Quest Journals
Journal of Research in Environmental and Earth Sciences
Volume 11 ~ Issue 5 (May 2025) pp: 26-38
ISSN(Online) :2348-2532
www.questjournals.org

Research Paper

Exploring Artificial Intelligence Competence For Project Managers And Impact Of Project Risk Management Domain In The Construction Industry In The United Kingdom: A Review

Omobolanle Olatoye[a] and Yetunde Adebayo[b]
a: Robert Gordon University, Aberdeen Business School, Scotland, United Kingdom
b: Robert Gordon University, Aberdeen Business School, Scotland, United Kingdom.
Corresponding Author: Omobolanle Olatoye
Corresponding Author Email: o.olatoye@rgu.ac.uk

Abstract
Background: *The evolving business environment and technological advancements in the UK construction industry, particularly Artificial Intelligence (AI), are reshaping project management processes, including risk management (RM). As the industry continues to evolve, project managers need to develop AI competencies to effectively mitigate emerging risks.*
Background*: The UK construction industry is undergoing a transformation, driven by technological advancements, particularly the integration of Artificial Intelligence (AI). This shift is reshaping traditional project management practices, including risk management (RM). With the increasing complexity of construction projects and evolving risks, it is essential for project managers to develop AI competencies to effectively navigate and mitigate emerging risks.*
Aim: *This review aimed to evaluate the significance of AI competence for project managers and its impact on risk management practices within the UK construction industry.*
Methods: *Using diverse databases including ProQuest, MEDLINE, and IEEE Xplore, a comprehensive literature review was conducted focused on studies from 2010 to the present related to AI competencies for project managers and risk management in the UK construction industry. The articles were initially screened based on relevant and specific keywords including Boolean operators and followed by full-text review to determine final choice articles used for this review. The findings were summarized using the narrative synthesis approach to report the findings in line with the review objectives.*
Results: *The findings of this review highlight the critical role of AI competence among project managers in enhancing risk management (RM) practices within the UK construction industry. While AI integration improves decision-making, efficiency, and accuracy while reducing human error, the effectiveness of these benefits hinges on project managers' ability to competently utilize AI tools. The findings were thematically categorized into: (1) AI in the construction industry, (2) AI integration in RM practices, (3) benefits and challenges of AI adoption, and (4) assessing project managers' AI competencies. Case studies, such as IBM's Watson Explorer and RiskLens, underscore the necessity of AI competence for optimizing RM strategies.*
Conclusion: *AI is revolutionizing RM practices by offering data-driven insights and predictive risk analysis within the UK construction industry. To harness AI's full potential, project managers must develop AI-related competencies. However, for successful adoption of AI in construction, addressing challenges related to competency, ethics, and cost is crucial. AI competencies development among project managers is key to maximizing AI's benefits, ensuring effective risk management and successful projects.*

Keywords: Artificial Intelligence, Risk Management, Project Managers, Construction Industry, AI Competence

Received 12 May., 2025; Revised 20 May., 2025; Accepted 22 May., 2025 © The author(s) 2025.
*Published with open access at **www.questjournas.org***

I. Introduction

Evidence suggests that the evolving business environment continue to impact and create new challenges for successful delivery of projects within the constraints of time, budget, and scope [1]. Whyte [2] also agreed that the constantly changing landscape, including technology, has brought about significant changes in project management processes with emphasised reference to the construction industry [3,4]. This technology, specifically Artificial Intelligence (AI) which Hamet and Tremblay [5] regarded as a generic term that describes the use of a computer to simulate human intelligent behaviour and started as a robots' invention, is used by 81% of organisations in project management practices [6] and transforming the existing project management practices [7]. Essentially, traditional project management processes and responsibilities continue to evolve with the advancing adoption of AI technology.

Of the project management processes, PMI [8] described risk management (RM) as essential while APM [9] defined it as an important proactive process to identify, assess, and respond appropriately to threats necessary to bolster the resilience of a project [10]. In agreement, Zou, Kiviniemi, and Jones [11] maintained that though Al introduction is transforming project management practices, risk management remain a critical practice to determine project success as incidences not managed can be severe with impact to lives and project evolution, thus project manager role includes to ensure that imminent risks present in every project are minimized, if not eliminated [12]. These submissions list RM as a key project management practice that guarantees project success. With the construction industry regarded as a most impactful and contributor to UK economy [13], with 353,365 companies [14] employing 9% of total national workforce and contributing 6.7% of the country's total economy [15] to a gross value of £128.9 billion in 2022 which represents a 6% increase over the previous year [16], and incremental economic contribution of 1.6% volume increase reported in June 2023 [17], the importance of RM for this industry cannot be over-emphasised.

As AI adoption increases in different phases of the construction industry [18,19], the nature of risk in this industry especially for complex and data-intensive projects also changes [12] and project managers' expertise to identify, assess and mitigate the new risks are challenged. To overcome this challenge that could impact the construction industry, organisations aiming to prevent potential risks and enhance positive outcomes of projects introduce and adopt Al to its RM processes [12,20,21].

PMI [8] demonstrated that certain competencies are required to successfully overcome challenges in project management processes, while effectively accomplishing the desired objectives [22]. With the growing need for AI adoption in risk management (RM) processes [23,24], driven by its ability to analyze vast amounts of data in real time and generate valuable insights for proactive risk identification, assessment, and strategy formulation, there is an equally urgent need to redefine and enhance the competencies required of project managers to effectively leverage AI technology. El Khatib and Al Falasi [25], likewise, summarily recorded that project management experts and professionals must understand the significance of Al to maintain their competitiveness and effectively utilise emerging technologies.

With the absence or improper RM reportedly having adverse effects on projects [26] up to the company's insolvency or liquidation [27] depending on the value of the project and organisation, RM has been described as a critical element of project success [28, 29]. RM is, particularly, important in the construction industry due to its contribution to the economic and social infrastructure development of any nation [30, 26]. Van Thuyet, Ogunlana, and Dey [31] equally submitted that, while risk factors vary based on the project, RM is critical for project success. The complexity of modern projects adopting Al in its processes thus requires alternative RM approaches to traditional risk assessment and mitigation approaches, thus, birthing the need to embrace technologies, particularly AI, to enhance RM practices. Al-driven RM has been identified to provide more accurate, proactive, and data-driven insights into potential risks and opportunities [32, 33].

Although project management continues to be identified as a critical profession to resolve challenging and complex organisational matters [34, 35], the continuous technological advancement and increasing integration of Al technology into project management practices are revolutionising the functional roles of project managers [36] requiring the project managers to possess Al competence and understand the significance of this competence in project RM to drive project success. [37,38,39]. The rationale for this research on assessing the significance of Al competence for project managers, hence, stems from primary factors which include the evolving project managers' role due to the increasing adoption of Al technologies in project management and the change in project RM practices from the traditional RM approaches. This extended research, therefore, aims to evaluate the significance of Al as a competence for project managers and its impact on RM practices in the UK construction industry. It seeks to assess the synergies between Al technology and Al competence in project managers to continually drive RM for project success in this technology-driven project environment in the United Kingdom.

II. Methodology

A robust methodology is essential for ensuring the validity and reliability of research findings. This study employed a narrative literature review approach to explore the significance of AI competence for project managers and its impact on risk management (RM) practices in the UK construction industry. The following sections outline the research design, data sources, search strategy, inclusion and exclusion criteria, data extraction, and synthesis approach.

2.1 Research Design

This study adopted a narrative literature review to synthesize existing research on AI competence in project management. A narrative approach was chosen due to its ability to integrate diverse findings from multiple studies into a coherent discussion while allowing for an in-depth thematic analysis. Unlike systematic reviews, which follow a rigid protocol, a narrative review provides contextual insights by analyzing literature across different study designs, methodologies, and theoretical perspectives. Given the evolving nature of AI in project risk management, this approach enabled the study to capture emerging trends, challenges, and competencies required by project managers.

2.2 Data Sources and Search Strategy

A comprehensive search of academic literature was conducted using three major electronic databases:

- ProQuest (for business, technology, and management-related studies)
- MEDLINE (for health and safety aspects of AI in project management)
- IEEE Xplore (for technical and engineering perspectives on AI applications)

The search was conducted between 2014 and 2024 to capture the most relevant studies on AI competence and its implications for RM practices. To enhance the precision of results, the study utilized Medical Subject Headings (MeSH) terms [40-43], which are standardized keywords assigned by database specialists. The primary MeSH terms used included:

- 'Artificial Intelligence'
- 'Project Managers'
- 'Construction Industry'

These terms were prioritized over author-generated keywords to ensure greater consistency and accuracy in retrieving relevant studies.

III. Findings

3.1 AI in the Construction Industry

According to Mich et al. [44], John McCarthy's group first proposed the idea of Al in 1959 with the belief that machines could stimulate human intelligence. This belief was adopted in Al definition by Abioye et al. [45] and Hamet and Tremblay [5] describing Al as a replication of human intelligence in machines built to think and learn like humans. Wan, Liu and Zhang [46] definition of Al as a technologically intelligent machine that emulates human intelligence capable of performing complex tasks autonomously and efficiently equally supports the concept of Al is to mimic humans with the advantage of reducing human error as well as time and cost savings to execute tasks that normally require some human- like intelligence to be performed [47]. Recording that AI application in projects improves business and project processes and offers automated advantages, Abioye et al.'s [45] definition of Al recorded that Al encompasses subfields such as machine learning, natural language processing (NLP), computer vision, and expert systems which are all aimed to emulate humans in their different applications to improve current processes. These various definitions point that Al in whatever form is machine/tools created to replicate human intelligence through continuous learning and problem-solving to improve productivity and lower error rates in tasks across a variety of domains.

Although Öztürk [48] submission acknowledges that Al is beneficial for current ongoing easy and complex project tasks, it also identifies that Al impact determines the future of organisation with both theoretical challenges and opportunities. In agreement, Mich et al. [44] recorded that Al technology, though regarded as a transformative field with the potential to bring about significant advancements is not without its critiques and challenges. A major challenge of AI according to Öztürk [48] impacting all industries and processes lies in its rapid development which is increasingly becoming an autonomous Al system with own reflex and intentional action, requiring zero human interaction with the potential to result in significant challenging changes in existing need for human management and organisations [49]. This will result in declined human capabilities/expertise if there is no need to increase or apply knowledge, job displacement leading to unemployment and eventual negative impact on the societal economy [50]. Gries and Naudé, though, queried Al negative impact citing historical low record of unemployment and high GDP in many advanced technically advanced economies, agreed that Al adoption is witnessing stagnation in wages and productivity with increase in inequality [51].

The cost of implementing Al is a challenge in the UK construction industry especially as less than 1% of UK Construction Company is regarded as big companies with the multiple financial resources employing over three hundred (300) employees and the majority of 81.8% are small organisation with less than 4 employees [14]. Other concerns regarding Al adoption in the construction industry after its implementation are ethical considerations relating to biased recruitment and personnel allocation using previous data on record with little option to update project requirements and new members [52,53,54]; difficulty in determining liability and accountability between Al systems, operator, or company process for safety errors/accident [54]; and concerns about privacy of confidential personal and company data to prevent breach and unauthorized access [53, 54] are concerns of Al requiring commitment to responsible Al adoption.

3.2 RM in the Construction Industry

Risks refer to the likelihood of harm, loss, or damage [55] which is acknowledged as numerous and always occurring in the construction industry [56,57] either as internal risk within the project manager's control to prevent or mitigate or external risks [26, 57]. For the effective management of these risks, the significance to implement necessary different RM techniques after assessing the identified risks has been advocated as either Prevention RM to manage risk before the start of projects, Remediate RM used during project execution for existing risk [57] or the Enterprise RM which advocate that all risk should be comprehensively managed [58]. The management of these risks is described by APM [9] as an initiative-taking process to identify, assess and respond appropriately to risk. It plays a crucial role in successful project execution by identifying potential threats or uncertainties that may hinder goal attainment [59] PMI [8] in its definition of risk as an uncertain incidence with either a positive or negative impact; recorded RM as the process of fore-planning, identifying, analyzing, preventing, monitoring, and controlling identified risks with the aim of either increasing the occurrence and impact of positive risks or reducing the occurrence and impact of negative risks as the impact determines the success of a project [59, 26] and thus an important responsibility for the project manager.

Despite the significance of RM in determining the level of success of a project, there are concerns that undermine its effectiveness. RM has been recorded to disregard arising risk due to scope change and ambiguity using a simple but generalised risk analysis for all risk types [60,61]; assuming a one-size fit all strategies for all arising risks from project changes or unclear risks leave projects vulnerable to unplanned complications, potential misunderstanding and underestimating of the impact of such risks. Fernandes [60] also criticise risk management for misaligning risks following manipulating definition of risks from multiple stakeholders to suit their different objectives. Chatterjee et al. [62] in recommending strategies to manage emerging risk in the construction industry agree that there would remain hidden risks from having different stakeholders especially as these risks impacts cost, resulting in time delays and quality of projects.

These criticisms highlight the criticality for RM to adapt and address new challenges posed by scope change or risk ambiguity. With the incorporation of Al into project practices and emerging new risks, the need for a more flexible, holistic, and proactive RM to improve an organisation's ability to navigate the uncertain project environment is increasingly pronounced. Thus, as AI adoption in project practices especially modern RM increases, it is necessary to draw insights from past literature to inform a more holistic perspective.

3.3 AI Integration in Project Management: A Focus on RM Practice

Project management, the core to manage the dynamic and ever-evolving landscape of business and industries, is defined by APM [63] as the utilisation of set processes, skills, and experience to achieve expected results/objectives within set timeline and budgets. PMI [8] stated that it involves efficient planning and organisation of resources to achieve predetermined goals while effectively managing risks as one of its essential practice. Marnewick and Marnewick [64] in defining Project management cited various definitions from PMI and APM with summarised definition as the use skills, tools, and processes aimed at achieving specific project objectives within specified constraints. The growth of technology, particularly artificial intelligence (AI), which is intended to restructure all domains, necessitates a well-structured project management approach to guide organisations ensuring that objectives are achieved within scope, time and cost.

Al has emerged as a transformative technology that holds the potential to revolutionise various domains of human activity [65]. Its impact on project management practices, specifically in the realm of RM, is an area that requires extensive study and analysis. Taboada [66] and Kabanda [67] submitted that there has been growing interest in integrating AI technologies into project management practices, in recent years, as organisations strive for greater efficiency and effectiveness when dealing with uncertainties and risks. The Harvard Business Review report [68] acknowledged that the constantly evolving technology results continue to witness patterns of Al adoption into project and business plans albeit at a low rate thus resulting in only 35% of successful projects. The report attributed the low project success rate to the low technology experience in this field with a prediction of increased utilization of AI by year 2030 especially for risk forecasting and assessment [68].

Kabanda [67] also reported that Al technologies have immense potential to enhance risk-management processes through intelligent solutions encompassing Identification, analysis, and mitigation measures. He, further, emphasized that Project managers are responsible for managing risk [67] and are thus able to leverage Al competencies with Al technologies in RM. Jöhnk, Weißert and Wyrtki [65] collaborated that Project managers can generate data-driven insights by using recent innovative methods including automated risk identification predictive analysis amongst others in addition to conducting comprehensive analyses, incorporating existing literature reviews, relevant case studies, and industry practices.

Whilst Pournader, Kach and Talluri [69] reported some unresolved challenges with Al adoption including substandard and inaccurate inputs leading to flawed decision-making, Ahmad et al. emphasized that there seems to be a clear positive trajectory relating to technologies Integration within project management entities, particularly for risk detection [70]. Statistical records from Gov UK [71] showed that although only 15% of companies within the UK and only 13% of construction companies have adopted at least one Al technology into its operations, El Khatib et al. [72] survey indicated that 68% of UK companies that have integrated Al into its processes use Al technologies for risk assessment and prediction. This indicates an increasing recognition among businesses regarding the benefits that could potentially result from adopting Al into project management practices, specifically concerning RM.

One prevalent case is IBM's Watson Explorer platform, which integrates NLP algorithms to effectively analyse large volumes of unstructured data sourced including contracts to extract pertinent information, thereby enabling the detection of risks and associated threats such as contractual obligations or compliance issues more efficiently than traditional manual methods [73]. RiskLens, another software application, employs both advanced analytical tools and machine learning principles in its predictive capability to quantify the impact/prospective losses and priority levels of various uncertainties and risks in specific projects. It, thus, enables organisations to prioritise their areas of focus [62].

Apart from the shift in conventional models and new methodologies characterised by the advent of Al technological intelligence, other noteworthy illustrative embracing change propagated according to Kabanda [67] is the multiple innovative predictive risk analysis advantage of Al experienced by organisations that have adopted Al. Calkin et al. [74] reiterated that undeniably Al-driven predictive risk analysis has gained significant traction within the realm of project management practices in relation to acknowledging the importance of quality decision-making processes and overall success rates. Companies are leveraging these technologies by employing machine learning algorithms capable of analysing extensive datasets encompassing information pertaining to previous projects' risk likelihoods, including potential over-budget undertakings, or scheduling to make decisions that ensure successful project results [74].

By identifying keywords associated with various risk sentiments attached to them through rigorous scrutiny, NLP-based systems provide early warnings concerning impending hazards previously undetected via traditional approaches [65]. The adoption of predictive risk analysis in project management is supported by empirical statistics, demonstrating its increasing popularity. Other empirical statistics demonstrating the increasing popularity of adopting predictive risk analysis in project management include Fitzsimmons et al. [75] study to accurately estimate risk boundaries and risk analysis in project scheduling and planning of 302 construction projects and 10 case studies in the UK with the use of machine intelligence (a subset of Al); the study examined the influence of predictive risk analysis on project outcomes. The research found that organisations employing Al-powered predictive risk analysis tools experienced 54.4% more accuracy in risk prediction resulting in lower levels of cost overruns and schedule delays compared to those relying solely on traditional methods.

Of particular importance are studies that examine real-world applications integrating technology into managing risks effectively evidence predictive risk analysis utilizing historical data alongside algorithms to forecast potential risks impact on project outcomes with improved accuracy. Labinsky et al. [76] agreed that integrating Al technologies into organisational RM practices enhances decision- making capabilities. Abioye et al.'s [45] comprehensive survey among construction companies operating in the UK evaluated adopting diverse Al technology within various areas related to project management practices-including whether it was employed for predictive risk analysis in which 70% reported successful adoption of at 5 of the 6 different versions of Al in their RM practice (Table 1).

	Al Subfields					
Construction Areas	Machine Learning	Computer Vision	Robotics	Knowledge based systems	Natural Language Processing	Optimisation
Health & Safety	✓	✓		✓	✓	
Scheduling	✓			✓		✓
Cost Estimation	✓			✓		✓

Legal	✓	✓		✓	✓	✓
Supply Chain & Logistics	✓			✓		✓
Site Monitoring	✓	✓	✓	✓	✓	
Material Mgt	✓	✓	✓		✓	✓
Offsite Assembly	✓		✓			
Plant & Equipment Met	✓	✓	✓		✓	✓
Project Planning	✓	✓		✓	✓	✓
Knowledge Mgt	✓	✓		✓		
Design	✓	✓	✓	✓		✓
Risk Migt	✓			✓	✓	✓
Temporary Structure	✓					✓
Bids/Tenders	✓		✓	✓		
Energy Migt	✓		✓			
Sustainability	✓			✓		

Table 1 Al adoption in UK project management practice (Construction Industry)
Source: Adapted from Abioye et al. [45]

Similarly, although Jallow et al. [18] contrary opinion decries the popularity of Al use in the construction industry, the case study equally indicates full implementation of Al predictive analytics tools as part of a broader approach towards identifying and mitigating potential risks faced during construction projects undertaken within the United Kingdom. The report concluded that Al in construction is used for RM in three ways: Asset management handling tasks that human staff members would normally be endangered to do, Health and Safety automatic risk evaluations for onsite risks and risk mitigation detect risks that human staff would not be aware of [18]. Likewise, companies like Balfour Beatty have implemented effective real-live Al-driven systems focused explicitly on managing risks [77]. Apart from construction, other studies include Al technology in airline industry with the adoption of machine learning algorithms and predictive risk analysis to determine flight cancellation risks were illustrated by Zoutendijk and Mitici [78] and Yazdi et al. [79]. By analysing historical data such as weather conditions, maintenance records, and crew availability, their Al system accurately forecasts potential disruptions. Consequently, proactive decision-making becomes possible while enabling the implementation of mitigation strategies beforehand to reduce inconvenience for passengers and minimise financial losses. These Al systems analyse real-time project data to identify patterns and trends indicative of potential risks as they arise continuously, utilising machine learning algorithms for evaluating different project parameters such as budget allocation, resource utilisation, and schedule adherence [72]. By combining historical data from similar projects with up-to-the-minute information regarding ongoing ones, these integrated Al systems generate accurate predictions about potential risks along with their expected impact on overall project outcomes.

3.4 Benefits and Challenges of AI Implementation in UK Construction Industry Project Management

3.4.1 Benefits

One of the benefits of integrating Al as a competence for project managers is improved decision-making. By harnessing Al technologies capable of processing vast amounts of data, identifying patterns and trends, and providing valuable insights, project managers in construction industry can make more informed and accurate decisions [80]. This enhanced decision-making ability significantly improves project outcomes by enabling early identification of potential risks, effective evaluation of their impact, and development of appropriate mitigation strategies [81]. Other industry's empirical evidence supports the positive impact achieved through integrating Al into RM decision-making processes: Rodriguez-Espíndola et al. [82] study in digital manufacturing and Paul, Riaz and Das [83] research in the supply chain space examined how Al-based tools are implemented to assess and manage risks. The studies highlighted advanced analytics capabilities such as machine learning algorithms, which facilitated better identification of risks through analysis involving vast datasets related to similar projects or occurrences from historical data sources.

Improved efficiency and productivity are identified as other benefits resulting from incorporating Al technology into RM practices. Abioye et al.'s [45] research demonstrated higher levels of efficiency when utilising Al tools compared to traditional methods employed solely on projects without such integration. Similarly, research by Yaseen et al. [84] illustrated how using Machine Learning algorithms enhances human capability, leading towards quicker identifications and strategising processes, thereby making them efficient at handling day-to-day routine activities like report generation. Furthermore, Endsley [85] suggested that Al automation leads to

efficiency as it saves valuable time and improves the accuracy of risk assessment. Al technologies, according to Ribeiro et al. [86], simplify and facilitate the automation of routine tasks such data gathering and analysis, report production, and resource allocation, thus resulting in more time for project managers to focus on more complex aspects of RM.

Another advantage is the potential for reduced human error through Al integration in RM. Ribeiro et al. [86] submission maintained that Al technology automation not only simplifies routine tasks ensuring efficiency, but also reduces human error rates. Human errors can have significant consequences for project success failure [87] due to cognitive biases, misinterpretation of data, or lapses in attention or judgment. Incorporating Al mitigates these risks by accurately processing large data without subjective biases humans may exhibit when interpreting information [88]. In conclusion, integrating Al into project management in the construction industry offers potential benefits in decision-making processes, enabling early identification and evaluation of risks as well as improving efficiency and productivity through automation and reducing human error [89].

3.4.2 Challenges

The implementation of Al in RM for project managers presents numerous benefits; however, its successful integration faces several challenges that hinder progress [80]. Abioye et al. [45] in the demonstration of the impact of AI from benefits to opportunities reported that Al adoption is challenged by numerous factors which primarily revolve around two major issues: the lack of understanding and expertise among project managers [12], as well as resistance to change [72], especially within the organisation [90]. One significant barrier is the limited comprehension of Al technology and its application in RM by many project managers. This lack of understanding often leads to skepticism or hesitation when it comes to embracing Al tools and techniques [76]. Project managers may struggle with grasping how Al algorithm's function, resulting in difficulties interpreting the outputs generated by these systems. Without sufficient knowledge and expertise, they fail to fully leverage the capabilities offered by Al for identifying and mitigating risks effectively.

Moreover, organisational resistance poses another challenge for integrating Al into RM practices. The Implementation of such technologies typically requires restructuring within an organisation, along with redefining traditional roles and responsibilities [82]. Employees fearing job displacement or changes in their workflows can impede the successful adoption of Al tools in RM processes. Strong leadership support is crucial within organisations alongside effective change management strategies addressing employee concerns about job security while emphasising how adopting Al can enhance their role as project managers [82]. As highlighted by a survey conducted by Benbya, Davenport, and Pachidi [91], majority of surveyed organisations cited recruiting of efficient human talent as a primary challenge for implementing initiatives related to AI due to a lack of skills, understanding, and training. The data suggests this inadequate preparation prevents many from embracing the new competencies required. Moreover, in one case study focusing on the construction industry reports that 38%-45% of construction roles would be completely automated by 2030 as stated by Araújo et al. cited in Regona et al. [92] thus eliciting resistance when attempting to introduce an artificially intelligent predictive analytics system designed specifically for identifying potential risks. A company aimed at implementing this innovative solution but encountered considerable pushback from project managers accustomed to using traditional risk assessment methods. Resistance arose from concerns regarding the accuracy and trustworthiness of the AI system's outputs.

3.5 Assessing Project Managers' Competencies in Utilizing AI for RM

Defining competence as the skillset to understand and employ contextually relevant knowledge and psychosocial factor like beliefs, attitudes, and willingness to undertake tasks efficiently, Vitello, Greatorex, and Shaw [93] described it as a significant factor to determine success. It is a key factor in determining success because it represents a holistic combination of knowledge, skills, abilities, and behaviours [8] including the capacity to adapt and innovate performance effectively and efficiently. The increasing integration of AI tools in business processes is a clear reflection of this technologically driven era, a trend that is also visible in project management, which is regarded as the lead of organizational operations [94] and RM practices [83]. Consequently, it becomes imperative for project managers to possess the necessary competences and understanding that enable them to effectively utilise AI tools for RM.

In the context of this research, competence is the possession of knowledge, skills, and capabilities required to effectively understand, utilize, and manage Al technologies within the construction project management domain. Al competency for project managers is the ability to use Al tools, evaluate Al-generated insights, and make educated decisions to reduce risk and effectively achieve project success. Exploring this topic provides valuable insights into what project managers require to leverage AI technologies and maximise their potential benefits while mitigating associated risks. In this, three key areas (figure 3.1) emerge as particularly important: technical proficiency with AI tools, domain expertise related to risk principles, and effective human managerial skills.

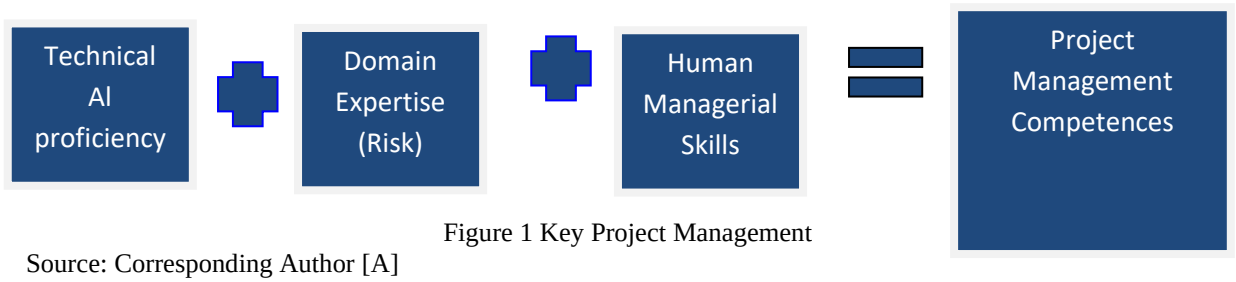

Figure 1 Key Project Management

Source: Corresponding Author [A]

Technical proficiency stands out as a fundamental knowledge area required by project managers seeking to effectively utilise Al tools for RM purposes. Verma et al.'s [95] study emphasised that possessing a strong understanding of Al tools' technical aspects is crucial when aiming to harness their full potential in managing risks within projects. By having technical proficiency with these tools, project managers are better equipped to accurately assess risks through pattern identification and data-driven processes facilitated by machine learning algorithms - exemplifying their capability to analyse large volumes of historical data and efficiently identify trends or anomalies suggestive of potential hazards. Project managers who excel at interpreting algorithm-generated results make informed decisions based on reliable information derived from these outputs; they understand different algorithms' inner workings along with parameters affecting performance quality alongside sensitivity towards changes encountered concerning input datasets [96, 80]. Ashtari et al.'s [94] case study also highlighted the importance of technical competence among construction-based project manager teams working with implemented systems. The study focused on how effectively using Al technical competence can help with accurate hazard identification, prioritisation according to severity metrics, and the development of effective mitigation strategies.

Another focal area demanding attention is competencies around domain expertise of fundamental RM practices and principles. According to Yabanci [97] research, high-level proficiency in particular domain knowledge/expertise as crucial. The research described domain expertise as possessing a deep understanding of the industry or field-specific aspects under which a project(s) operates. Although Al tools provide valuable assistance via analysis involving large data volumes while detecting patterns and trends indicative of possible risks; nevertheless, lacking relevant context renders these insights without their due relevance- a project problem addressed by project managers who have access to domain experts' understanding and interpretations, enables them to make well-informed decisions impacting the development of effective mitigation strategies. Developing a profound knowledge base pertaining to RM principles provides project managers with solid foundations, which enables them to monitor threats/hazards in different initiatives that are linked to specific sectors, industries, or fields and to better understand their intricate complexity [98]. These skills enable them to recognise potential risks as they arise across the lifecycles of ongoing project operations, accurately determining likelihood levels and associated potential impacts, and creating effective response strategies.

Beyond the technical competencies necessary for implementing and effectively using AI in project RM are the traditional managerial skills that are critical to maximising Al's potential in a project. The importance of critically reviewed and necessary project manager's competence has been stressed since the emergence of project management, with different competencies established and maintained over the evolution years [99]. Mcgrath and Kostalova [100] reported that although there is a fundamental ongoing shift in project management with empirical evidence of increased reliance on Al tools, techniques, and procedures, project management success is enabled by a combination of all factors, including the human factor, such as creativity, innovation, decision-making team spirit, and communication.

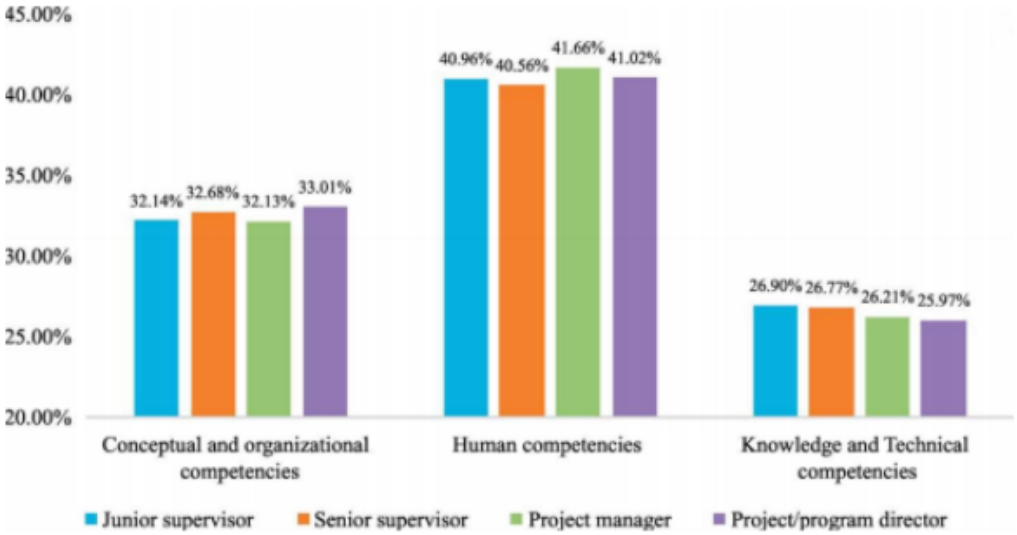

Figure 2 Competency levels based on project managers' professional expertise.
Source: Chen et al. 2019 [101]

Chen et al. [101] and Ahmad and Imam [102] agreed that although it is necessary to combine all the required key project management competencies (Figure 3.1) including the general technical skills of the industry in varying degrees dependent on the level of the project manager (figure 3.2); the evolving changes ongoing with Al integration in project management and particularly in project RM practices require new technical competencies.

IV. Conclusion

This review underscores the increasing adoption of Al in project management practices, especially RM, as demonstrated earlier, as well as the relevance of RM in determining project success and the project manager's responsibility to reduce, if not eliminate, project risks, drive the importance of conducting the study. Empirical evidence from past literature pointed out that whilst there seems to be a clear positive trajectory relating to technology adoption within UK- based project management entities due to its relative benefits such as improved efficiency and productivity, reduction of human error and improved decision making, especially in protocols governing risk identification, there remain some unresolved challenges including resistance to change for fear of job loss and lack of understanding and expertise of project managers.

4.1 Recommendations

This extended research provides valuable insights with contribution to existing literature revealing the significance of Al competence for Project Managers and its importance in influencing project. RM practices within the construction industry in the United Kingdom with transferable insight into other industries and countries. The research enriches the practical understanding of project managers changing responsibilities in an AI-driven project landscape, adapting to the change by embracing technology, enhancing skills, and evolving roles. By investigating the significance of Al competence for project managers, the study provides insights into how to navigate the challenges posed by complex contemporary projects and devise appropriate strategies to manage the risk evolving from these projects; like the application of risk tools like stakeholder mapping and analysis to identify real- time key players, their concems and identifiable risk management supports to address one of the major concern of having multiple stakeholders with different priorities in a complex contemporary projects.

This research further highlights the necessity for project managers to continually upskill and receive Al competency training to identify and utilise the evolving adaptive effects of Al-driven technologies on RM and other project management practices. Consequently, the evaluation of the influence of Al on project RM provides guiding patterns for a positive adoption of Al across the project lifecycle from planning to completion. The significance of this research extends beyond project teams and managers to impact the entire organisation and provide theoretical implications for the professional industry. Through empowering project managers with AI competency necessary for RM, organisations can improve their success rating card, optimise resource allocation, and maintain a competitive edge. The insights from this research would aid organisations in implementing strategic Al trainings/programs that would foster effective RM practices, foster innovative reasoning leading to sustainable project success and Al advancement in the project management lifecycle. The study further supports the inclusion of a theoretical framework on the hypothesis the project managers' intent to learn and adapt to change

is important; this is because the empirical reviews evidenced that the successful integration of Al into project management practices is dependent not only on technological capabilities but also on the project managers' knowledge, as well as the positive impact of combining human expertise with Al technologies on risk management, decision-making and project success. This certifies project managers to understand, accept and adapt to new processes and responsibilities in the context of accepting innovative practices or technologies in the construction industry.

Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Authors Contribution

All authors contributed to the review process.

Final Approval of Manuscript

All authors

Ethics Approval and consent to Participate

Not Applicable

Consent to Publish

Not applicable

Availability of Data and Materials

Not Applicable.

Competing Interests

Authors have declared that they have no competing interests

Funding

No funds were received for this study

Acknowledgements

Not Applicable

References

[1]. Al-Mashari M, Zairi M. Revisiting BPR: a holistic review of practice and development. Business process management journal. 2000 Mar 1;6(1):10-42.
[2]. Whyte J. How digital information transforms project delivery models. Project management journal. 2019 Apr;50(2):177-94.
[3]. Lavikka RH, Kyrö R, Peltokorpi A, Särkilahti A. Revealing change dynamics in hospital construction projects. Engineering, Construction and Architectural Management. 2019 Sep 4;26(9):1946-61.
[4]. Miozzo M, Ivory C. Restructuring in the British construction industry: Implications of recent changes in project management and technology. Technology Analysis & Strategic Management. 2000 Dec 1;12(4):513-31.
[5]. Feduniw S, Golik D, Kajdy A, Pruc M, Modzelewski J, Sys D, Kwiatkowski S, Makomaska-Szaroszyk E, Rabijewski M. Application of artificial intelligence in screening for adverse perinatal outcomes—a systematic review. InHealthcare 2022 Oct 29 (Vol. 10, No. 11, p. 2164). MDPI.
[6]. Huemann M, Turner JR, editors. The Handbook of Project Management. Routledge; 2024 Feb 28.
[7]. Pan Y, Zhang L. Roles of artificial intelligence in construction engineering and management: A critical review and future trends. Automation in Construction. 2021 Feb 1;122:103517.
[8]. Project Management Institute. The PMI Guide to Business Analysis. Project Management Institute.
[9]. Risk WD. What is Risk Management?.
[10]. Sax J, Andersen TJ. Making risk management strategic: Integrating enterprise risk management with strategic planning. European Management Review. 2019 Sep;16(3):719-40.
[11]. Zou Y, Kiviniemi A, Jones SW. A review of risk management through BIM and BIM-related technologies. Safety science. 2017 Aug 1;97:88-98.
[12]. Alzoubi HM. BIM as a tool to optimize and manage project risk management. International Journal of Mechanical Engineering. 2022;7(1).
[13]. GOV.UK. Construction sector deal. [online]. London: GOV UK. 2019. Available from: https://www.gov.uk/government/publications/construction-sector- deal/construction-sector-deal [Accessed 3 August 2023].
[14]. STATISTA. Number of construction firms in Great Britain in the 3rd quarter of 2021, by employment size. 2023. [online]. London: Statista. Available from: https://www.statista.com/statistics/564807/construction-firms-size-region-great- britain/ [Accessed 18 August 2023].
[15]. Bozorgzadeh A, Umar T. Automated progress measurement using computer vision technology in UK construction. Proceedings of the Institution of Civil Engineers-Smart Infrastructure and Construction. 2023 Jul 6;176(4):165-82.
[16]. Edirisinghe R, Jayasuriya S, Almulla J, Abobakr M, Bastos Costa D, Alberte E, Hastak M, Tzortzopoulos P. Gender diversity in construction: demystifying the pipeline leaks in Australia, United States, United Kingdom and Brazil. International Journal of Construction Management. 2024 Aug 25:1-5.
[17]. Allcoat J. Construction Output in Great Britain: February 2021. Office for National Statistics: Newport, UK. 2021 Feb 13.
[18]. Jallow H, Renukappa S, Suresh S, Rahimian F. Artificial intelligence and the UK construction industry–empirical study. Engineering Management Journal. 2023 Oct 2;35(4):420-33.
[19]. Newman C, Edwards D, Martek I, Lai J, Thwala WD, Rillie I. Industry 4.0 deployment in the construction industry: a bibliometric literature review and UK-based case study. Smart and Sustainable Built Environment. 2021 Nov 12;10(4):557-80.
[20]. Afzal F, Yunfei S, Nazir M, Bhatti SM. A review of artificial intelligence based risk assessment methods for capturing complexity-risk interdependencies: Cost overrun in construction projects. International Journal of Managing Projects in Business. 2021 Feb 15;14(2):300-28.

[21]. Wamba-Taguimdje SL, Wamba SF, Kamdjoug JR, Wanko CE. Influence of artificial intelligence (AI) on firm performance: the business value of AI-based transformation projects. Business process management journal. 2020 May 12;26(7):1893-924.
[22]. Silvius AG, Schipper RP. Sustainability in project management competencies: analyzing the competence gap of project managers. Journal of Human Resource and Sustainability Studies. 2014 May 15;2014.
[23]. Davahli MR. The last state of artificial intelligence in project management. arXiv preprint arXiv:2012.12262. 2020 Dec 16.
[24]. Ong S, Uddin S. Data science and artificial intelligence in project management: the past, present and future. The Journal of Modern Project Management. 2020;7(4).
[25]. El Khatib M, Al Falasi A. Effects of artificial intelligence on decision making in project management. American Journal of Industrial and Business Management. 2021 Mar 15;11(3):251-60.
[26]. Siraj NB, Fayek AR. Risk identification and common risks in construction: Literature review and content analysis. Journal of construction engineering and management. 2019 Sep 1;145(9):03119004.
[27]. Chłodnicka H, Zimon G. Bankruptcu risk assessment measures of polish SMEs. WSEAS Transactions on Business and Economics. 2020 Apr;17(3):14-20.
[28]. Goswami V. The Effectiveness of Risk Management in Project Success.
[29]. Kishk M, Ukaga C. The impact of effective risk management on project success.
[30]. Bahamid RA, Doh SI, Khoiry MA, Kassem MA, Al-Sharafi MA. The current risk management practices and knowledge in the construction industry. Buildings. 2022 Jul 14;12(7):1016.
[31]. Van Thuyet N, Ogunlana SO, Dey PK. Risk management in oil and gas construction projects in Vietnam. InRisk Management in Engineering and Construction 2019 Sep 9 (pp. 225-247). Routledge.
[32]. Herath HM, Mittal M. Adoption of artificial intelligence in smart cities: A comprehensive review. International Journal of Information Management Data Insights. 2022 Apr 1;2(1):100076.
[33]. Zhang Y, Geng P, Sivaparthipan CB, Muthu BA. Big data and artificial intelligence based early risk warning system of fire hazard for smart cities. Sustainable Energy Technologies and Assessments. 2021 Jun 1;45:100986.
[34]. Denicol J, Davies A. The megaproject-based firm: Building programme management capability to deliver megaprojects. International Journal of Project Management. 2022 Jul 1;40(5):505-16.
[35]. Hobday M. The project-based organisation: an ideal form for managing complex products and systems?. Research policy. 2000 Aug 1;29(7-8):871-93.
[36]. PMI. Pulse of the Profession: Power Skills, redefining project success 14th Edition. 2023. [online]. Newton Square, PA: PMI. Available from: pmi-pulse-of-the- profession-2023-report.pdf [Accessed 8 August 2023).
[37]. Ahmad S, Gul W, Sadiq I, Rehman SU. IMPACT OF USING AI TO MANAGE PROJECT RISKS INCLUDING CHANGE IN SCOPE AND LACK OF REQUIRED SKILLS: MODERATING EFFECT OF TEAM EXPERTISE IN IT INDUSTRY OF PAKISTAN. Russian Law Journal. 2023;11(12S):753-75.
[38]. APM. The Al project management-driven revolution is here. [online]. Buckinghamshire: APM. 2023.Available from: The Al project management driven revolution is here (apm.org.uk) [Accessed 21 July 2023).
[39]. Schwarz IJ, Sánchez IP. Implementation of artificial intelligence into risk management decision-making processes in construction projects. Universität der Bundeswehr München, Institut für Baubetrieb. 2015:357-78.
[40]. Patel M, Patel N. Exploring research methodology. International Journal of Research and Review. 2019;6(3):48-55.
[41]. Aczel P. Virtual reality and education-world of teachcraft?. Perspectives of Innovations, Economics and Business. 2017 Jan 1;17(1):6-23.
[42]. Barlish K, Sullivan K. How to measure the benefits of BIM—A case study approach. Automation in construction. 2012 Jul 1;24:149-59.
[43]. Verner JM, Abdullah LM. Exploratory case study research: Outsourced project failure. Information and Software Technology. 2012 Aug 1;54(8):866-86.
[44]. Mich L. Artificial intelligence and machine learning. Handbook of e-Tourism. 2020:1-21.
[45]. Abioye SO, Oyedele LO, Akanbi L, Ajayi A, Delgado JM, Bilal M, Akinade OO, Ahmed A. Artificial intelligence in the construction industry: A review of present status, opportunities and future challenges. Journal of Building Engineering. 2021 Dec 1;44:103299.
[46]. Wan H, Liu G, Zhang L. Research on the application of artificial intelligence in computer network technology. InProceedings of the 2021 5th International Conference on Electronic Information Technology and Computer Engineering 2021 Oct 22 (pp. 704-707).
[47]. Anantrasirichai N, Bull D. Artificial intelligence in the creative industries: a review. Artificial intelligence review. 2022 Jan;55(1):589-656.
[48]. Öztürk D. What does artificial intelligence mean for organizations? A systematic review of organization studies research and a way forward. The Impact of Artificial Intelligence on Governance, Economics and Finance, Volume I. 2021 Apr 27:265-89.
[49]. Van Rijmenam M, Logue D. Revising the 'science of the organisation': Theorising AI agency and actorhood. Innovation. 2021 Jan 2;23(1):127-44.
[50]. Mutascu M, Hegerty SW. Predicting the contribution of artificial intelligence to unemployment rates: an artificial neural network approach. Journal of Economics and Finance. 2023 Jun;47(2):400-16.
[51]. Gries T, Naudé W. Artificial intelligence, jobs, inequality and productivity: Does aggregate demand matter?.
[52]. Roemmich K, Rosenberg T, Fan S, Andalibi N. Values in emotion artificial intelligence hiring services: Technosolutions to organizational problems. Proceedings of the ACM on Human-Computer Interaction. 2023 Apr 16;7(CSCW1):1-28.
[53]. Niederman F. Project management: openings for disruption from AI and advanced analytics. Information Technology & People. 2021 Nov 16;34(6):1570-99.
[54]. Pillai VS, Matus KJ. Towards a responsible integration of artificial intelligence technology in the construction sector. Science and Public Policy. 2020 Oct 1;47(5):689-704.
[55]. Sieber JE. Protecting research subjects, employees and researchers: Implications for software engineering. Empirical Software Engineering. 2001 Dec;6:329-41.
[56]. Szymański P. Risk management in construction projects. Procedia engineering. 2017 Jan 1;208:174-82.
[57]. Iqbal S, Choudhry RM, Holschemacher K, Ali A, Tamošaitienė J. Risk management in construction projects. Technological and economic development of economy. 2015 Jan 2;21(1):65-78.
[58]. Choi Y, Ye X, Zhao L, Luo AC. Optimizing enterprise risk management: a literature review and critical analysis of the work of Wu and Olson. Annals of Operations Research. 2016 Feb;237:281-300.
[59]. Jonek-Kowalska I. Efficiency of Enterprise Risk Management (ERM) systems. Comparative analysis in the fuel sector and energy sector on the basis of Central-European companies listed on the Warsaw Stock Exchange. Resources policy. 2019 Aug 1;62:405-15.
[60]. Fernandes G, Domingues J, Tereso A, Pinto E. A stakeholders' perspective on risk management for collaborative university-industry R&D programs. Procedia Computer Science. 2021 Jan 1;181:110-8.

[61]. Aven T. Risk assessment and risk management: Review of recent advances on their foundation. European journal of operational research. 2016 Aug 16;253(1):1-3.
[62]. Chatterjee K, Zavadskas EK, Tamošaitienė J, Adhikary K, Kar S. A hybrid MCDM technique for risk management in construction projects. Symmetry. 2018 Feb 13;10(2):46.
[63]. Dacre N, Kockum F. Artificial Intelligence in project management: a review of AI's usefulness and future considerations for the project profession: a review of AI's usefulness and future considerations for the project profession.
[64]. Marnewick C, Marnewick AL. Digitalization of project management: Opportunities in research and practice. Project leadership and society. 2022 Dec 1;3:100061.
[65]. Jöhnk J, Weißert M, Wyrtki K. Ready or not, AI comes—an interview study of organizational AI readiness factors. Business & Information Systems Engineering. 2021 Feb;63(1):5-20.
[66]. Taboada I, Daneshpajouh A, Toledo N, de Vass T. Artificial intelligence enabled project management: a systematic literature review. Applied Sciences. 2023 Apr 17;13(8):5014.
[67]. Kabanda G. An evaluation of big data analytics projects and the project predictive analytics approach. Oriental Journal of Computer Science and Technology. 2020 Jan 1;12(4):132-46.
[68]. Nieto-Rodriguez A, Vargas RV. How AI Will Transform Project Management (2023) [Internet]. 2023
[69]. Pournader M, Kach A, Talluri S. A review of the existing and emerging topics in the supply chain risk management literature. Decision sciences. 2020 Aug;51(4):867-919.
[70]. Ahmad T, Zhu H, Zhang D, Tariq R, Bassam A, Ullah F, AlGhamdi AS, Alshamrani SS. Energetics Systems and artificial intelligence: Applications of industry 4.0. Energy Reports. 2022 Nov 1;8:334-61.
[71]. GOV. UK, Al activity in UK businesses: Executive Summary. [online]. London: GOV UK. 2022. Available from: https://www.gov.uk/government/publications/al- activity-in-uk-businesses/al-activity-in-uk-businesses-executive-summary [Accessed 14 August 2023].
[72]. El Khatib M, Alabdooli K, AlKaabi A, Al Harmoodi S. Sustainable Project Management: Trends and Alignment. Theoretical Economics Letters. 2020 Dec 15;10(06):1276.
[73]. Malik YS, Sircar S, Bhat S, Ansari MI, Pande T, Kumar P, Mathapati B, Balasubramanian G, Kaushik R, Natesan S, Ezzikouri S. How artificial intelligence may help the Covid-19 pandemic: Pitfalls and lessons for the future. Reviews in medical virology. 2021 Sep;31(5):1-1.
[74]. Calkin DE, O'Connor CD, Thompson MP, Stratton RD. Strategic wildfire response decision support and the risk management assistance program. Forests. 2021 Oct 15;12(10):1407.
[75]. Fitzsimmons JP, Lu R, Hong Y, Brilakis I. Construction schedule risk analysis-a hybrid machine learning approach.
[76]. Labinsky H, Ukalovic D, Hartmann F, Runft V, Wichmann A, Jakubcik J, Gambel K, Otani K, Morf H, Taubmann J, Fagni F. An AI-powered clinical decision support system to predict flares in rheumatoid arthritis: a pilot study. Diagnostics. 2023 Jan 1;13(1):148.
[77]. EUROPE MA. Construction.
[78]. Zoutendijk M, Mitici M. Probabilistic flight delay predictions using machine learning and applications to the flight-to-gate assignment problem. Aerospace. 2021 May 28;8(6):152.
[79]. Yazdi MF, Kamel SR, Chabok SJ, Kheirabadi M. Flight delay prediction based on deep learning and Levenberg-Marquart algorithm. Journal of Big Data. 2020 Nov 26;7(1):106.
[80]. Armenia S, Dangelico RM, Nonino F, Pompei A. Sustainable project management: A conceptualization-oriented review and a framework proposal for future studies. Sustainability. 2019 May 10;11(9):2664.
[81]. El Khatib M, Al Mulla A, Al Ketbi W. The role of blockchain in E-governance and decision-making in project and program management. Advances in Internet of Things. 2022 Jul 8;12(3):88-109.
[82]. Rodríguez-Espíndola O, Chowdhury S, Dey PK, Albores P, Emrouznejad A. Analysis of the adoption of emergent technologies for risk management in the era of digital manufacturing. Technological Forecasting and Social Change. 2022 May 1;178:121562.
[83]. Paul SK, Riaz S, Das S. Adoption of artificial intelligence in supply chain risk management: An Indian perspective. Journal of Global Information Management (JGIM). 2021 Sep 1;30(8):1-8.
[84]. Yaseen ZM, Ali ZH, Salih SQ, Al-Ansari N. Prediction of risk delay in construction projects using a hybrid artificial intelligence model. Sustainability. 2020 Feb 18;12(4):1514.
[85]. Endsley MR. From here to autonomy: lessons learned from human–automation research. Human factors. 2017 Feb;59(1):5-27.
[86]. Ribeiro J, Lima R, Eckhardt T, Paiva S. Robotic process automation and artificial intelligence in industry 4.0–a literature review. Procedia Computer Science. 2021 Jan 1;181:51-8.
[87]. Read GJ, Shorrock S, Walker GH, Salmon PM. State of science: Evolving perspectives on 'human error'. Ergonomics. 2021 Sep 2;64(9):1091-114.
[88]. Ronquillo CE, Peltonen LM, Pruinelli L, Chu CH, Bakken S, Beduschi A, Cato K, Hardiker N, Junger A, Michalowski M, Nyrup R. Artificial intelligence in nursing: Priorities and opportunities from an international invitational think-tank of the Nursing and Artificial Intelligence Leadership Collaborative. Journal of advanced nursing. 2021 Sep;77(9):3707-17.
[89]. Cui M, Zhang DY. Artificial intelligence and computational pathology. Laboratory Investigation. 2021 Apr 1;101(4):412-22.
[90]. Nkwunonwo UC, Whitworth M, Baily B. A review of the current status of flood modelling for urban flood risk management in the developing countries. Scientific African. 2020 Mar 1;7:e00269.
[91]. Benbya H, Davenport TH, Pachidi S. Artificial intelligence in organizations: Current state and future opportunities. MIS Quarterly Executive. 2020 Dec 3;19(4).
[92]. Regona M, Yigitcanlar T, Xia B, Li RY. Opportunities and adoption challenges of AI in the construction industry: A PRISMA review. Journal of open innovation: technology, market, and complexity. 2022 Feb 28;8(1):45.
[93]. Vitello S, Greatorex J, Shaw S. What Is Competence? A Shared Interpretation of Competence to Support Teaching, Learning and Assessment. Research Report. Cambridge University Press & Assessment. 2021 Dec 20.
[94]. Ashtari MA, Ansari R, Hassannayebi E, Jeong J. Cost overrun risk assessment and prediction in construction projects: A Bayesian network classifier approach. Buildings. 2022 Oct 11;12(10):1660.
[95]. Verma A, Lamsal K, Verma P. An investigation of skill requirements in artificial intelligence and machine learning job advertisements. Industry and Higher Education. 2022 Feb;36(1):63-73.
[96]. Holzmann V, Zitter D, Peshkess S. The expectations of project managers from artificial intelligence: A Delphi study. Project Management Journal. 2022 Oct;53(5):438-55.
[97]. Yabanci O. From human resource management to intelligent human resource management: a conceptual perspective. Human-Intelligent Systems Integration. 2019 Dec;1(2):101-9.
[98]. Fortino G, Guerrieri A, Pace P, Savaglio C, Spezzano G. Iot platforms and security: An analysis of the leading industrial/commercial solutions. Sensors. 2022 Mar 11;22(6):2196

[99]. Marnewick C, Marnewick A. Digital intelligence: A must-have for project managers. Project Leadership and Society. 2021 Dec 1;2:100026.
[100]. Mcgrath J, Kostalova J. Project management trends and new challenges 2020+.
[101]. Chen T, Fu M, Liu R, Xu X, Zhou S, Liu B. How do project management competencies change within the project management career model in large Chinese construction companies?. International Journal of project management. 2019 Apr 1;37(3):485-500.
[102]. Ahmad R, Imam H. Roles of competencies, career shock, and satisfaction in career commitment: Evidence from project-based organizations. Project Leadership and Society. 2022 Dec 1;3:100052.