to examine the effects of the 4IR on the project management discipline. A qualitative technique was employed for the collection and analysis of data. A theoretical framework for project management in the 4IR was developed. The framework identifies (i) what constitutes 4IR projects in terms of characteristics, challenges and success factors, (ii) what skills and competencies are required to deliver these projects, and lastly, (iii) what tools and techniques can be employed to deliver these projects. There is a need for such a framework which offers valuable perspectives and a comprehensive plan for the effective management of 4IR projects, specifically targeting project management professionals.

Keywords

industrial revolutions; conceptual model; characteristics; skills and competencies.

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1. Introduction

A revolution is a change that occurs suddenly; it is drastic in most instances and pervasive (Schwab, 2016). An evolution, on the other hand, is related to the developments that affect a structure over time and it is characterised by continuous and incremental changes in the existing structure (Meyer & Keas, 2011). Within the context of technology, a technological evolution implies a process of enhancement and optimisation of the existing technology rather than the introduction of new frameworks or models (Coccia, 2019), whereas a technology revolution like the Fourth Industrial Revolution (4IR) introduces swift disruptive changes through technologies such as advanced robotics, data analytics and artificial intelligence (AI) that change the ways industries work (Anshari & Hamdan, 2022). The significance and magnitude of advancements associated with the 4IR cannot be disregarded (Li et al., 2017) as they indicate considerable progression and growth in technology and invention, surpassing any previous advancements in human history.

The different Industrial Revolutions have radically influenced the social and economic activities of societies (Easterlin, 2019). The First Industrial Revolution paved the way for the use of the steam engine and mechanisation of products, which in turn enhanced production and the creation of factories (Griffin, 2018). With the Second Industrial Revolution, industry and everyday life were changed and improved by the electrification process. Other notable technological advancements of this era include progress in the internal combustion engine, the integration of electricity into manufacturing and notable breakthroughs in chemical, civil and electrical engineering. The Third Industrial Revolution brought about the digital or information technology age, resulting in an enormous change in the field of information processing and its storage and distribution. Information turned into an important economic product, leading to information economy and knowledge-based industries (Rifkin, 2011). The Fourth Industrial Revolution represents the integration of technologies that blur the boundaries between the physical, digital and biological worlds (Schwab, 2016). These technologies facilitate more effective, accurate and individualised systems (Schwab, 2018). New economic opportunities are created in technology-enabled industries such as technology, health care and financial sectors, resulting in employment in technology-based and skilled positions (Thuemmler & Bai, 2017). Technological developments brought about by the 4IR are expected to result in a significant technological change within the realm of business management, encompassing project management as well (Emejom et al., 2019). However, there are also challenges regarding privacy, security and job displacement resulting from automation (Waidner & Kasper, 2016).

Project management has existed for as long as humans have been on earth (Seymour & Hussein, 2014). Throughout history, several projects were successfully completed despite the difficulties and risks that may have caused the project to fail (Procter & Kozak-Holland, 2019). Most of these projects necessitated a large workforce, big scope, years of work, rigorous planning and flawless execution. Project management in the 1900s was based on the management of construction projects and their successful delivery while mitigating the inevitable risks. The existing literature delineates four significant periods that formed the foundation of project management's advancement: the pre-1958 period, the 1958-1979 period, the 1980-1994 period and the 1995 period (Kwak et al., 2014). The first phase saw the creation of notable milestones, including the Gantt chart, the completion of the Hoover Dam project, the Manhattan project, as well as the Interstate Highway System (Kwak et al., 2014). During the second period, technological advancements emerged and the Program Evaluation and Assessment Technique and Critical Path Technique were also formulated (Seymour & Hussein, 2014). In the third period, personal computers became able to perform multiple tasks simultaneously and therefore software that could be used for handling complex data for projects was developed. With the era of 4IR, there is a greater need once again to develop approaches, tools and techniques to implement and manage 4IR projects effectively, especially in relation to their complex and data-driven nature (Emejom et al., 2019). Project management has played a substantial role in global change since the pre-industrial era. Over the years, projects and project management provided businesses with established techniques and methodologies to achieve specific strategic objectives. Likewise, even in the context of the 4IR, project management is gradually evolving into a strategic process that is increasingly embraced by organisations (Sari et al., 2021).

This study explores the management of 4IR projects, which integrate advanced technologies such as AI, IoT, automation and digital technologies to revolutionise industries and business processes (Lasi et al., 2014; World Economic Forum, 2017). The complexity of these projects, influenced by the integration of 4IR and technology-driven innovations, necessitates an evolution of project management practices and the development of new tools and techniques. The management of 4IR projects varies based on factors such as industry, project scale and organisational context, ranging from extensive transformations in manufacturing to localised technical enhancements in service sectors (Brettel et al., 2017; Lasi et al., 2014). This diversity complicates project management, but the aim of this study is to establish a fundamental framework for managing these projects by identifying essential trends and techniques applicable across various contexts (Pereira & Romero, 2017). The findings highlight general trends in managing projects utilising 4IR technologies, acknowledging that the specific dynamics of individual projects vary based on their unique characteristics (Müller & Voigt, 2018). The 4IR has profoundly transformed project management, requiring significant development in approaches, capabilities and tools (World Economic Forum, 2020). 4IR projects present new challenges and opportunities that differ significantly from conventional project management paradigms. The existing literature lacks a comprehensive understanding of effective project management approaches in the 4IR era. This gap highlights the urgent need for academic research to identify and cultivate the necessary approaches, resources and methods for managing 4IR project complexities. This research enhances academic knowledge and provides valuable insights for practitioners to lead projects effectively in the 4IR. It ensures that project management methodologies align with the requirements of the digital age.

The project management field must undergo further development to adapt to the transformative effects of the 4IR. Project practitioners must have the necessary readiness to navigate these circumstances effectively, as they assume the responsibility of overseeing and executing technology-driven initiatives that seek to enact transformative changes within businesses (Emejom et al., 2019). It is now advised that the existing tools, techniques, skills and competencies are inadequate in addressing the necessary and obligatory evolution required in this particular context. This paper aims to address this deficiency by presenting a conceptual framework for project management in the context of the 4IR. The results and conclusions, derived from a comprehensive assessment of existing literature, provide valuable insights for both project management practitioners and academics. Specifically, these insights aim to enhance the understanding of how the management of projects in the context of the 4IR is influenced by the transformative changes brought about by the 4IR. The aim of the research was to develop a conceptual framework for effectively managing projects that leverage 4IR technologies, denoted as 4IR projects. The following research objectives were identified as key areas to be explored to achieve the study's main research aim:

- Research objective 1: Re-evaluate how projects are transforming in the era of the 4IR.
- Research objective 2: Identify characteristics of 4IR-enabled projects.
- Research objective 3: Determine 4IR project management tools and techniques.
- Research objective 4: Analyse skills and competencies for 4IR project success.

To investigate and address these research objectives, a systematic literature review (SLR) approach was adopted to examine the impact of the 4IR on project management and present a synthesis of the current literature. SLR is a process known for its rigour and reproducibility in searching, selecting, appraising and synthesising existing research articles to answer a set of research questions (Liao et al., 2018; Siddaway et al., 2019). After a comprehensive comparison of top project management journals, the SLR and analysis were conducted on articles published in the *International Journal of Project Management (IJPM)* between 2011 and 2021; this is a period that marked the inception of the 4IR as a transformative concept (Bahrin et al., 2016; Dopico et al., 2016). This study employed a coding system where the analysis was guided by a coding framework developed in line with the study research objectives. The framework entailed pilot testing, a cycle of modifications and systematic coding of 1,214 articles, and made use of auto coding and code-by-search to code the dataset. The dynamic process facilitated the periodic identification of patterns, trends and emerging themes which led to the formulation of a conceptual framework that illustrates the important technical and soft competencies in

managing 4IR projects. This research methodology process ensured that the analysis was transparent, can be easily reproduced by other researchers and provides sufficient comprehension of the effects of the 4IR on the practice of project management.

The remainder of the article is divided into five sections. The literature review provides insights into 4IR projects. The research methodology explains in detail the process that was followed to select the articles as well as the coding process. The third section presents the analysis of the articles based on the codes and themes. A conceptual framework derived from the results is presented in the fourth section. The fifth section concludes the article.

2. Literature review

The rate at which projects are transitioning and evolving by integrating technologies such as AI, robotics, cloud computing, IoT and other related technologies is experiencing significant acceleration. According to Whitmore et al. (2020), the process of project transformation is predominantly observable in large-scale projects conducted in diverse sectors, including construction, manufacturing, agriculture, mining and ICT. They examined two main factors that have had a substantial impact on project management. The factor discussed here pertains to the dramatic advancements in digital technology, which significantly alter the interactive and collaborative environment within which projects are carried out. There has been growing public sentiment toward recognising the urgent importance of prioritising human-centred factors, such as ensuring the safety and well-being of employees (Janse van Rensburg et al., 2019).

4IR projects are oriented around people's psychological needs and pay attention to their human-centred needs (Abbasi & Jaafari, 2018). 4IR projects are centred on design thinking, consumer empathy and iterative designs where there is a focus on the user's expectations, needs and obstacles. These projects take into account the changing workplace environments by leveraging the current shift of employment and employing flexible work schedules (Whitmore et al., 2020). Abbasi and Jaafari (2018) agree with the notion that numerous conventional projects fail to address fundamental human-centred considerations, such as equality, diversity, inclusivity, mental health and welfare. This deficiency poses a significant obstacle to the successful management of projects in the context of the 4IR.

The embedding of 4IR technologies in projects is increasing (Güngör, 2019). Within the IT sector specifically, projects undertaken seem to be transitioning by integrating technologies such as full automation and robotics, application of AI, as well as the move to cloud-based platforms, making cloud computing the dominant form of 4IR technology used across this industry (Berawi, 2018). This transformation in projects forces project management as a discipline to evolve. This evolution is critical for a thorough understanding of 4IR projects and their major challenges, the skills and competencies, as well as effective tools and techniques required to deliver 4IR projects. Agile as a mindset for managing IT projects has been one principal strategy to respond to the current digitalisation and globalisation models (Emejom et al., 2019; World Economic Forum, 2017).

The future of managing projects in the 4IR is about the necessity to grasp digital competencies (Janse van Rensburg et al., 2019). The 4IR focuses on integrating products, services and multiple technologies that allow ecosystems to work intelligently and autonomously (Santos et al., 2017). In the opinion of Marnewick and Marnewick (2021), essential competencies have changed from manual to digital. The demand for physical talents is currently declining, as the labour market moves towards cognitive, social and digital competencies. As the world progresses further into the 4IR, the need for digitally competent skill sets becomes increasingly crucial (Liu et al., 2024). Furthermore, the level of technological interaction within a team is also another factor to consider, which varies depending on the generations team members were born into (Marnewick & Marnewick, 2020). Regarding project management, project managers of the 4IR are required to administer project management tasks as well as manage the ever-evolving digital transformation. Cakmakci (2019) reiterates that when such a task is properly performed, project management duties supplemented by technology may

enhance agile teams, increase team member well-being and support the implementation of better organisational procedures and practices.

3. Research methodology

A comprehensive SLR was undertaken to examine and understand evolving trends at the convergence of the 4IR and project management. The review was done to uncover existing knowledge on how 4IR is reshaping project management, including its approaches, practices, competencies and techniques.

The Scopus database was chosen as an online database to identify the journals from which to review the data. The Scopus online database has many merits specifically necessary for the required datasets of this study. Firstly, it offers an interdisciplinary field coverage feature, which is beneficial for gaining a broader view and definition of the focus journals (IOWA State University Library, 2018). Secondly, Scopus offers the largest abstract and citation database of peer-reviewed literature; this is inclusive of scientific journals. In addition, it provides smart tools that track, examine, analyse and visualise research. From Scopus, a search for the best-reviewed journal rankings was conducted (Elsevier, 2019). The top three journals within the project management area were selected based on Scopus results on a combination of factors including the cites score, percentile, citations, SNIP and SJR findings. These findings are given in Appendix 1. Once the top three journals were identified, the list was exported for further analysis.

Further analysis aimed to search for the highest impact peer-reviewed journal within the project management field. To construct the dataset for the analysis, a comparison of the top three peer-reviewed project management journals was made. This examination and comparison of top project management journals was done to determine which journal rated the best according to the following criteria: (1) Journal impact factor, (2) quartile and (3) Eigenfactor score.

- Journal impact factor (JIF) is a subset of citation analysis that is used to classify or rank journals according to their comparative relevance (Journal Citation Report, 2021). JIFs are based on the notion that journals with a high JIF publish articles that are cited more frequently than journals with a low JIF. The most credible and well-known source on JIFs, according to Martín-Martín et al. (2018), is the Thomson Scientific's Journal Citation Reports (JCR), which is an annual release.
- Quartile is a rank of a journal or manuscript based on the journal's combination rates of impact factor, citations as well as indexing, showing its performance and rank in the year's four quarters (Journal Citation Report, 2021). A high Scopus quartile indicates that the journal is influential in research and that its researchers are highly qualified and experienced in the specific field.
- Eigenfactor score (EFS) is a ratio of the total citations to the overall number of publications (Bergstrom, 2007). The EFS counts and incorporates all citations in journals, including both in the sciences and the social sciences, while excluding self-citations. Both the Eigenfactors and impact factors are often used for evaluating the value and significance of a journal (Haley, 2019). They do not, however, measure the same thing and therefore cannot be used interchangeably.

These three criteria were applied to determine which journal should be used for deriving the dataset. The results are listed in Table 1.

Table 1: Summary of comparison of top three project management journals

Journal	Impact factor	Quartile	Eigenfactor score	Total cites
International Journal of Project Management (IJPM)	7.172	Q1	0.007320	13.640
Project Management Journal (PMJ)	3.570	Q2	0.002030	2.668
International Journal of Managing Projects in Business (IJMPiB)	2.634	Q3	0.001240	1.242

Based on the results of Table 1, the *IJPM* was the peer-reviewed journal selected. The process for the data collection and analysis consisted of the following steps:

1. **Data extraction:** All articles across all volumes of the *IJPM* from 2011 to 2021 were extracted and downloaded. The year 2011 was chosen as the starting point, as it marks the emergence of Industry 4.0 as a concept (Vogel-Heuser & Hess, 2016), initially introduced in Germany to describe changes in automation and IT integration (Ortiz, 2020). This resulted in a dataset of 1 214 journal articles.
2. **Data organisation:** The articles were imported into Atlas.ti version 22, which is qualitative data analysis software, where they were grouped by publication date for systematic review.
3. **Development of coding framework:** A coding framework was developed based on the study's four research objectives. These objectives guided the creation of predefined codes, which were mapped to key concepts aligned with the research constructs. These predefined codes were entered into Atlas.ti for systematic application during the analysis.
4. **Pilot coding and refinement:** To assess the validity of the coding framework, a pilot coding process was applied to a small sample of articles. This step allowed for testing the initial framework and making the necessary improvements to enhance the system's accuracy and consistency.
5. **Systematic coding:** After refining the coding framework, the entire dataset was reviewed systematically. Each article was read in detail, and relevant codes and subcodes were applied to the pertinent text fragments. Atlas.ti's auto-coding, code-by-search and code-by-list features were used to expedite the process, ensuring efficient and comprehensive coding of the dataset.
6. **Dynamic and iterative coding process:** The coding process was dynamic, allowing for adjustments as new insights emerged. As additional patterns and themes were identified, new subcodes were created under the major research objectives. This iterative process ensured that the analysis was flexible and capable of capturing evolving trends in the literature.
7. **Synthesis and organisation of key findings:** Once the qualitative analysis was complete, the coded data were synthesised and organised to extract the key findings. The systematic coding process allowed for comprehensive organisation and identification of important trends, ultimately facilitating the development of a conceptual model for managing 4IR projects.
8. **Establishment of supplementary categories and codes:** To further support the research objectives, supplementary data categories and codes were created. These categories complemented the primary objectives and provided additional context for understanding the relationship between 4IR and project management.

By applying this methodology, the analysis enabled a thorough and structured review of the literature, uncovering emerging patterns and trends. This process was essential for providing insights that directly informed the research objectives and the development of the study's framework. Based on the four research objectives, supplementary data categories and codes that supplement the objectives as per point 3 were established (see Table 2).

From the analysis, 130 codes and subcodes, with 394 corresponding quotations were derived and presented as per Appendix 2 (detailed analysis is too extensive to present in an article, and is therefore available on request). Findings and detailed discussions on the findings are presented and explained in the following sections. For the interpretation of the findings, it is crucial to note that one article reviewed as part of the literature is representative of one project for the findings.

Table 2: Qualitative analysis codes

Research objective	Pre-defined code	Subcodes
Re-evaluate how projects are transforming in the era of the 4IR.	Transformation in terms of increase and change in projects	Project type Project industry Year of publication
Identify characteristics of 4IR-enabled projects.	Change in the nature and form of projects	Project characteristics Project challenges Project success factors Transformation into 4IR evidence Complexities in projects
Determine 4IR project management tools and techniques.	Transformation of project management as a discipline Effective project management tools and techniques	Project management technique Project management tools Communication techniques
Analyse skills and competencies for 4IR project success.	4IR project management transformation in terms of skills and competencies	Project management competencies Project management skills

4. Findings and interpretation

4.1. The transformation of projects in the 4IR era

Throughout the course of the four Industrial Revolutions, there has been a successive introduction of novel projects that predominantly incorporate ideas and technology relevant to the respective period and era (Whitmore et al., 2020). The 4IR has been characterised by significant advancements in technology which have served as the primary catalysts for transformative undertakings. The field of IT has emerged as a fundamental component in the ongoing technological revolution, playing a pivotal role in the overall transformation brought about by the 4IR. Ortiz (2020) posits that the technological advancements driving the 4IR encompass AI, IoT, robots and automation, cloud computing and quantum computing, with IT serving as the facilitating mechanism. The dynamic role of IT as a vital component in emerging technologies has enabled the discipline to transition from a mere facilitator to a key driver of strategic initiatives within organisations (Whitmore et al., 2020).

To determine if projects are transforming through the integration of IT across various industries, an analysis of the coded dataset as per the methodology section was conducted. This analysis was performed by cross-mapping all the project types that were identified against the industries in which they were classified. The objective of this analysis was to ascertain which types of projects have been executed based on the dataset, as well as to identify the industries that undertook these projects. The analysis helped provide an understanding of the rate at which projects are transforming through the integration of new technologies and/or IT across various industries, with IT demonstrating a transformative force in projects related to the 4IR. The findings are illustrated in Fig. 1.

Based on the observations made in Fig. 1, it is evident that the dataset consisted of various articles that studied projects across various industries, with notable representation being articles focusing on construction, manufacturing and IT. The findings further show that the different articles reviewed covered various types of projects across those various industries as per the dataset. From the findings, there was less representation of articles on industries such as energy, finance and agriculture. These findings contribute to the comprehension that projects have been pursued consistently across diverse businesses since 2010. To fulfil research objective 1, a cross-analysis was conducted between the coded industries and project categories.

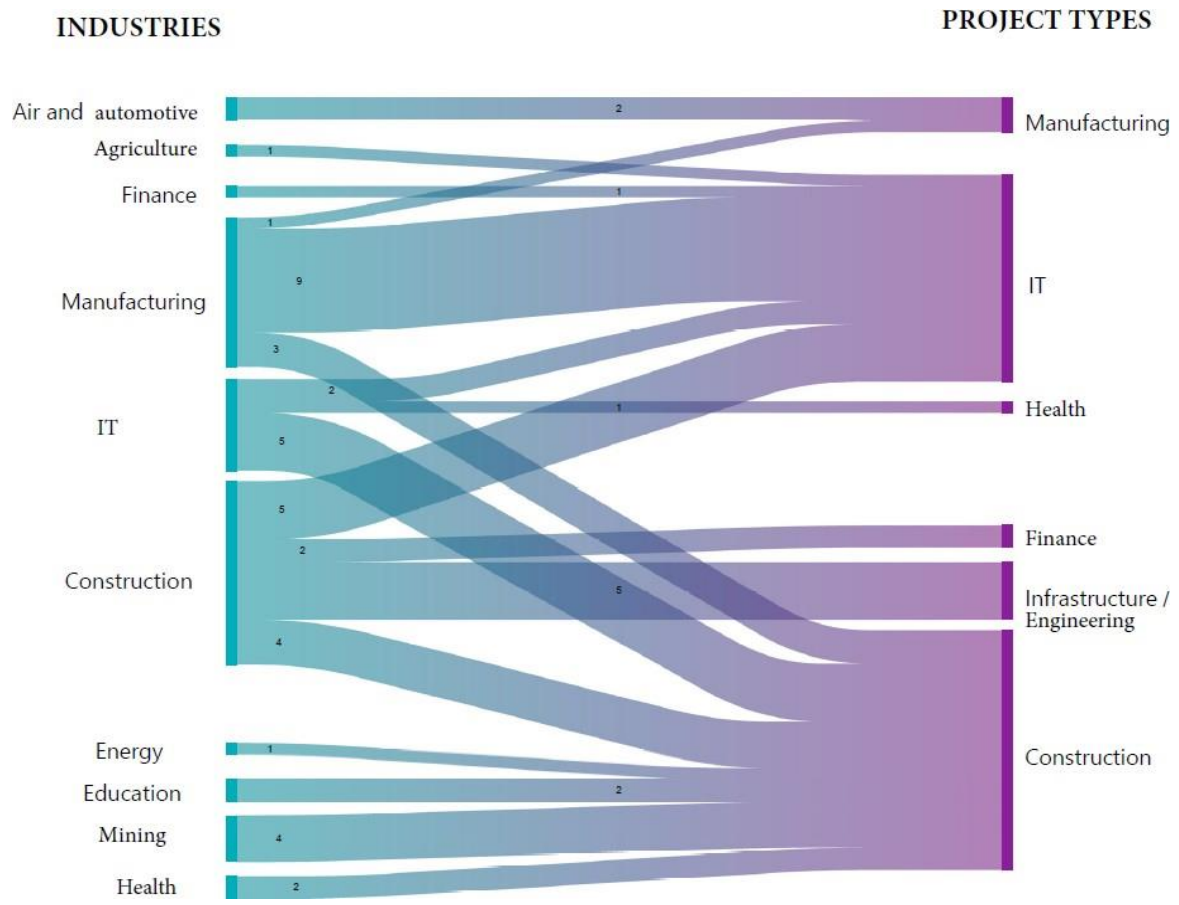

Fig. 1. Industries mapped against project types (2010 – 2021)

The analysis yielded the following observations:

- Most projects implemented were in the manufacturing sector. This observation is rather interesting as it aligns with the existing literature that initial implementation of new technology-driven projects was mostly in the manufacturing sector (Liu & Xu, 2017; Nigappa & Selvakumar, 2016). According to the literature, the integration of IT and new technologies within manufacturing subsequently led to the advancement and evolution of manufacturing projects, fuelling the change and evolution of manufacturing, which was labelled as Industry 4.0 (Cebeci, 2019). Industry 4.0 propelled the integration of these new technologies in other sectors and industries, revolutionising these industries and fuelling the 4IR (Schwab, 2018). From these findings, the significance and impact of IT as a transformer to digitalisation within the manufacturing sector are clear.
- The significant role of IT is also observed in the construction industry. This observation provides an understanding of the growing importance of IT across other sectors. The construction sector has seen significant integration of new technologies in projects and these have been in the form of autonomous construction machinery as well as AI-driven project tools and techniques. Like the manufacturing sector, these transformative undertakings have been radical enough to fuel a new form of construction sector referred to as Construction 4.0 (Bröchner, 2021; Schönbeck et al., 2021). The impact and significance of IT's role in transformation construction projects is immense (Cao et al., 2017).
- Thirdly, the significant representation of projects being undertaken is shown to be by the IT sector itself. These findings are quite expected since for the 4IR to be emerging, transformation within the IT sector itself had to have

taken place. The importance of IT in the transformation of the world, propelling transformations of other sectors, is a crucial finding that validates the growing significance of IT as a strategic driver in organisations (Colin et al., 2015).

Projects in the 4IR era span various industries, with significant representation in construction, manufacturing and IT. Radical technology innovation and the 4IR impact projects differently across industries. Publications emphasise technological innovations and infrastructure enhancement, reflecting industries' pivotal role in embracing and advancing 4IR technologies such as automation and data-centric solutions. However, research underrepresents energy, finance and agriculture, highlighting potential study gaps. The dataset shows consistent project investigation across diverse industries since 2010, illustrating the 4IR's extensive influence on project management and objectives. These findings provide a fundamental understanding of how the 4IR influences project environments across many sectors.

4.2. Characteristics of projects in the era of 4IR

The second objective was to gain an understanding of the traits and characteristics exhibited by projects which have undergone significant alteration because of the extensive incorporation of 4IR technology. This necessitates modifications to the tools, processes and abilities utilised for management, since they include novel qualities that give rise to new success factors and problems. To understand the evolution of certain projects comprehensively, it is necessary to initially grasp the factors that contribute to or serve as catalysts for change in such projects. In this particular instance, the transformative role of IT in projects is examined (Sari et al., 2021). 4IR projects encompass various groundbreaking technologies, including AI, IoT, automation and machine learning. Analysing articles on 4IR project management requires evaluating IT, as it underpins the implementation of advanced technologies key to 4IR. A robust IT environment is essential for effective 4IR project implementation (World Economic Forum, 2019). Analysing IT as a transformative catalyst reveals how technological infrastructure facilitates the transformation and innovation characteristic of 4IR projects. This understanding aids in identifying critical challenges and optimal methods for managing complex, technology-centric requirements and demands in 4IR projects. It also provides insights into the unique features, qualities and success criteria associated with such projects (Hussein, 2019; Ning & Ling, 2015; Pellerin et al., 2014; Tadayon & Andersen, 2021).

The codes and subcodes created under the second research objective were taken into consideration. The quotations from the literature that fell under these various codes and subcodes would help determine if there is indeed transformation of projects. The codes that are part of the findings, as discussed in the methodology section, inclusive of 'project characteristics', 'project challenges', 'project success factors' and 'transformation into 4IR evidence', were then adopted as critical impact factors, and labelled as impact factors 1 to 4, so that all information contained in the quotations, as findings under these codes, was presented accordingly. After the analysis of the dataset and categorisations of quotations under the codes and subcodes as per Appendix 2, the findings are as follows:

- **Impact Factor 1 - IT as a 4IR catalyst in projects:** The expansion of emerging markets, the swift rise of new technology, new environmental policies and shifting consumer expectations contribute to tremendous changes in today's economies, propelling the emergence of a new industrial revolution (Schwab, 2016). Governments and industries have been forced to make efforts to adapt successfully to this transition, and these initiatives have usually taken the form of new projects because of the transition into the "new" world (Whitford et al., 2020). Various industries have responded to the call for technological demands by incorporating new technologies into their processes and projects to increase productivity and efficiency. Table 3 illustrates the findings on 4IR projects regarding the digitalisation of projects.

Table 3: Transformation of projects in 4IR by IT

Industry	4IR techniques & technologies in projects	Compiled from the following articles
IT	Augmented reality Cloud AI	(Costantino et al., 2015), (Rezvani et al., 2018), (C. Wang et al., 2016)
Construction	Construction 4.0 technologies such as building information modelling (BIM) Offsite construction technologies Green and sustainable structures Smart city technologies and development, i.e. robotics	(Chen et al., 2015), (Oraee et al., 2019), (Zhu & Mostafavi, 2017), (Almahmoud et al., 2012)
Manufacturing	Smart manufacturing techniques are addictive manufacturing and robotics Industry 4.0 technologies, i.e. AI	(Stjerne et al., 2019), (Füller et al., 2021)

The findings indicate that the transformation of projects was through the embedding of new technologies such as cloud technologies, AI as well as augmented reality. Furthermore, advanced digital transformation in the form of integrating various technologies that make up smart manufacturing as well as Industry 4.0 technologies is demonstrated in the findings, specifically in the field of manufacturing where IT as a driver is changing and transforming projects. In addition, the same observation can be made in the construction space where 4IR technologies are transforming projects to form new industry concepts such as Construction 4.0. and Industry 4.0 (Ginigaddara et al., 2021; Schönbeck et al., 2021; Stjerne et al., 2019). It is important to further determine what critical success factors, challenges as well as characteristics are present in 4IR projects. Findings on the analysis are discussed the following sections and presented in Table 4.

- **Impact Factor 2 (Critical success factors):** Critical success factors are the components of a project that ensure that all the project's objectives are met (Banihashemi et al., 2017; Totten, 2017). Critical success factors concentrate on what must be accomplished and how it will be accomplished in areas such as cost, quality and customer satisfaction.
- **Impact Factor 3 (Project challenges):** Effective project management requires the effective management of uncertainty and also the ability to deal with a variety of challenges (Pajares et al., 2017). Project challenges are factors that have some likelihood of hindering successful delivery of any project (Pajares et al., 2017). They can originate from a variety of areas and have significant implications for projects (Akhavan-Tabassi et al., 2019). Project planning, information systems, team dynamics, client satisfaction, innovation, communication and quality are examples of such challenges, and they are not unique to a particular industry. More comprehensive efforts are required to identify and address the origins of these challenges (Akhavan-Tabassi et al., 2019). These efforts must consider the project managers' competencies as well as the maturity of the company, including the continuous learning abilities of the project teams.
- **Impact Factor 4 (Project characteristics):** Characteristic refers to a feature or attribute of quality that belongs to a specific entity or object (Pellerin et al., 2014). Project characteristics refer to distinguishing qualities and traits of projects depending on their specific nature and surroundings (Tadayon & Andersen, 2021). There are shared traits recognised about projects that distinguish them from other projects in the corporate context. One of these common features is the notion that projects are temporary endeavours that are unique and have a specific primary goal (Ning & Ling, 2015).

Table 4 illustrates the findings on 4IR critical success factors, challenges as well as characteristics as per the dataset.

Table 4: 4IR critical success factors, challenges and characteristics

Success factors	Compiled from the following articles
▪ A positive relationship between cultural factors such as collectivism, risk tolerance and positive work environment ▪ Effective stakeholder management ▪ Effective IT governance mechanisms ▪ Social alignment that supports and extends on previous work ▪ Effective risk assessment, mitigation, control and management ▪ Resource and project product transparency ▪ Close collaboration ▪ Team orientation ▪ Top management support ▪ Client participation ▪ Create quality indicator requirements and link them to the managers' goals ▪ Clearly defined overall strategic plan ▪ Effective communication ▪ Mechanism for cross-functional coordination ▪ Establishing a culture of cooperation and partnership throughout the life cycle process ▪ Clearly established project specifications and scale ▪ A well-defined project and contractual structure ▪ A capable and skilled project management team, including a principal and senior project manager ▪ Project management standards and procedures ▪ Aligned project team's commitment, cooperation and competence ▪ Effective management of scope, cost, quality and risk, communication in human resource and management ▪ Achieving the project's performance goals	(Gu et al., 2014), (Missonier & Loufrani-Fedida, 2014), (Terlizzi et al., 2016), (Gilchrist et al., 2018), (Neumeier et al., 2018), (Stettina & Hörz, 2015), (de Bakker et al., 2010), (Sirisomboonsuk et al., 2018), (Sun & Zhang, 2011), (Cserháti & Szabó, 2014)
Project challenges	**Compiled from the following articles**
▪ Extremely tight timelines ▪ Teams work on multiple projects at the same time ▪ Some developers also function as project manager ▪ Lack of deep understanding of the various project management methodologies ▪ No procedures in place to ensure good governance ▪ Lack of conformance to the project governance standards ▪ Difficult to get a clear goal for the project ▪ The amount of risk that the company is willing to accept when it comes to new technologies integrated in projects is high ▪ If clients make a special request for specific new technology to be employed, this raises complexity ▪ As the IT sector evolves, project managers are faced with new challenges and are required to take on jobs that have not previously been part of their responsibilities ▪ In comparison to projects with external, visible risk variables, IT projects are more prone to risks as they have internal risk factors	(Einhorn et al., 2019), (Marnewick & Labuschagne, 2011), (Hwang & Ng, 2013), (Jani, 2011)

Project characteristics	Compiled from the following articles
▪ Project success depends on digital intelligence ▪ Project success depends on technical and non-technical expert skills ▪ Projects are complex and ambiguous in nature ▪ Because there is considerable uncertainty, managing risk successfully is always a challenge ▪ Integration and digital competence is fixated and success dependent ▪ Start and finish timeframes are set but usually not achieved ▪ Initial budget and cost definitions are set but usually not achieved ▪ Specific end goal ▪ Integrate some 4IR technology driver to symbolise transformation, mostly cloud computing ▪ Project environment has various stakeholders	(C. Wang et al., 2016), (Sun & Zhang, 2011), (Sanchez et al., 2017), (Kanwal et al., 2017), (Liang et al., 2012), (Caniëls & Bakens, 2012), (Lieftink et al., 2019), (Wang et al., 2017), (Pellerin et al., 2014), (Marnewick & Marnewick, 2021), (Terlizzi et al., 2016)

Certain factors that constitute success factors, challenges and characteristics are not exclusive to 4IR projects, but have been inherited from traditional projects, maintaining relevance throughout different types of projects. It is also clear that projects leveraging innovative technology have unique success factors, challenges and characteristics. This emphasises the importance of a holistic approach to project management, acknowledging the continuity of certain factors across projects while simultaneously addressing the demands of projects driven by new technologies.

- **Success factors:** Knowledge and adequate comprehension of projects' crucial success factors allow individuals leading the project to focus on what is important, and to monitor and direct the project's success (Yu & Kwon, 2011). From the findings, critical success factors for 4IR projects include stakeholder engagement and management, adequate knowledge of project management standards, as well as effective client collaboration and participation. Understanding these success factors is vital, specifically because these kinds of projects are emerging worldwide. A sound understanding of what constitutes critical success factors for 4IR-driven projects would allow project managers and teams still trying to fully conceptualise the nature of these projects to effectively map out strategies towards their successful delivery. In brief, understanding and knowledge of critical success factors are crucial aspects of any project life cycle, as successful delivery and closure of the projects can then be planned for and crafted during the project planning and initiation stages.
- **Project challenges:** In addition, a knowledgeable view of different project challenges for specific kinds of projects is also important for project success. Project teams can address challenges with a knowledgeable view that paves the way for successful delivery of not only current projects, but future projects as well. Some of the notable challenges from the findings include inadequate risk management at the beginning of projects, which, according to the literature, can hinder successful project delivery from as early as the project planning phase (Jani, 2011). Furthermore, challenges such as unclear project deliverables and lack of conformance to IT project governance standards seem to also be some noticeable challenges inherent in these new kinds of projects. Therefore, effective mechanisms to handle such challenges would need to be evaluated and established since the 4IR is still in its emerging stages, and projects leveraging on its technologies are yet to be funded and implemented.
- **Project characteristics:** Common characteristics in projects are factors that make an activity a project as opposed to an ongoing operation within an organisation (Pellerin et al., 2014). The need to understand the characteristics shared by 4IR projects is an immense one, since this equips project management professionals with adequate knowledge of the scope of challenges to expect with such projects. Shared characteristics of these projects include being integration dependent, risky as well as mainly innovation driven; these are just a few examples of characteristics project management professionals can try to study and fully understand to later map out constructive techniques in handling and managing these projects. Adequate understanding of specific project characteristics is crucial not only to facilitate effective, proper management of these projects, but also provide possibilities of determining techniques that work and those that do not in managing these projects. This process would not only facilitate improved competency of project teams, but also pave the way for the project management

discipline to improve and evolve. Understanding the characteristics of 4IR projects is also crucial as it forms part of a better understanding of the successful delivery of these projects.

Regarding the critical success factors of 4IR projects, the study notes that their success is influenced by a confluence of cultural, organisational and managerial factors. Critical success factors encompass cultivating a constructive workplace atmosphere and adopting cultural attributes such as collectivism and risk tolerance. Efficient stakeholder management, client engagement and collaboration are crucial for synchronising project objectives with stakeholder expectations. Proactive risk assessment, resource transparency and robust IT governance safeguard project integrity, while explicit strategic planning, well-delineated project specifications and strong executive backing establish a firm foundation for project execution. Moreover, proficient communication, interdepartmental collaboration and a competent project management team are essential for sustaining alignment and attaining performance objectives, thus guaranteeing the overall success of 4IR initiatives.

Moreover, 4IR projects encounter numerous challenges, such as stringent timelines and the need to manage multiple projects concurrently. Many team members, particularly developers, are required to take on dual roles, such as acting as project managers, which can lead to conflicts in focus and priorities. There is frequently an inadequate comprehension of project management approaches and insufficient protocols for assuring appropriate governance and compliance with project governance requirements. Establishing clear project objectives can be challenging, and a heightened risk tolerance for the incorporation of novel technologies exacerbates the complexity, particularly when clients demand specific technological solutions. The growing IT sector introduces new issues for project managers, necessitating the management of tasks beyond their conventional scope. IT projects are also more prone to internal risks compared to projects with visible external risks, further complicating management and execution.

Lastly, regarding characteristics, 4IR projects are specifically distinguished by their dependence on digital intelligence and a combination of technical and non-technical expertise for successful outcomes. These projects are intrinsically complex and ambiguous, characterised by substantial uncertainty, rendering risk management a formidable challenge. Successful project outcomes rely on integration and digital proficiency, with a predominant focus on technology-driven transformations, especially in cloud computing. Although start and finish timeframes, along with initial budgets, are established, they are often not adhered to. A defined objective directs the project; nevertheless, its attainment is hindered by the dynamic characteristics of 4IR project environments. Moreover, these projects encompass multiple stakeholders, necessitating meticulous administration and coordination.

4.3. 4IR project management tools and techniques

The incorporation of 4IR technologies into current projects and project management tools and techniques is enhancing the development, implementation and management processes of the project life cycle (Emejom et al., 2019). These advanced and innovative technologies are also changing and intensifying the scope and complexity of projects tremendously. These developments add ambiguity to projects and make projects more unpredictable and dynamic (Camci & Kotnour, 2019). Adapting and developing new tools and techniques is crucial, especially as the 4IR is still in its emerging stage (Güngör, 2019). Coding was done to determine which project management tools and techniques have been employed in projects. The findings are presented in Table 5.

Table 5: Project management tools and techniques

Tools & techniques	Compiled from the following articles
▪ Techniques ▪ IT governance mechanisms ▪ Quality assurance ▪ Risk management ▪ Stakeholder management ▪ Fuzzy risk evaluation ▪ Lean thinking ▪ Tools ▪ Network and information modelling ▪ Decision support systems ▪ Social media communication tools ▪ STEEP tool	(Shmueli & Ronen, 2017), (Sudhaman & Thangavel, 2015), (Neumeier et al., 2018), (T. Wang et al., 2016), (Hazır, 2015), (Zhang et al., 2018), (Boateng et al., 2015)

The analysis demonstrates that certain project management tools and practices are universally applicable to both traditional and new projects, maintaining their relevance.

Technology-driven projects consistently adhere to established project management strategies such as IT governance, risk management and lean thinking practices. Given that most of the techniques emphasised in the findings have been present in previous Industrial Revolutions, the next stage of action involves identifying the specific project management environments in which these techniques can be employed. One of the aims of this study was to determine effective techniques that can facilitate the successful execution of IT projects that integrate 4IR technologies. The same sentiments apply to the identified tools. It is imperative to not only recognise these technologies as essential in new projects, but also to substantiate the project management environments in which they would function to establish foundational principles for executing these projects effectively. The research on the impact of this transformation on project management tools and processes is of the utmost importance at present, given the ongoing growth of the 4IR, which is expected to take several years to reach a mature state.

In essence, 4IR projects frequently depend on a combination of project management techniques such as governance, quality and analytical methodologies in conjunction with specific technical tools. Essential techniques encompass IT governance mechanisms that guarantee alignment between project objectives and organisational policies, quality assurance to uphold elevated standards throughout the project life cycle, and risk management, which integrates fuzzy risk evaluation to address ambiguous or swiftly evolving threats. Stakeholder management facilitates good communication and alignment across various parties, whereas lean thinking prioritises efficiency and ongoing enhancement. In terms of tools, network and information modelling and decision support systems assist in the assessment of sophisticated data for informed decision-making, social media communication tools enable real-time collaboration and feedback, and the STEEP (Social, Technological, Economic, Environmental and Political) tool provides a systematic framework for environmental scanning and strategic planning in dynamic 4IR environments.

4.4. Skills and competencies for 4IR project success

The transformation to the 4IR necessitates a focus on innovation, specifically in relation to projects initiated in response to this transformation (Jally et al., 2021). A shift in skills and competencies is required to effectively execute projects driven by innovation (Anshari & Hamdan, 2022). Several scholars have emphasised the importance of future-oriented competencies. Marnewick and Marnewick (2021) believe that the acquisition of new competencies is contingent upon intelligence, with emotional and social intelligence playing a particularly essential role. Digital intelligence is increasingly recognised as vital in the context of humanity's transition into the 4IR (IEEE, 2021; Liu et al., 2024).

The work of project managers on technology-driven projects involves more complex responsibilities beyond the mere planning and tracking of project activities (Doğan & Derici, 2019). The acquisition of digital competencies within a project context entails several key aspects (Marnewick & Marnewick, 2021). These include the cultivation of digital empathy, the establishment of a balanced approach to technology utilisation and the ability to facilitate productive online interactions and conversations. The identification of the project management role as a crucial leadership position necessitates the recruitment of proficient professionals who have a unique skill set and extensive expertise, which cannot be replicated by project management software (Project Management Institute, 2021). Effective communication with stakeholders at every step of the project and proactive thinking are essential attributes for a project manager. According to Zaman et al. (2019), project managers must possess certain essential talents to manage projects effectively that are centred on digital technologies. These skills include the ability to serve as a proficient motivator, a competent leader, an adept organiser and a reliable trust builder.

To have a comprehensive understanding of the skills and competencies that have been utilised in 4IR initiatives since their debut in 2010, additional analysis was conducted on the collected dataset. The findings are presented in Table 6.

Table 6: Project management skills and competencies

Skills & competencies	Compiled from the following articles
▪ Knowledge management ▪ Cost management skills ▪ Supervision and leadership skills ▪ Technical project management expertise ▪ Functional project management expertise ▪ Emotional intelligence ▪ Hard and soft skills competency modelling ▪ Digital intelligence and competency ▪ Innovation ▪ Agility ▪ Creativity ▪ Strategising ▪ Virtual and disperse team management skills ▪ Holistic perspective ▪ Ethics and integrity ▪ Analytical thinking	(Zhang et al., 2022), (Marnewick & Marnewick, 2021), (Reich et al., 2014), (C. Wang et al., 2016), (Zaman et al., 2019), (Chen et al., 2019), (Zhu et al., 2021), (Meng & Boyd, 2017), (Beaume et al., 2010), (Stettina & Hörz, 2015), (Marcella & Rowley, 2015), (Zhang et al., 2018)

To navigate the profound changes brought about by the 4IR effectively, it is imperative to cultivate a new form of intelligence alongside an additional set of competencies (Marnewick & Marnewick, 2021). The specific skills and competencies that should be prioritised, particularly in relation to the domain of project management, remain somewhat unclear. Project managers of 4IR projects have the challenge of managing and adapting to these new projects despite a lack of requisite capabilities and skills (World Economic Forum, 2017). A comprehensive examination of the broader understanding of key skills and competencies required for the effective execution and delivery of 4IR projects is of the utmost importance.

Based on the findings, key competencies include creativity and innovation, agility and emotional intelligence, as well as some sound digital intelligence. These findings align with the conclusions drawn by Marnewick and Marnewick (2021) which suggest that digital intelligence serves as a fundamental component of the necessary skills and abilities that project managers require for managing projects in the context of the 4IR. The significance of soft skills modelling capability in project managers of 4IR projects is emphasised by the results of this study, which align with previous research conducted by Zaman et al. (2019). The competency of soft skills plays a crucial role in the effective management of projects in the context of the 4IR (Azim et al., 2010). This competency enables project practitioners to gain a comprehensive understanding of the project dynamics and social perspectives, including stakeholder management. Moreover, it equips

them with the ability to navigate the complexities associated with these factors (Azim et al., 2010). The competencies that have been defined will equip project practitioners with the necessary information to enhance their skills and abilities, enabling them to execute projects related to the 4IR effectively and successfully.

In essence, the findings underscore a combination of technical, managerial and interpersonal competencies crucial for the success of 4IR projects. Expertise in technical and functional domains, encompassing cost management, digital intelligence and analytical reasoning, is essential for navigating the complexities of evolving technologies. Equally significant are soft skills, notably emotional intelligence, creativity and adaptability. These empower leaders to manage virtual or remote teams proficiently while cultivating an inventive and collaborative atmosphere. A comprehensive perspective, integrity and effective knowledge management promote balanced decision-making. These abilities highlight the necessity for a balanced skill set that combines hard and soft talents to attain sustainable success in the 4IR environment.

5. Conceptual framework for managing 4IR projects

The summary findings yielded a conceptual framework for the management of IT projects integrating the 4IR. The conceptual model depicted in Fig. 2 seeks to offer a comprehensive perspective and comprehension of the essential elements required by project practitioners for the efficient management of 4IR projects. The framework comprises four primary components, derived from the study findings: (i) the positioning of 4IR projects in organisations, which, according to the findings, is becoming one of the major strategic drivers in organisations, (ii) attributes of 4IR projects, i.e. traits such as critical success factors, challenges as well as characteristics, (iii) the skills and competencies needed to implement and deliver these projects successfully, and lastly, (iv) the project management tools and techniques employed during the implementation of 4IR projects.

The conceptual model emphasises three essential dimensions vital for the effective implementation and delivery of 4IR projects which are all interconnected in this model for effective implementation and delivery of 4IR projects. The findings reveal that skills and competencies encompass a wide range, including technical proficiency, digital literacy, emotional intelligence and creativity, highlighting the necessity for a comprehensive viewpoint. These abilities emphasise the need for flexible, imaginative and multidisciplinary teams adept at handling the complexities and ambiguities of 4IR initiatives. Furthermore, soft skills, such as stakeholder management, cooperation and governance alignment, are essential for maintaining project coherence and alignment with strategic objectives. The growing reliance on specialised skills and digital technologies illustrates the sophisticated technological environment of 4IR projects, necessitating leaders to cultivate both hard and soft talents within their teams. In addition, the critical success factors constitute the foundation for project success, encompassing leadership, governance, transparency and team participation. Efficient stakeholder management and executive assistance are essential for navigating projects through the intricacies of emerging technology, regulatory requirements and integration challenges. Transparency in resource distribution, client engagement and cohesive governance frameworks guarantee that projects remain flexible and focused on objectives. Moreover, the framework reveals the challenges inherent in 4IR project environments, such as skill deficiencies, ambiguous deliverables and the elevated risk linked to innovative technology. These variables necessitate adaptive leadership and strong frameworks to reduce risks while using the potential offered by technological breakthroughs.

Finally, the model outlines the tools and techniques that underscore the significance of project management tools and techniques inclusive of IT governance, quality assurance and lean approaches in navigating the complexities and dangers associated with 4IR projects. The adoption of tools and techniques, such as social media platforms, information modelling and STEEP analysis, is also highlighted in the findings, which guarantees that projects are anchored in both technological and social frameworks. Risk assessment, team multitasking and the incorporation of new technology are further outlined as they are essential for maintaining resilience and adaptability. The framework adeptly connects the difficulties and potential of 4IR projects by offering a systematic method to synchronise talents, governance and technical resources. This

integration is essential for attaining both immediate success and enduring sustainability in the swiftly changing project management environment of the 4IR.

Fig. 2. Conceptual model for 4IR project management

In summary, the transformation into the 4IR is one catalyst that has radicalised the changes and conventions of project management to accommodate the technology transformation (Hwang & Ng, 2013). With the specific focus on 4IR projects, the study found that there are three crucial factors that need consideration to target successful delivery. These are firstly a clear conceptualisation of the value of these types of projects in organisations. From the investigation, it has been confirmed that these types of projects are becoming one form of strategic driver in organisations, which show not only value, but criticality of success for such projects. Secondly, a clear understanding of the nature and attributes of these projects is a significant success contributor as this allows for proper planning and implementation to facilitate successful delivery. Lastly, with comprehensive understanding of the previous factors, the right skills and competencies as well as tools and techniques can be mapped, which directly impacts delivery of the projects. From the findings, it is observed that skills and competencies such as creativity and emotional and digital intelligence are crucial. The conceptual model in Fig. 2 will enable professionals within the project management discipline to not only get a clearer understanding of the nature of these new types of projects, but also be equipped with some of the approaches and techniques that can facilitate successful delivery of these projects.

6. Conclusion

The advent of the Industrial Revolutions has had a profound impact on global society since the 17th century, and their transformative influence is expected to persist in the forthcoming generations. The perpetual progress and evolution of the world are vital for the ongoing existence and survival of humanity. The 4IR is currently in its nascent phase, having commenced in the 2010s, and is poised to fuel significant shifts on a global scale (Schwab, 2016). The 4IR is instigating a profound transformation within business environments. It can be seen as a natural evolution stemming from the concept of Industry 4.0, which prioritises the integration of new technologies across various organisational boundaries to foster a digitalised business environment (L. D. Xu et al., 2018; M. Xu et al., 2018). The implementation and deployment of projects has emerged as a significant strategy adopted by corporations in response to this transformative period (Emejom et al., 2019). Like previous Industrial Revolutions, it is crucial to explore and develop effective methodologies for delivering these projects successfully. This article has made a substantial contribution to this cause by illustrating the rapid transformation of projects into 4IR projects through IT and the transformative integration of new 4IR technologies in projects. Additionally, it has provided a comprehensive understanding of various techniques and approaches that project practitioners can employ to manage these projects efficiently. With the aim of the study being to investigate the impact of 4IR transformation on projects, the investigation conducted based on the study objectives has provided a comprehensive view of the following:

- The advent of the new Industrial Revolution has led to a shift and significant growth in the number of projects being executed. These projects that are leveraging 4IR technologies represent 4IR projects. This assertion is substantiated by the escalating growth in the number of projects executed across various industries which employ the integration of IT and 4IR technology-driven developments in an innovative manner (Lööw et al., 2019; Schönbeck et al., 2021; M. Xu et al., 2018).
- The dawn of the new Industrial Revolution has brought about changes in the features, characteristics, obstacles and success factors associated with projects, making them increasingly complex and challenging to oversee. The assertion is corroborated by Abbasi and Jaafari (2018), who argue that the increasing complexity and modernity of technology have led to greater ambiguity in project outputs and outcomes. Consequently, the field of project management has had to adapt to this shift.
- There is a need to do additional research and develop innovative tools and approaches that may efficiently oversee initiatives related to the 4IR. This observation is substantiated by the empirical evidence indicating that the predominant tools and techniques employed in projects spanning the period from 2011 to 2021 exhibit a notable continuity with those utilised in projects during the Second and Third Industrial Revolutions. While certain tools and techniques play a crucial role in guaranteeing the effective execution of projects, there is a need for new tools and processes that cater specifically to the requirements of projects influenced by advancements in technology.
- Finally, the advent of the 4IR has required project management teams to undergo transformation, develop agility and acquire new skills to maintain their competence. The findings of the study have underscored the significance of creative and agile project competencies across diverse industries. This observation is in line with the Project Management Institute (2018) that a transformation of skills and competencies is necessary for the successful management of projects led by the 4IR.

In conclusion, this study's findings emphasise the importance of a diverse skill set, including technical abilities, emotional intelligence, creativity and digital proficiency, to manage 4IR projects effectively. These findings are in line with those of Ribeiro et al. (2021), who highlight the need for not only technical proficiency but also soft skills such as communication, leadership and stakeholder management. Emotional intelligence is also linked to Agile project management approaches, which are crucial for managing projects in uncertain and rapidly evolving contexts (Ribeiro et al., 2021). Stakeholder management, governance alignment and transparency are essential success determinants and governance structures for 4IR projects. These findings align with research by Müller and Turner (2007) as well as Pinto and Slevin (1987) on a project success framework, and by Sirisomboonsuk et al. (2018) on project governance. Synchronised governance

systems promote explicit processes and decision-making frameworks to address regulatory and technological issues specific to 4IR projects.

The model incorporates crucial project management tools and techniques such as information modelling, IT governance and risk assessment, which align with the increasing focus on technology-oriented project management methodologies. Building information modelling (BIM) is a revolutionary tool in building and IT projects, while lean project management principles aim to eradicate waste and improve value delivery. The model further recognises risks and complexities associated with adopting new technologies, emphasising proactive risk management and comprehensive contingency planning. In brief, the model affirms the multifaceted requirements of 4IR project management and highlights the need for project managers to adapt their strategies to the changing environment, integrating both human and technological elements to achieve sustainable project results.

The following research limitations have been identified:

- The study analysed publications from the *International Journal of Project Management (IJPM)*, which may not include significant ideas from other relevant journals.
- The analysis was confined to articles published from 2011 to 2021, which may not reflect the most recent evolving practical issues faced by professionals working within 4IR project environments.
- The coding system was based on predetermined objectives. However, a flexible, dynamic analysis approach that allowed for adjustments through the introduction of new subcodes was adopted to identify any new emerging insights obtained from the literature being reviewed. This iterative process ensured that the analysis was flexible and capable of capturing evolving trends in the literature.
- The study also excluded non-English articles, which may have resulted in overlooking significant contributions from non-English sources, especially considering the global context of the 4IR.

The study opened various avenues for future research. Firstly, extending the range of journals, the timeframe and integrating primary data would assist in a more comprehensive validation of the framework. Cross-cultural perspectives could be investigated to understand the topic across various cultural contexts since 4IR is a world phenomenon.

References

Abbasi, A., & Jaafari, A. (2018). Evolution of project management research and industry-focused innovations. *Journal of Modern Project Management*, *6*(1), 60-69. https://doi.org/10.19255/JMPM01606.

Akhavan-Tabassi, A., Bryde, D., Mustafa Kamal, E., & Dowson, J. (2019). *Challenges for project management in the 21st century*. https://doi.org/10.15405/epms.2019.12.63.

Almahmoud, E. S., Doloi, H. K., & Panuwatwanich, K. (2012). Linking project health to project performance indicators: Multiple case studies of construction projects in saudi arabia. *International Journal of Project Management*, *30*(3), 296-307. https://doi.org/10.1016/j.ijproman.2011.07.001.

Anshari, M., & Hamdan, M. (2022). Understanding knowledge management and upskilling in fourth industrial revolution: Transformational shift and seci model. *VINE Journal of Information and Knowledge Management Systems*, *52*(3), 373-393. https://doi.org/10.1108/VJIKMS-09-2021-0203.

Azim, S., Gale, A., Lawlor-Wright, T., Kirkham, R., Khan, A., & Alam, M. (2010). The importance of soft skills in complex projects. *International Journal of Managing Projects in Business*, *3*(3), 387-401. https://doi.org/10.1108/17538371011056048.

Bahrin, M. A. K., Othman, M. F., Azli, N. H. N., & Talib, M. F. (2016). Industry 4.0: A review on industrial automation and robotic. *Jurnal Teknologi (Sciences & Engineering)*, *78*(6-13). https://doi.org/10.11113/jt.v78.9285.

Banihashemi, S., Hosseini, M. R., Golizadeh, H., & Sankaran, S. (2017). Critical success factors (csfs) for integration of sustainability into construction project management practices in developing countries. *International Journal of Project Management*, *35*(6), 1103-1119. https://doi.org/10.1016/j.ijproman.2017.01.014.

Beaume, R., Maniak, R., & Midler, C. (2010). Crossing innovation and product projects management: A comparative analysis in the automotive industry. *International Journal of Project Management*, *27*(2), 166-174. https://doi.org/10.1016/j.ijproman.2008.09.004.

Berawi, M. A. (2018). The fourth industrial revolution: Managing technology development for competitiveness. *International Journal of Technology*, *9*(1), 291-319. https://doi.org/10.14716/ijtech.v9i1.1504.

Bergstrom, C. (2007). Eigenfactor: Measuring the value and prestige of scholarly journals. *College and Research Libraries News*, *68*, 314-316. https://doi.org/10.5860/crln.68.5.7804.

Boateng, P., Chen, Z., & Ogunlana, S. O. (2015). An analytical network process model for risks prioritisation in megaprojects. *International Journal of Project Management*, *33*(8), 1795-1811. http://dx.doi.org/10.1016/j.ijproman.2015.08.007.

Brettel, M., Friederichsen, N., Keller, M., & Rosenberg, M. (2017). How virtualization, decentralization and network building change the manufacturing landscape: An industry 4.0 perspective. *FormaMente*, *12*, 47-62. https://research.ebsco.com/linkprocessor/plink?id=3f54a822-0119-39fb-9e8d-73d64a096019

Bröchner, J. (2021). Construction project management fiction: Individual values. *International Journal of Project Management*, *39*(6), 594-604. https://doi.org/10.1016/j.ijproman.2021.04.005.

Cakmakci, M. (2019). Interaction in project management approach within industry 4.0. In *Lecture Notes in Mechanical Engineering* (pp. 176-189): Pleiades Publishing.

Camci, A., & Kotnour, T. (2019). How to manage projects in industry4.0 environment: Aligning management style with complexity. In H. B. Bolat & G. T. Temur (Eds.), *Agile approaches for successfully managing and executing projects in the fourth industrial revolution* (pp. 20-39). IGI Global. https://doi.org/https://doi.org/10.4018/978-1-5225-7865-9.ch002

Caniëls, M. C. J., & Bakens, R. J. J. M. (2012). The effects of project management information systems on decision making in a multi project environment. *International Journal of Project Management*, *30*(2), 162-175. https://doi.org/10.1016/j.ijproman.2011.05.005.

Cao, D., Li, H., Wang, G., & Huang, T. (2017). Identifying and contextualising the motivations for bim implementation in construction projects: An empirical study in china. *International Journal of Project Management*, *35*(4), 658-669. https://doi.org/10.1016/j.ijproman.2016.02.002.

Cebeci, U. (2019). The project management of industry 4.0 strategy for software houses. In H. B. Bolat & G. T. Temur (Eds.), *Agile approaches for successfully managing and executing projects in the fourth industrial revolution* (pp. 228-241). IGI Global. https://doi.org/https://doi.org/10.4018/978-1-5225-7865-9.ch012

Chen, K., Lu, W., Peng, Y., Rowlinson, S., & Huang, G. Q. (2015). Bridging bim and building: From a literature review to an integrated conceptual framework. *International Journal of Project Management*, *33*(6), 1405-1416. http://dx.doi.org/10.1016/j.ijproman.2015.03.006.

Chen, T., Fu, M., Liu, R., Xu, X., Zhou, S., & Liu, B. (2019). How do project management competencies change within the project management career model in large chinese construction companies? *International Journal of Project Management*, *37*(3), 485-500. https://doi.org/10.1016/j.ijproman.2018.12.002.

Coccia, M. (2019). Theories of the evolution of technology based on processes of competitive substitution and multi- mode interaction between technologies. *6*(2), 99-109. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3424108

Colin, M., Galindo, R., & Hernández, O. (2015). Information and communication technology as a key strategy for efficient supply chain management in manufacturing smes. *Procedia Computer Science*, *55*, 833-842. https://doi.org/10.1016/j.procs.2015.07.152.

Costantino, F., Di Gravio, G., & Nonino, F. (2015). Project selection in project portfolio management: An artificial neural network model based on critical success factors. *International Journal of Project Management*, *33*(8), 1744-1754. http://dx.doi.org/10.1016/j.ijproman.2015.07.003.

Cserháti, G., & Szabó, L. (2014). The relationship between success criteria and success factors in organisational event projects. *International Journal of Project Management*, *32*(4), 613-624. http://dx.doi.org/10.1016/j.ijproman.2013.08.008.

de Bakker, K., Boonstra, A., & Wortmann, H. (2010). Does risk management contribute to it project success? A meta-analysis of empirical evidence. *International Journal of Project Management*, *28*(5), 493-503. https://doi.org/10.1016/j.ijproman.2009.07.002.

Doğan, N. Ö., & Derici, S. (2019). Project management and efficiency of the projects in the industry 4.0 era. 188-209. https://doi.org/10.4018/978-1-5225-7865-9.ch010.

Dopico, M., Gomez, A., De la Fuente, D., García, N., Rosillo, R., & Puche, J. (2016). *A vision of industry 4.0 from an artificial intelligence point of view*. Proceedings on the International Conference on Artificial Intelligence (ICAI), Athens, Greece. https://www.proquest.com/conference-papers-proceedings/vision-industry-4-0-artificial-intelligence-point/docview/1806561919/se-2?accountid=13425

Easterlin, R. A. (2019). Three revolutions of the modern era. *Comparative Economic Studies*, *61*(4), 521-530. https://doi.org/10.1057/s41294-019-00098-9.

Einhorn, F., Marnewick, C., & Meredith, J. (2019). Achieving strategic benefits from business it projects: The critical importance of using the business case across the entire project lifetime. *International Journal of Project Management*, *37*(8), 989-1002. https://doi.org/10.1016/j.ijproman.2019.09.001.

Elsevier, B. V. (2019). Scopus factsheet. (February), 2-2. https://www.elsevier.com/__data/assets/pdf_file/0017/114533/Scopus_GlobalResearch_Factsheet2019_FINAL_WEB.pdf

Emejom, A. A., Burgess, C., Pepper, D., & Adkins, J. (2019). Agile approaches for successfully managing and executing projects in the fourth industrial revolution. In H. B. Bolat & G. T. Temur (Eds.), *Agile approaches for successfully managing and executing projects in the fourth industrial revolution* (pp. 1-19). IGI Global. https://doi.org/https://doi.org/10.4018/978-1-5225-7865-9.ch001

Füller, J., Hutter, K., & Kröger, N. (2021). Crowdsourcing as a service – from pilot projects to sustainable innovation routines. *International Journal of Project Management*, *39*(2), 183-195. https://doi.org/10.1016/j.ijproman.2021.01.005.

Gilchrist, A., Burton-Jones, A., & Green, P. (2018). The process of social alignment and misalignment within a complex it project. *International Journal of Project Management*, *36*(6), 845-860. https://doi.org/10.1016/j.ijproman.2018.04.004.

Ginigaddara, B., Perera, S., Feng, Y., & Rahnamayiezekavat, P. (2021). Offsite construction skills evolution: An australian case study. *Construction Innovation*.

Griffin, E. (2018). Diets, hunger and living standards during the british industrial revolution. *Past and Present*, *239*(1), 72-111. https://doi.org/10.1093/pastj/gtx061.

Gu, V. C., Hoffman, J. J., Cao, Q., & Schniederjans, M. J. (2014). The effects of organizational culture and environmental pressures on it project performance: A moderation perspective. *International Journal of Project Management*, *32*(7), 1170-1181. http://dx.doi.org/10.1016/j.ijproman.2013.12.003.

Güngör, D. Ö. (2019). Industry 4.0 technologies used in project management. In H. B. Bolat & G. T. Temur (Eds.), *Agile approaches for successfully managing and executing projects in the fourth industrial revolution* (pp. 40-63). IGI Global. https://doi.org/https://doi.org/10.4018/978-1-5225-7865-9.ch003

Haley, M. R. (2019). An eigenfactor-weighted power mean generalization of the euclidean index. *PLOS ONE*, *14*(2), e0212760. https://doi.org/10.1371/journal.pone.0212760.

Hazır, Ö. (2015). A review of analytical models, approaches and decision support tools in project monitoring and control. *International Journal of Project Management*, *33*(4), 808-815. http://dx.doi.org/10.1016/j.ijproman.2014.09.005.

Hussein, B. (2019). The influence of project characteristics on project success factors. Insights from 21 real life project cases from norway. *Procedia Computer Science*, *164*, 350-357. https://doi.org/10.1016/j.procs.2019.12.193.

Hwang, B.-G., & Ng, W. J. (2013). Project management knowledge and skills for green construction: Overcoming challenges. *International Journal of Project Management*, *31*(2), 272-284. http://dx.doi.org/10.1016/j.ijproman.2012.05.004.

IEEE. (2021). Ieee standard for digital intelligence (dq)–framework for digital literacy, skills, and readiness. In *IEEE Std 3527.1-2020* (pp. 1-47). New York, USA: The Institute of Electrical and Electronics Engineers, Inc.

IOWA State University Library, I. (2018). Scopus vs. Web of science vs. Google scholar. 9-11.

Jally, V., Kulkarni, V. N., Gaitonde, V. N., Satis, G. J., & Kotturshettar, B. B. (2021). A review on project management transformation using industry 4.0.

Jani, A. (2011). Escalation of commitment in troubled it projects: Influence of project risk factors and self-efficacy on the perception of risk and the commitment to a failing project. *International Journal of Project Management*, *29*(7), 934-945. https://doi.org/10.1016/j.ijproman.2010.08.004.

Janse van Rensburg, N., Telukdarie, A., & Dhamija, P. (2019). Society 4.0 applied in africa: Advancing the social impact of technology. *Technology in Society*, *59*, 1-12. https://doi.org/10.1016/j.techsoc.2019.04.001.

Journal Citation Report, J. (2021). *Journal impact factor list 2021*. Clavirate Analytics. https://impactfactorforjournal.com/jcr-2021/

Kanwal, N., Zafar, M. S., & Bashir, S. (2017). The combined effects of managerial control, resource commitment, and top management support on the successful delivery of information systems projects. *International Journal of Project Management*, *35*(8), 1459-1465. https://doi.org/10.1016/j.ijproman.2017.08.007.

Kwak, Y. H., Walewski, J., Sleeper, D., & Sadatsafavi, H. (2014). What can we learn from the hoover dam project that influenced modern project management? *International Journal of Project Management*, *32*(2), 256-264. http://dx.doi.org/10.1016/j.ijproman.2013.04.002.

Lasi, H., Fettke, P., Kemper, H., Feld, T., & Hoffmann, M. (2014). Industry 4.0 [journal article]. *Business & Information Systems Engineering*, *6*(4), 239-242. https://doi.org/10.1007/s12599-014-0334-4.

Li, G., Hou, Y., & Wu, A. (2017). Fourth industrial revolution: Technological drivers, impacts and coping methods. *Chinese Geographical Science*, *27*(4), 626-637. https://doi.org/10.1007/s11769-017-0890-x.

Liang, T.-P., Wu, J. C.-H., Jiang, J. J., & Klein, G. (2012). The impact of value diversity on information system development projects. *International Journal of Project Management*, *30*(6), 731-739. https://doi.org/10.1016/j.ijproman.2011.11.006.

Liao, Y., Loures, E. d. F. R., & Deschamps, F. (2018). Industrial internet of things: A systematic literature review and insights. *IEEE Internet of Things Journal*, *5*(6), 4515-4525. https://doi.org/10.1109/JIOT.2018.2834151.

Lieftink, B., Smits, A., & Lauche, K. (2019). Dual dynamics: Project-based institutional work and subfield differences in the dutch construction industry. *International Journal of Project Management*, *37*(2), 269-282. https://doi.org/10.1016/j.ijproman.2018.03.005.

Liu, Y., & Xu, X. (2017). Industry 4.0 and cloud manufacturing: A comparative analysis. *Journal of Manufacturing Science and Engineering*, *139*(3), 1-8. https://doi.org/10.1115/1.4034667.

Liu, Y., Zeng, N., Papadonikolaki, E., Maritshane, K., & Chan, P. W. (2024). The future of digitalized project practices through data-savvy talent: A digital competence formation perspective. *Project Leadership and Society*, *5*, 1-15. https://doi.org/10.1016/j.plas.2024.100120.

Lööw, J., Abrahamsson, L., & Johansson, J. (2019). Mining 4.0—the impact of new technology from a work place perspective. *Mining, Metallurgy & Exploration*, *36*(4), 701-707. https://doi.org/10.1007/s42461-019-00104-9.

Marcella, M., & Rowley, S. (2015). An exploration of the extent to which project management tools and techniques can be applied across creative industries through a study of their application in the fashion industry in the north east of scotland. *International Journal of Project Management*, *33*(4), 735-746. http://dx.doi.org/10.1016/j.ijproman.2014.12.002.

Marnewick, A. L., & Marnewick, C. (2020). The ability of project managers to implement industry 4.0-related projects. *IEEE Access*, *8*(1), 314-324. https://doi.org/10.1109/ACCESS.2019.2961678.

Marnewick, C., & Labuschagne, L. (2011). An investigation into the governance of information technology projects in south africa. *International Journal of Project Management*, *29*(6), 661-670. https://doi.org/10.1016/j.ijproman.2010.07.004.

Marnewick, C., & Marnewick, A. L. (2021). Digital intelligence: A must-have for project managers. *Project Leadership and Society*, *2*, 1-12. https://doi.org/10.1016/j.plas.2021.100026.

Martín-Martín, A., Orduña-Malea, E., Thelwall, M., Delgado-López-Cózar, E., Orduna-Malea, E., Thelwall, M., Delgado-López-Cózar, E., & Delgado López-Cózar, E. (2018). Scopus: A systematic comparison of citations in 252 subject categories. *Journal of Informetrics*, *12*(4), 1160-1177. https://doi.org/10.1016/J.JOI.2018.09.002.

Meng, X., & Boyd, P. (2017). The role of the project manager in relationship management. *International Journal of Project Management*, *35*(5), 717-728. https://doi.org/10.1016/j.ijproman.2017.03.001.

Meyer, S., & Keas, M. (2011). The meanings of evolution. In J. A. Campbell & M. S.C. (Eds.), *Darwinism, design, and public education*. Michigan State University Press. http://arn.org/docs/meyer/sm_meaningsofevolution.pdf

Missonier, S., & Loufrani-Fedida, S. (2014). Stakeholder analysis and engagement in projects: From stakeholder relational perspective to stakeholder relational ontology. *International Journal of Project Management*, *32*(7), 1108-1122. http://dx.doi.org/10.1016/j.ijproman.2014.02.010.

Müller, J. M., & Voigt, K.-I. (2018). The impact of industry 4.0 on supply chains in engineer-to-order industries - an exploratory case study. *IFAC-PapersOnLine*, *51*(11), 122-127. https://doi.org/10.1016/j.ifacol.2018.08.245.

Müller, R., & Turner, R. (2007). The influence of project managers on project success criteria and project success by type of project. *European Management Journal*, *25*(4), 298-309. https://doi.org/10.1016/j.emj.2007.06.003.

Neumeier, A., Radszuwill, S., & Garizy, T. Z. (2018). Modeling project criticality in it project portfolios. *International Journal of Project Management*, *36*(6), 833-844. https://doi.org/10.1016/j.ijproman.2018.04.005.

Nigappa, K., & Selvakumar, J. (2016). Industry 4.0: A cost and energy efficient micro plc for smart manufacturing. *Indian Journal of Science and Technology*, *9*(44), 1-6. https://doi.org/10.17485/ijst/2016/v9i44/125304.

Ning, Y., & Ling, F. Y. Y. (2015). The effects of project characteristics on adopting relational transaction strategies. *International Journal of Project Management*, *33*(5), 998-1007. http://dx.doi.org/10.1016/j.ijproman.2014.12.006.

Oraee, M., Hosseini, M. R., Edwards, D. J., Li, H., Papadonikolaki, E., & Cao, D. (2019). Collaboration barriers in bim-based construction networks: A conceptual model. *International Journal of Project Management*, *37*(6), 839-854. https://doi.org/10.1016/j.ijproman.2019.05.004.

Ortiz, J. H. (Ed.). (2020). *Industry 4.0: Current status and future trends*. InTechOpen. https://doi.org/http://dx.doi.org/10.5772/intechopen.86000.

Pajares, J., Poza, D., & Villafa, F. (2017). Project management methodologies in the fourth technological revolution. 121-144. https://doi.org/10.1007/978-3-319-55889-9.

Pellerin, R., Perrier, N., Guillot, X., & Léger, P.-M. (2014). Project characteristics, project management software utilization and project performance: An impact analysis based on real project data. *International Journal of Information Systems and Project Management*, *1*. https://doi.org/10.12821/ijispm010301.

Pereira, A. C., & Romero, F. (2017). A review of the meanings and the implications of the industry 4.0 concept. *Procedia Manufacturing*, *13*, 1206-1214. https://doi.org/10.1016/j.promfg.2017.09.032.

Pinto, J. K., & Slevin, D. P. (1987). Critical factors in successful project implementation. *IEEE Transactions on Engineering Management*, *EM-34*(1), 22-27. https://doi.org/10.1109/TEM.1987.6498856.

Procter, C., & Kozak-Holland, M. (2019). The giza pyramid: Learning from this megaproject. *Journal of Management History*, *25*(3), 364-383. https://doi.org/10.1108/JMH-11-2018-0061.

Project Management Institute. (2018). *The project manager of the future: Developing digital-age project management skills to thrive in disruptive times* (Pulse of the Profession, Issue. P. M. Institute. https://www.pmi.org/learning/thought-leadership/pulse/the-project-manager-of-the-future

Project Management Institute. (2021). *Top 10 most influential projects by industry*. I. Project Management Institute. https://www.pmi.org/most-influential-projects-2021/top-10-by-industry/technology

Reich, B. H., Gemino, A., & Sauer, C. (2014). How knowledge management impacts performance in projects: An empirical study. *International Journal of Project Management*, *32*(4), 590-602. http://dx.doi.org/10.1016/j.ijproman.2013.09.004.

Rezvani, A., Khosravi, P., & Ashkanasy, N. M. (2018). Examining the interdependencies among emotional intelligence, trust, and performance in infrastructure projects: A multilevel study. *International Journal of Project Management*, *36*(8), 1034-1046. https://doi.org/10.1016/j.ijproman.2018.08.002.

Ribeiro, A., Amaral, A., & Barros, T. (2021). Project manager competencies in the context of the industry 4.0. *Procedia Computer Science*, *181*, 803-810. https://doi.org/10.1016/j.procs.2021.01.233.

Rifkin, J. (2011). *The third industrial revolution: How lateral power is transforming energy, the economy, and the world*. Palgrave Macmillan.

Sanchez, O. P., Terlizzi, M. A., & de Moraes, H. R. d. O. C. (2017). Cost and time project management success factors for information systems development projects. *International Journal of Project Management*, *35*(8), 1608-1626. https://doi.org/10.1016/j.ijproman.2017.09.007.

Santos, M. Y., Oliveira e Sá, J., Andrade, C., Vale Lima, F., Costa, E., Costa, C., Martinho, B., & Galvão, J. (2017). A big data system supporting bosch braga industry 4.0 strategy. *International Journal of Information Management*, *37*(6), 750-760. https://doi.org/10.1016/j.ijinfomgt.2017.07.012.

Sari, I. U., Cafer, E., & Ak, U. (2021). Feasibility analysis of industry 4.0 projects and an application in automotive maintenance systems. In I. R. M. Association (Ed.), *Research anthology on cross-industry challenges of industry 4.0* (pp. 755-771). IGI Global. https://doi.org/https://doi.org/10.4018/978-1-7998-8548-1.ch038

Schönbeck, P., Löfsjögård, M., & Ansell, A. (2021). Collaboration and knowledge exchange possibilities between industry and construction 4.0 research. *Procedia Computer Science*, *192*, 129-137. https://doi.org/10.1016/j.procs.2021.08.014.

Schwab, K. (2016). The fourth industrial revolution: What it means and how to respond. *World Economic Forum*.

Schwab, K. (2018). The fourth industrial revolution (industry 4.0) a social innovation perspective. *Tạp chí Nghiên cứu dân tộc*, *7*(23), 12-21. https://doi.org/10.25073/0866-773x/97.

Seymour, T., & Hussein, S. (2014). The history of project management. *International Journal of Management & Information Systems (IJMIS)*, *18*(4), 233-240. https://doi.org/10.19030/ijmis.v18i4.8820.

Shmueli, O., & Ronen, B. (2017). Excessive software development: Practices and penalties. *International Journal of Project Management*, *35*(1), 13-27. http://dx.doi.org/10.1016/j.ijproman.2016.10.002.

Siddaway, A. P., Wood, A. M., & Hedges, L. V. (2019). How to do a systematic review: A best practice guide for conducting and reporting narrative reviews, meta-analyses, and meta-syntheses. *Annual Review of Psychology*, *70*, 747-770. https://doi.org/10.1146/annurev-psych-010418-102803.

Sirisomboonsuk, P., Gu, V. C., Cao, R. Q., & Burns, J. R. (2018). Relationships between project governance and information technology governance and their impact on project performance. *International Journal of Project Management*, *36*(2), 287-300. https://doi.org/10.1016/j.ijproman.2017.10.003.

Stettina, C. J., & Hörz, J. (2015). Agile portfolio management: An empirical perspective on the practice in use. *International Journal of Project Management*, *33*(1), 140-152. http://dx.doi.org/10.1016/j.ijproman.2014.03.008.

Stjerne, I. S., Söderlund, J., & Minbaeva, D. (2019). Crossing times: Temporal boundary-spanning practices in interorganizational projects. *International Journal of Project Management*, *37*(2), 347-365. https://doi.org/10.1016/j.ijproman.2018.09.004.

Sudhaman, P., & Thangavel, C. (2015). Efficiency analysis of erp projects—software quality perspective. *International Journal of Project Management*, *33*(4), 961-970. http://dx.doi.org/10.1016/j.ijproman.2014.10.011.

Sun, J., & Zhang, P. (2011). Owner organization design for mega industrial construction projects. *International Journal of Project Management*, *29*(7), 828-833. https://doi.org/10.1016/j.ijproman.2011.04.005.

Tadayon, A., & Andersen, B. (2021). Characteristics of a project that are suitable for a relational pdm. *Procedia Computer Science*, *181*, 1089-1096. https://doi.org/10.1016/j.procs.2021.01.305.

Terlizzi, M. A., Meirelles, F. d. S., & de Moraes, H. R. O. C. (2016). Barriers to the use of an it project management methodology in a large financial institution. *International Journal of Project Management*, *34*(3), 467-479. http://dx.doi.org/10.1016/j.ijproman.2015.12.005.

Thuemmler, C., & Bai, C. (2017). Health 4.0: Application of industry 4.0 design principles in future asthma management. In C. Thuemmler & C. Bai (Eds.), *Health 4.0: How virtualization and big data are revolutionizing healthcare* (pp. 23-37). Springer International Publishing. https://doi.org/https://doi.org/10.1007/978-3-319-47617-9_2

Totten, J. (2017). *Critical success factors for agile project management in non-software related product development teams* [Doctoral, Western Michigan University]. Kalamazoo, Michigan, United States. https://scholarworks.wmich.edu/cgi/viewcontent.cgi?article=4210&context=dissertations

Vogel-Heuser, B., & Hess, D. (2016). Guest editorial industry 4.0–prerequisites and visions. *IEEE Transactions on Automation Science and Engineering*, *13*(2), 411-413. https://doi.org/10.1109/TASE.2016.2523639.

Waidner, M., & Kasper, M. (2016, 14-18 March 2016). Security in industrie 4.0 - challenges and solutions for the fourth industrial revolution. 2016 Design, Automation & Test in Europe Conference & Exhibition (DATE), Dresden, Germany.

Wang, C., Wood, L. C., Abdul-Rahman, H., & Lee, Y. T. (2016). When traditional information technology project managers encounter the cloud: Opportunities and dilemmas in the transition to cloud services. *International Journal of Project Management*, *34*(3), 371-388. http://dx.doi.org/10.1016/j.ijproman.2015.11.006.

Wang, L., Kunc, M., & Bai, S.-j. (2017). Realizing value from project implementation under uncertainty: An exploratory study using system dynamics. *International Journal of Project Management*, *35*(3), 341-352. http://dx.doi.org/10.1016/j.ijproman.2017.01.009.

Wang, T., Wang, S., Zhang, L., Huang, Z., & Li, Y. (2016). A major infrastructure risk-assessment framework: Application to a cross-sea route project in china. *International Journal of Project Management*, *34*(7), 1403-1415. http://dx.doi.org/10.1016/j.ijproman.2015.12.006.

Whitford, A. B., Yates, J., Burchfield, A., Anastasopoulos, J. L., & Anderson, D. M. (2020). The adoption of robotics by government agencies: Evidence from crime labs [https://doi.org/10.1111/puar.13301]. *Public Administration Review*, *80*(6), 976-988. https://doi.org/10.1111/puar.13301.

Whitmore, D., Papadonikolaki, E., Krystallis, I., & Locatelli, G. (2020). Are megaprojects ready for the 4th industrial revolution? *Proceedings of the Institution of Civil Engineers - Management, Procurement and Law*, *174*, 1-9. https://doi.org/10.1680/jmapl.20.00002.

World Economic Forum. (2017). *Realizing human potential in the fourth industrial revolution*. World Economic Forum. http://www3.weforum.org/docs/WEF_EGW_Whitepaper.pdf

World Economic Forum. (2019). *Fourth industrial revolution: Beacons of technology and innovation in manufacturing*. World Economic Forum. https://www3.weforum.org/docs/WEF_4IR_Beacons_of_Technology_and_Innovation_in_Manufacturing_report_2019.pdf

World Economic Forum. (2020). *Jobs of tomorrow: Mapping opportunity in the new economy*. World Economic Forum. https://www.weforum.org/reports/jobs-of-tomorrow-mapping-opportunity-in-the-new-economy

Xu, L. D., Xu, E. L., & Li, L. (2018). Industry 4.0: State of the art and future trends. *International Journal of Production Research*, *56*(8), 2941-2962. https://doi.org/10.1080/00207543.2018.1444806.

Xu, M., David, J. M., & Kim, S. H. (2018). The fourth industrial revolution: Opportunities and challenges. *International Journal of Financial Research*, *9*(2), 90-95. https://doi.org/10.5430/ijfr.v9n2p90.

Yu, J.-H., & Kwon, H.-R. (2011). Critical success factors for urban regeneration projects in korea. *International Journal of Project Management*, *29*(7), 889-899. https://doi.org/10.1016/j.ijproman.2010.09.001.

Zaman, U., Jabbar, Z., Nawaz, S., & Abbas, M. (2019). Understanding the soft side of software projects: An empirical study on the interactive effects of social skills and political skills on complexity – performance relationship. *International Journal of Project Management*, *37*(3), 444-460. https://doi.org/10.1016/j.ijproman.2019.01.015.

Zhang, Y., Sun, J., Yang, Z., & Wang, Y. (2018). Mobile social media in inter-organizational projects: Aligning tool, task and team for virtual collaboration effectiveness. *International Journal of Project Management*, *36*(8), 1096-1108. https://doi.org/10.1016/j.ijproman.2018.09.003.

Zhang, Z., Min, M., Cai, X., & Qiu, H. (2022). Mitigating the negative performance effect of project complexity through an informal mechanism: The conditional mediating role of knowledge hiding. *International Journal of Project Management*, *40*(3), 192-204. https://doi.org/10.1016/j.ijproman.2022.01.002.

Zhu, F., Wang, X., Wang, L., & Yu, M. (2021). Project manager's emotional intelligence and project performance: The mediating role of project commitment. *International Journal of Project Management*, *39*(7), 788-798. https://doi.org/10.1016/j.ijproman.2021.08.002.

Zhu, J., & Mostafavi, A. (2017). Discovering complexity and emergent properties in project systems: A new approach to understanding project performance. *International Journal of Project Management*, *35*(1), 1-12. http://dx.doi.org/10.1016/j.ijproman.2016.10.004.

Appendix 1. Journal comparison

Source title	CiteScore	Highest percentile	2020-23 citations	2020-23 documents	% cited	SNIP	SJR	Publisher
International Journal of Project Management	12.3	92.0% 32/443 Business and International Management	3119	253	87	2.549	2.039	Elsevier
Project Management Journal	9.3	87.0% 57/443 Business and International Management	1370	148	89	1.959	1.327	SAGE
International Journal of Managing Projects in Business	7	79.0% 92/443 Business and International Management	1647	235	85	1.394	0.757	Emerald Publishing
Journal of Project Management (Canada)	3.7	78.0% 108/511 Communication	302	82	71	0.845	N/A	Growing Science
International Journal of Information Systems and Project Management	6.3	75.0% 33/131 Management Information Systems	406	64	81	1.307	0.59	UMinho Editora

Appendix 2. Codes and subcodes

Codes	Subcodes
Project challenges	Project management specific Manufacturing Construction projects IT projects
Communication techniques	Construction teams
Complexities in projects Environmental issues	Construction projects
Evolution of industries to 4IR	Manufacturing Construction IT
Evolution of projects to 4IR – benefits & challenges	Cloud
Project management competencies in construction	Environmental, safety, health management Understanding of project management processes Stakeholder management Creativity Conflict management Knowledge & skill intensive personnel Competency management Effective change management Hard skills important Virtual disperse teams Change management
Project management competencies in IT	Technical and functional management skill Risk management Knowledge management
Project management competencies in manufacturing	Effective stakeholder engagement Cost management
Project management development stages	Closure Initiation Acquisition Planning Development Training
Project management explanations	Construction
Project management skill	Software development specialist Required in construction Technical management skill Functional management skill Soft skills Technical & hard skills
Project management technique	Stakeholder analysis Conflict management

Codes	Subcodes
	● Risk management: construction
	● Process stages
	● Fuzzy logic
	● Risk management: IT
	● SDLC construction
	● Project structures
	● Risk management
	● Lean production systems
	● Analytical Network Process (ANP)
	● Effective communication and collaborations
	● Quality assurance
	● Task analysis
	● Network planning
	● Team fragmentation
● Project management tool	● Ontology evaluation
	● Remote real-time monitoring system
	● Critical path
	● STEEP
	● Collaborative networks
	● Diagramming technique tool
	● Electronic procurement system
	● Building information modelling
	● Project management software
	● Last planner system
○ Progression stats in projects	○ Construction – China
● Project characteristics	● Construction
	● Oil and gas industry
	● IT projects
	● Air & automotive
	● Health projects
○ Project deliverable	○ Construction
● Project industry	● Health
	● Energy
	● Education
	● Oil and gas industry
	● Infrastructure
	● Air and automotive
	● IT
	● Mining
	● Construction
	● Agriculture
	● Manufacturing
	● Finance industry
● Project success factors	● Construction

Codes	Subcodes
	• Manufacturing
	• All projects
	• IT
	• Oil & gas sector
• Project type	• Energy
	• IT
	• Construction
	• Manufacturing
	• Infrastructure
	• Health
• Year	• 2010
	• 2011
	• 2012
	• 2013
	• 2014
	• 2015
	• 2016
	• 2017
	• 2018
	• 2019
	• 2020
	• 2021

Biographical notes

Mothepane Tshabalala is a proactive academic and an IT consultant within the industry. In addition, she is an emerging researcher and supervisor with the research interest of effective implementation and management of IT projects in the Fourth Industrial Revolution. Internationally she was nominated to participate in the doctoral colloquium for the European Academy of Management in 2021. She is an active member of the South African Computer Scientists and Information.
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