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Artificial intelligence tools for project management: A knowledge-based perspective

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ABSTRACT

The rapid evolution of artificial intelligence is pressing the need to understand how organisations can integrate it into namely project management to enhance performance and outcomes. Through a systematic literature review, this paper explores artificial intelligence's potential use in project management. The thematic analysis of relevant literature identified key project management knowledge areas, such as integration, scope, communication, risk and stakeholder management, were as domains where artificial intelligence holds significant potential. The study further investigates the relationship between these knowledge areas and the most suitable types of artificial intelligence tools, such as generative artificial intelligence, and machine learning algorithms for optimisation and automation, based on the dominant knowledge type each knowledge area requires, namely formal, data-driven, or tacit knowledge. Based on the main findings, the study proposes a conceptual framework for the integration of artificial intelligence tools in project management, offering valuable insights for scholars and practitioners. Moreover, guidelines for future research to accelerate the wide adoption of artificial intelligence in the field are proposed.

1. Introduction

Project Management Institute (2021) indicates that around 12 % of the projects among the different industries around the world present complete failure, and around 35 % overrun costs or experience scope changes, indicating the need for more effective PM. Diverse reasons contribute to project failure, for example, a low level of maturity of the available technologies, the use of inadequate PM methodologies, poor leadership, and a lack of commitment from the stakeholders (Najdawi and Shaheen, 2021). Artificial Intelligence (AI) is rapidly transforming the Project Management (PM) field, offering new capabilities to support project managers and enhancing their performance (Alayed, 2025). The Project managers who are already adopting AI perceive significant benefits in project scope, schedule, cost, and quality management, enhancing their capabilities, such as problem-solving, creativity, effectiveness, collaboration, and productivity (Project Management Institute, 2024). However, despite it being currently experiencing rapid growth, being used across many industries and transforming the way tasks are executed and problems are solved (Gomes et al., 2022; Karnouskos, 2024; Storey et al., 2024), the use of AI in PM still struggles with uncertainty and complex challenges related to procurement, budget, and schedule management constraints, due to relying on relatively traditional tools, as excel spreadsheets, hindering project's effectiveness and often causing project failure (Marnewick and Marnewick, 2022).

AI is defined as the ability of a system to identify, interpret, make inferences, and learn from data to achieve predetermined organisational and societal goals, involving the creation of computational systems capable of thinking and acting humanely while reasoning and acting rationally (Enholm et al., 2022; Mikalef and Gupta, 2021; Todorović, 2022; Uchihira et al., 2020). AI tools are currently essential to tackle complex challenges across various domains with increasing autonomy and efficiency (Carayannis et al., 2024; Weber et al., 2023). However, the application of AI to the PM field is still emerging, and significant developments are still needed to achieve greater PM performance (Sklias et al., 2024). This causes some project managers to find it difficult to predict the future role of AI in the PM field (Fridgeirsson et al., 2021).

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There is a hesitation in adopting AI due to managers' uncertainty about how to effectively integrate it into their project's operations. They often face questions about which areas of their business could benefit from it and how to handle these models for different tasks (Dzhusupova et al., 2024). Knowledge areas refer to key areas of activity and responsibility within a project, defined by the type of knowledge required (Fridgeirsson et al., 2023). Also, there is a lack of clarity on how AI fits into existing workflows and processes (Mikalef and Gupta, 2021). This uncertainty forms a barrier to its adoption, as managers are careful about investing in new technologies without clearly understanding their potential impact (Enholm et al., 2022).

Although recent studies have begun to explore AI applications in PM, most reviews are either fragmented or focused on the impact of the use of AI tools or AI techniques, such as neural networks, fuzzy logic, and genetic algorithms, in certain PM domain areas or specific industries, such as construction or IT (Gil et al., 2021; Hashfi and Raharjo, 2023; Magaña Martínez and Fernandez-Rodriguez, 2015; Nenni et al., 2024; Taboada et al., 2023). Other researchers concentrate on gaps in existing knowledge and on the obstacles encountered and impacts observed during the implementation of AI in PM (Alevizos et al., 2024; Costa et al., 2022). The review of benefits and challenges, detailed in the following section shows that while AI has the potential to enhance many areas of PM, its implementation is often constrained by specific barriers. Current literature does not yet offer a unified approach to help project managers determine where and how AI tools can be most effectively applied. The conceptual framework of this study directly responds to the implementation barriers highlighted in the literature, translating them into a structured basis for more effective AI adoption in PM or how future research can facilitate the embedding of such tools in organisations.

Building on the existing literature, our study, based on a Systematic Literature Review (SLR), seeks to address the following research question: How can AI be integrated into project management? It adds to existing literature by providing a comprehensive overview of the existing AI integrations into PM, proposing a conceptual framework for leveraging the relationship between the most suitable AI tools and each PM knowledge area, and also by offering guidelines for future research.

The following section provides a literature foundation by detailing the key benefits and challenges of embedding AI in PM. The employed methodology is then described, and the main findings are presented. In light of the extant literature, the main results are discussed in the form of an integrative conceptual framework and future avenues for research. Finally, the main conclusions are provided, including the study limitations.

2. Benefits and challenges of embedding AI in PM

2.1. Benefits of using AI in PM

The benefits of using AI tools in PM are undoubtedly significant, such as better task duration estimation, issue resolution, risk mitigation, and enhanced resource allocation (Barcaui and Monat, 2023; Ko and Cheng, 2007; Niederman, 2021).

When applied to project risk management, project managers tend to bias risk responses towards avoidance as much as possible (Robert et al., 2020). AI may be helpful in detecting these cognitive biases (Uchihira et al., 2020).

The flexibility of AI tools enhances project agility by facilitating adjustments to resource allocation over time, which is crucial in dynamic project environments characterised by continuous change. This helps project managers to quickly respond to changing circumstances, formulate rapid conclusions, and eliminate bottlenecks, enhancing overall project agility and responsiveness (Cancer et al., 2023; Enholm et al., 2022).

With an example from a past project and aiming to start a similar one in the future, AI tools can be a potent tool in executing this new project. Since the basic approach will be similar, AI can help in predicting risks, facilitating more efficient planning, and conducting analyses of reports and meeting minutes efficiently.

Table 1 summarises the key benefits of AI adoption in PM, the knowledge areas that are impacted by these benefits, and the supporting

Table 1
Benefits of using AI in PM.

Benefits	Impacted knowledge areas	References
Better task duration estimation	Integration management, schedule management	Fridgeirsson et al. (2023); Ko and Cheng (2007); Nemati et al. (2002); Nenni et al. (2024); Song and Minku (2023); Tominc et al. (2023)
Risk mitigation	Integration management, risk management, quality Management, Stakeholder Management	Barcaui and Monat (2023); Cancer et al. (2023); Carayannis et al. (2024); Feuerriegel et al. (2022); Fridgeirsson et al. (2023); Gupta et al. (2022); Holzmann et al. (2022); Nenni et al. (2024); Odeh (2023); Sarafanov et al. (2024); Storey et al. (2024); Wijayasekera et al. (2022)
Improved resource allocation	Integration management, resource management	Barcaui and Monat (2023); Bodea et al. (2020); Cancer et al. (2023); Carayannis et al. (2024); Fridgeirsson et al. (2021); Holzmann et al. (2022); Jüngen and Kowalczyk (1995); Magaña Martínez and Fernandez-Rodriguez (2015); Mesa Fernández et al. (2022); Miller (2022); Nenni et al. (2024); Roth and Hendrickson (1991); Song and Minku (2023); Tominc et al. (2023); Wijayasekera et al. (2022)
Real-time Visibility	Integration management, resource management, risk management, quality management, communication management, schedule management, stakeholder management	Ko and Cheng (2007); Robert et al. (2020); Wijayasekera et al. (2022)
Enhanced communication	Integration management, communication management, stakeholder management	Bodea et al. (2020); Cancer et al. (2023); Carayannis et al. (2024); Feuerriegel et al. (2022); Fridgeirsson et al. (2021); Holzmann et al. (2022); Jüngen and Kowalczyk (1995); Mesa Fernández et al. (2022); Miller (2022); Nenni et al. (2024); Storey et al. (2024); Wijayasekera et al. (2022)
Efficient administrative tasks	Integration management, cost management, resource management, communication management, schedule management	Barcaui and Monat (2023); Bushuyev et al. (2024); Cancer et al. (2023); Carayannis et al. (2024); Enholm et al. (2022); Fridgeirsson et al. (2021); Holzmann et al. (2022); Jüngen and Kowalczyk (1995); Nenni et al. (2024); Sarafanov et al. (2024); Tominc et al. (2023)
Enhanced project agility	Integration management, scope management, resource management, communication management, schedule management, stakeholder management	Bushuyev et al. (2024); Cancer et al. (2023); Enholm et al. (2022); Holzmann et al. (2022); Nenni et al. (2024); Song and Minku (2023); Todorović (2022); Tominc et al. (2023)
Assistance in New Projects	Integration management, scope management, risk management, schedule management, stakeholder management	Enholm et al. (2022); Fridgeirsson et al. (2023); Song and Minku (2023)

studies. The most frequently cited benefits include risk mitigation, improved resource allocation, enhanced communication, and efficient administrative tasks.

2.2. Challenges of using AI in PM

Despite the large advancements facilitating the collection, sharing, and analysis of high-quality data related to software and development processes, as well as the expanded potential for prediction through Machine Learning (ML), and the enhanced intelligent processing of natural language and unstructured documents, numerous difficulties and challenges persist regarding the adoption of AI tools in PM (Fridgeirsson et al., 2023; Sarafanov et al., 2024; Uchihira et al., 2020). Combining AI with PM may present some challenges in terms of cost, security measures, privacy concerns, autonomy limitations, data quality/availability, as well as implications for employment opportunities (Sarafanov et al., 2024).

Regarding the security and privacy matters, AI may encounter challenges in discerning between public and restricted data, including private documents of a certain project, the collection of personal data, and potential violations of privacy rights (Dzhusupova et al., 2024; Gomes et al., 2022; Merhi and Harfouche, 2023), highlighting the need for robust safeguards and ethical guidelines in AI development and implementation (Enholm et al., 2022; Holzmann et al., 2022). It is also a leading priority, in AI implementation for PM, to defend against algorithmic biases (caused by biases in the dataset used to train these models), ensuring data privacy, and preventing unauthorised access (Enholm et al., 2022; Feuerriegel et al., 2022; Robert et al., 2020; Van Berkel et al., 2022). Trust and transparency in algorithms are also essential for project managers to understand AI's decision-making rationale and prevent resistance to its recommendations (Dzhusupova et al., 2024; Enholm et al., 2022; Robert et al., 2020; Van Berkel et al., 2022; Weber et al., 2023). However, PM is not a domain already dominated by AI tools, which require good quality of data because the available data in PM is usually unstructured and/or unavailable (Hofmann et al., 2020), causing wrong answers by AI, commonly called "hallucinations". It is important to always check whether the information provided by AI is trustworthy and correct (Carayannis et al., 2024) and to have a large amount of data with good quality and different types of data, since the AI tools are only as good as the data you feed them with (Weber et al., 2023).

Granting excessive autonomy to AI systems may apply dominance over the project environment, resulting in project managers losing control and oversight over processes and progress. Insufficient access to valid and accurate data can further aggravate the issue (Weber et al., 2023), leading to the formulation of invalid decisions and conclusions. Also, the immaturity of many AI solutions, as numerous tools and applications are not yet fully developed or reliable enough for general use, causes delays in the adoption of those specific tools (Bodea et al., 2020).

This integration of AI in PM comes with a significant repercussion: the reduction in the demand for low-skilled jobs. As AI becomes more proficient in handling repetitive tasks, jobs that rely primarily on manual labour or basic cognitive skills are increasingly at risk of being automated (Jauhar et al., 2023). The integration of AI may reduce the demand for low-skilled employment opportunities, consequently exerting an impact on the job market. With fewer opportunities available for low-skilled workers, there is a risk of increased unemployment, particularly for individuals with limited education or training (Carayannis et al., 2024; Dzhusupova et al., 2024). This can happen not because the human workers are going to be replaced by AI workers, but human workers being replaced by other human workers who can work with AI, for example, by mastering "prompt engineering". This can lead to socioeconomic disparities and exacerbate existing inequalities within society (Dzhusupova et al., 2024). However, it may free up time and enable these employees to focus on delivering projects more successfully.

The displacement of low-skilled workers by AI raises questions about the future of work and the need for retraining and upskilling initiatives. As traditional job roles evolve or become obsolete, there is a growing need for individuals to acquire new skills that are in demand in the digital economy (Vărzaru et al., 2022; Weber et al., 2023). Some authors argue that it is essential to invest in training on how to use AI in complex projects, because most of the current knowledge project managers have about AI is self-taught, due to their personal interest in the field (Carayannis et al., 2024; Felicetti et al., 2024).

From an ethical point of view, it is imperative for companies to ensure that AI systems do not create biases or discriminate against any particular group, which could lead to poor decision-making and unfair practices (Carayannis et al., 2024; Enholm et al., 2022; Van Berkel et al., 2022).

As AI systems become more integrated into PM, some dependency on these tools can occur, which can pose significant risks for project managers. As they start to rely on AI to handle some tasks, their critical thinking and analytical skills may decrease. This decrease can lead to a reduction in their ability to perform these tasks without the AI tools, eroding their competencies in PM. It is crucial for project managers to maintain a balanced approach to the available AI tools, ensuring they continue to develop and apply their own judgment and expertise (Bushuyev et al., 2024).

According to the survey conducted by Bodea et al. (2020), 70 % of participants identified a limited understanding of AI tools as the main obstacle to their implementation. This indicates a significant knowledge gap that blocks the effective utilisation of AI tools in PM. 62 % of respondents struggled to identify the most suitable AI applications for their needs, reflecting a lack of experience and expertise in AI-driven solutions. Also, data privacy, digital ethics, and security risks were highlighted by many respondents as critical concerns. These issues are decisive, as AI systems often handle sensitive information of organisations, and any lapse could have severe consequences. Additionally, 58 % of participants noted the limited IT capabilities of their employees, including inadequate technical skills and substandard IT processes, and insufficient IT infrastructure, as significant barriers, reducing their effectiveness.

Table 2 presents a summary of all the challenges discussed and their possible impact.

3. Methodology

A SLR was conducted to address the research question by performing a thematic analysis of relevant research studies, in order to attain the two following research objectives (1) identify the key knowledge areas of PM where AI is or may be applied and (2) identify the current key types of AI tools that can be used in PM.

The SLR follows the "Preferred Reporting Items for Systematic Reviews and Meta-Analyses" (PRISMA) model, which is widely used to ensure the transparency and quality of systematic reviews (Moher et al., 2009).

An initial exploratory review of the literature was conducted to gain a clear understanding of the subject area and to refine the search strategy for the SLR. The databases used were Scopus and Web of Science due to their review due to their wide coverage, academic reliability, and multidisciplinary scope. The string for the research on those two databases was established as follows: "artificial intelligence" AND "project management" (Title/Abstract/Keywords). Only peer-reviewed journal articles, classified as "articles", were considered in order to ensure a consistent level of academic rigor across the selected literature.

In the first phase, the search processes resulted in 317 documents from the Scopus Database and 463 from all the databases of Web of Science, i.e., a total of 780 papers. To ensure the reliability and relevance of the included literature, a quality assessment was conducted by evaluating each article according to two key criteria: its relevance to the research objectives and its scholarly impact. Relevance was determined

Table 2
Challenges of introducing AI into PM.

Challenges	Brief description	References
Data privacy and security	AI Tools do not always ensure project data is protected from unauthorised access.	Bodea et al. (2020); Carayannis et al. (2024); Dzhusupova et al. (2024); Fridgeirsson et al. (2021); Gomes et al. (2022); Holzmann et al. (2022); Merhi and Harfouche (2023); Sarafanov et al. (2024); Vărzaru (2022); Wijayasekera et al. (2022)
Cost	The investment required for AI implementation can be substantial, including software, hardware, and training expenses.	Bodea et al. (2020); Carayannis et al. (2024); Feuerriegel et al. (2022); Fridgeirsson et al. (2021); Merhi and Harfouche (2023)
Autonomy and loss of control	Sometimes, it can be challenging to balance the automation provided by AI with the need for human oversight.	Bushyev et al. (2024); Merhi and Harfouche (2023); Sarafanov et al. (2024)
Data quality and availability	Effective AI requires large volumes of high-quality data, which may not always be available or reliable.	Carayannis et al. (2024); Enholm et al. (2022); Feuerriegel et al. (2022); Fridgeirsson et al. (2021), 2023; Hofmann et al. (2020); Merhi and Harfouche (2023); Sarafanov et al. (2024); Weber et al. (2023); Wijayasekera et al. (2022)
Employment impact	The automation of tasks by AI can lead to concerns about job displacement and the need for workforce reskilling.	Dzhusupova et al. (2024); Fridgeirsson et al. (2021); Sarafanov et al. (2024); Vărzaru (2022)
Algorithmic bias and ethical concerns	AI systems can unintentionally perpetuate biases present in their training data, leading to unfair or unethical outcomes.	Bodea et al. (2020); Bushyev et al. (2024); Carayannis et al. (2024); Enholm et al. (2022); Feuerriegel et al. (2022); Fridgeirsson et al. (2021); Holzmann et al. (2022); Merhi and Harfouche (2023); Robert et al. (2020); Sarafanov et al. (2024); Van Berkel et al. (2022); Vărzaru (2022); Wijayasekera et al. (2022)
Lack of training and need of skill development	There is often a gap in the necessary skills and training required to effectively implement and manage AI tools in PM.	Bodea et al. (2020); Bushyev et al. (2024); Carayannis et al. (2024); Fridgeirsson et al. (2021), 2023; Holzmann et al. (2022); Merhi and Harfouche (2023); Vărzaru (2022); Wijayasekera et al. (2022)
Resistance to change	Organisations and employees may be resistant to adopting new AI technologies due to fear of the unknown and changing the way they work.	Carayannis et al. (2024); Enholm et al. (2022); Feuerriegel et al. (2022); Fridgeirsson et al. (2021), 2023; Holzmann et al. (2022); Merhi and Harfouche (2023); Mikalef and Gupta (2021); Vărzaru (2022); Wijayasekera et al. (2022)
Immaturity of AI solutions	Some AI technologies are still in developmental stages and may not yet be reliable for all PM tasks.	(Bodea et al., 2020; Enholm et al., 2022; Fridgeirsson et al., 2023; Holzmann et al., 2022; Nemati et al., 2002; Sarafanov et al., 2024; Weber et al., 2023; Wijayasekera et al., 2022)
Transparency and trust	Ensuring that AI tools are transparent and understandable to build trust among users and stakeholders.	Bodea et al. (2020); Dzhusupova et al. (2024); Enholm et al. (2022); Feuerriegel et al. (2022); Fridgeirsson et al. (2021), 2023; Merhi and Harfouche (2023); Robert et al. (2020); Van Berkel et al. (2022); Vărzaru (2022)

by screening all articles through a detailed review of titles and abstracts, and included only if they directly addressed the application, integration, or impact of AI tools in PM and contributed to at least one of the research objectives described above. To assess scholarly impact, particular attention was given to the quartile ranking of the journals in which the articles were published. Studies published in Q1 and Q2 journals were prioritized.

Finally, the Scopus database, there were 19 eligible documents, and in all of the Web of Science databases, there were 27 papers. This relatively lower number can be explained by the fact that this is a recent topic and also due to the fact that the selected search string (“artificial intelligence” AND “project management”) is too broad and also finds documents related to the PM of AI development projects of many scopes and in various business areas. So, from both databases, 46 documents were selected. There were 6 duplicated documents identified and removed, resulting in 40 articles.

The snowballing method was also used to include more references for this study. A total of 5 references were identified, resulting in 45 articles reviewed (identified with an asterisk in the references section). Fig. 1 illustrates the process described above, following the PRISMA process guidelines.

Following this screening process, a thematic analysis was employed to identify recurring patterns (Vaismoradi et al., 2013) and extract insights relevant to the integration of AI in PM. First, all 45 selected articles were read in full by the three researchers, who engaged in a detailed familiarisation with the content. During this phase, we highlighted recurring ideas, concepts, and practices related to the integration of AI in PM. In the second phase, we identified initial themes based on recurring patterns across the literature, including references to specific PM knowledge areas and types of AI tools. These were grouped into thematic categories that reflected how AI was being applied or discussed in the context of PM. The third stage involved clustering and aligning the emerging themes with the PM knowledge areas, with the dominant knowledge types and the types of AI tools. This process was iterative and involved collaborative discussion between the three researchers to achieve consensus and ensuring consistency.

4. Artificial intelligence in project management

4.1. Knowledge areas amenable to AI use

An analysis of the existing literature reveals that AI can support various knowledge areas of PM, particularly in integration, scope, communication, risk, and stakeholder management (Barcaui and Monat, 2023; Felicetti et al., 2024; Gupta et al., 2022; Vărzaru et al., 2022). AI has the potential to streamline the entire scope management process, analysing historical data to predict potential risks and opportunities (Ko and Cheng, 2007). When it comes to time and resource estimation, AI tools can process huge amounts of data to generate forecasts, ensuring that projects are adequately resourced and that timelines are realistic (Jüngen and Kowalczyk, 1995). Scheduling is another area where AI can

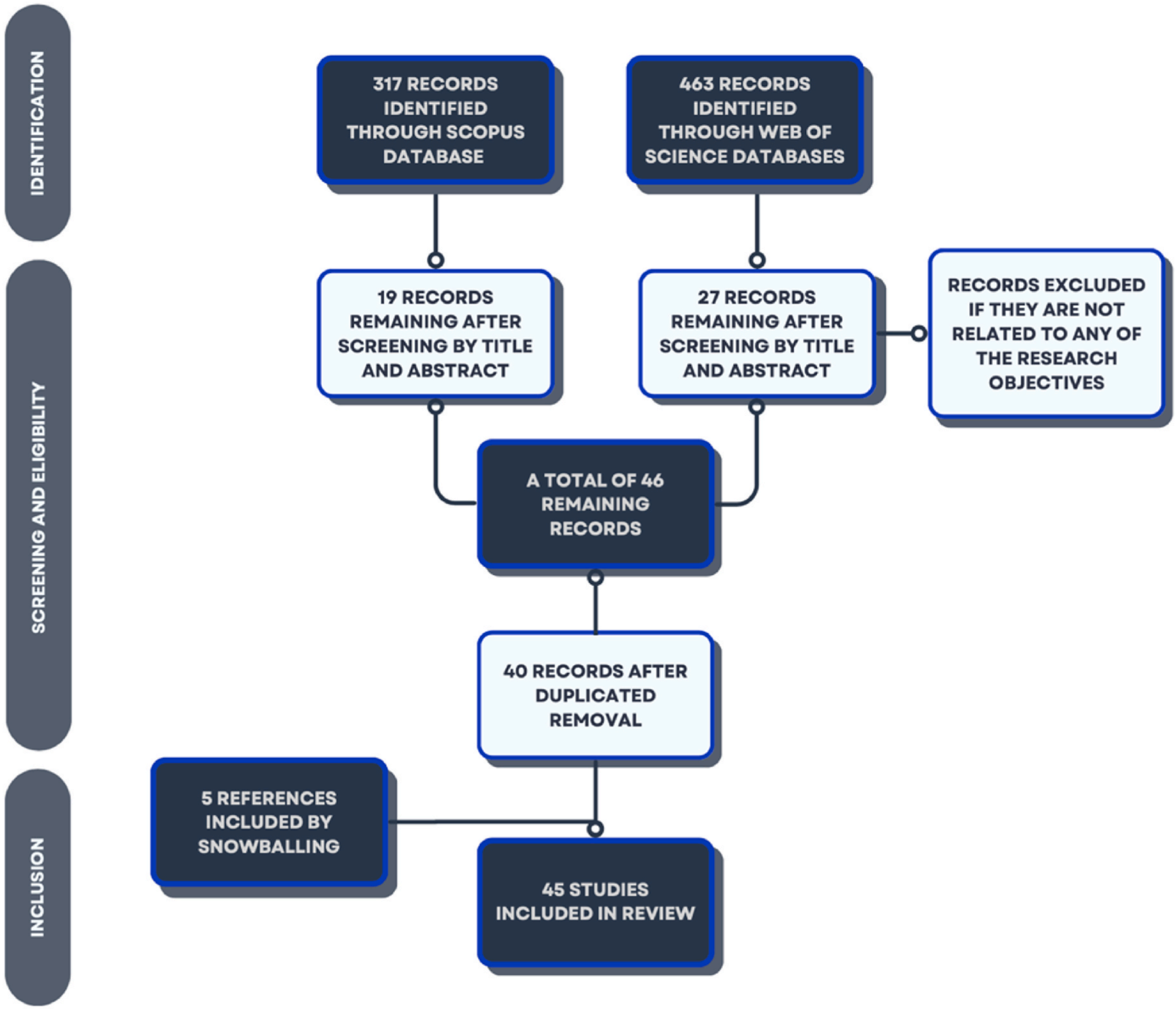

Fig. 1. Research protocol adopted.

be beneficial (Roth and Hendrickson, 1991). Advanced AI systems can create optimised schedules by considering various constraints and dependencies, leading to more efficient project timelines (Barcaui and Monat, 2023). Additionally, AI can assist in making time-cost trade-off decisions, helping project managers balance project timelines and budgets successfully by evaluating different scenarios and their potential impacts on the project's objectives (Enholm et al., 2022). When it comes to choosing between available technologies, AI can analyse the benefits and weaknesses of various technological options based on project requirements and constraints (Tominc et al., 2023).

AI also plays a key role in replanning by dynamically adjusting project plans in response to changes and unforeseen events. AI systems can continuously monitor project progress, providing real-time updates and identifying deviations from the original plan (Cancer et al., 2023; Dzhusupova et al., 2024; Niederman, 2021; Robert et al., 2020). This capability allows project managers to make suitable adjustments and ensure that the project stays on track while managing all the risks. AI can also automate the process of collecting information about project execution and gathering data from various sources to provide a comprehensive view of project performance (Tominc et al., 2023). This automated data collection reduces the administrative burden on project managers and ensures that they have access to up-to-date information for informed decision-making (Gupta et al., 2022; Jüngen and Kowalczyk, 1995).

Table 3 summarises the knowledge areas emerged in this SLR, which are coincident with Project Management Body knowledge (Project Management Institute, 2016).

The application of AI tools in each of these knowledge areas depends on the underlying type of knowledge and logic required in each (Uchihira et al., 2020):

- **Formal knowledge** refers to explicit, codified, and structured information that follows logical rules and deductive reasoning, making it highly amenable to standardisation and automation (Van Driel et al., 2001).
- **Data-driven knowledge** refers to empirical data and observed patterns, enabling insights that emerge from trends rather than predefined logic (Urbinati et al., 2019).
- **Tacit knowledge** refers to experiential, intuitive, and often unspoken understanding developed through practice, which is context-dependent and challenging to formalise or digitise (Boiral, 2002; Nonaka, 1994).

For each one of the knowledge areas, human intuition and experience, supported by information collected and data analysis, are required (Van Berkel et al., 2022). And this is the reason why not every knowledge area can be fully replaced by AI. A task can only be replaced/automated by AI if it doesn't depend on tacit knowledge, because simple and repetitive tasks, such as procurement and quality management tasks, are easy to automate and can be replaced by AI (Barcaui and Monat, 2023). While knowledge areas such as integration and communication management, which rely essentially on human judgment and

Table 3
Knowledge areas amenable to AI use.

Knowledge Area	Description	References
Integration management	Involves the coordination of all project elements to ensure they work together effectively toward the project's objectives including the process of monitoring and controlling project's performance according to its plan and objectives, identifying deviations, and decision-making.	Bork et al. (2023); Cancer et al. (2023); Carayannis et al. (2024); Felicetti et al. (2024); Feuerriegel et al. (2022); Fridgeirsson et al. (2021); Gupta et al. (2022); Holzmann et al. (2022); Jüngen and Kowalczyk (1995); Magaña Martínez and Fernandez-Rodriguez (2015); Mesa Fernández et al. (2022); Mikalef and Gupta (2021); Nenni et al. (2024); Sklias et al. (2024); Song and Minku (2023); Tominc et al. (2023); Wijayasekera et al. (2022)
Scope management	Involves defining the scope of the project and what is included and excluded in the project.	Barcaui and Monat (2023); Cancer et al. (2023); Fridgeirsson et al. (2021); Holzmann et al. (2022); Magaña Martínez and Fernandez-Rodriguez (2015); Mesa Fernández et al. (2022); Miller (2022); Wijayasekera et al. (2022)
Cost management	Involves planning, estimating, budgeting, and controlling costs to complete the project with success.	Barcaui and Monat (2023); Cancer et al. (2023); Drydakis (2022); Enholm et al. (2022); Fridgeirsson et al. (2021), 2023; Holzmann et al. (2022); Jüngen and Kowalczyk (1995); Li et al. (2002); Magaña Martínez and Fernandez-Rodriguez (2015); Mahdi et al. (2021); Mesa Fernández et al. (2022); Nenni et al. (2024); Roth and Hendrickson (1991); Song and Minku (2023); Tominc et al. (2023); Wijayasekera et al. (2022)
Resource Management	Includes identifying, applying and managing resources effectively.	Cancer et al. (2023); Felicetti et al. (2024); Fridgeirsson et al. (2021); Holzmann et al. (2022); Jüngen and Kowalczyk (1995); Magaña Martínez and Fernandez-Rodriguez (2015); Mesa Fernández et al. (2022); Miller (2022); Nenni et al. (2024); Roth and Hendrickson (1991); Song and Minku (2023); Tominc et al. (2023); Wijayasekera et al. (2022)
Risk management	Focuses on identifying, analysing, and reacting to project risks.	(Cancer et al., 2023; Carayannis et al., 2024; Drydakis, 2022; Felicetti et al., 2024; Feuerriegel et al., 2022; Fridgeirsson et al., 2021, 2023; Holzmann et al., 2022; Karnouskos, 2024; Magaña Martínez and Fernandez-Rodriguez, 2015; Mahdi et al., 2021; Mesa Fernández et al., 2022; Miller, 2022; Nenni et al., 2024; Sklias et al., 2024; Song and Minku, 2023; Tominc et al., 2023; Wijayasekera et al., 2022)
Quality management	Ensures that the project satisfies its requirements through quality planning, assurance, and control.	Barcaui and Monat (2023); Dzhusupova et al. (2024); Feuerriegel et al. (2022); Fridgeirsson et al. (2021); Holzmann et al. (2022); Jüngen and Kowalczyk (1995); Magaña Martínez and Fernandez-Rodriguez (2015); Mesa Fernández et al. (2022); Song and Minku (2023); Tominc et al. (2023)
Communication management	Ensures timely and appropriate generation, collection, dissemination, storage, and disposition of project information.	Cancer et al. (2023); Feuerriegel et al. (2022); Fridgeirsson et al. (2021); Holzmann et al. (2022); Jüngen and Kowalczyk (1995); Mesa Fernández et al. (2022); Miller (2022); Nenni et al. (2024); Tominc et al. (2023); Wijayasekera et al. (2022)
Procurement management	Involves acquiring goods and services from external sources through procurement planning, solicitation and contract administration.	Feuerriegel et al. (2022); Fridgeirsson et al. (2021); Holzmann et al. (2022); Miller (2022); Song and Minku (2023)
Schedule management	Includes defining the project timeline and ensures its successful completion through activity definition, sequencing, duration estimating and schedule development and control.	Fridgeirsson et al. (2021), 2023; Holzmann et al. (2022); Jüngen and Kowalczyk (1995); Magaña Martínez and Fernandez-Rodriguez (2015); Roth and Hendrickson (1991); Sklias et al. (2024); Song and Minku (2023); Wijayasekera et al. (2022)
Stakeholder management	Includes the identification and management of the needs and expectations of those affected by the project through stakeholder identification, engagement, and communication.	Barcaui and Monat (2023); Cancer et al. (2023); Fridgeirsson et al. (2021); Holzmann et al. (2022); Magaña Martínez and Fernandez-Rodriguez (2015); Mesa Fernández et al. (2022); Miller (2022); Wijayasekera et al. (2022)

experience cannot be replaced and only complemented by AI (Bork et al., 2023; Seeber et al., 2020).

While AI can provide valuable insights through deductive reasoning and data analysis, human expertise and intuition play a vital role in interpreting these findings and making informed decisions (Storey et al., 2024). Thus, a suitable PM system should effectively combine AI capabilities with human judgment, highlighting the importance of synergies between technology and human expertise to achieve project success (Van Berkel et al., 2022).

4.2. AI tools for PM

Recent advances in AI have already introduced innovative tools that can be applied within the PM landscape (Barcaui and Monat, 2023; Odeh, 2023) through the integration of AI tools software platforms that use AI tools to perform tasks that typically require human intelligence in the PM field (Nenni et al., 2024). These resources are technologies that originated from ongoing research and development. However, most of them are still under development or constantly being updated (Merhi and Harfouche, 2023). For a successful AI tools implementation, organisations expect them to be less complex and more intuitive, making it easier for employees to understand and apply them effectively (Odeh, 2023; Weber et al., 2023).

There are some types of AI tools amenable to use in PM, that are built upon different types of AI tools, each with distinct methodologies and objectives tailored to different practical needs.

- **Generative AI (GenAI):** refers to systems capable of producing novel content, such as text, code, images, or audio, by leveraging deep learning models, a sophisticated branch of ML. These models, particularly Large Language Models (LLMs), have shown

considerable potential in supporting project managers in tasks that often require unstructured knowledge, qualitative, and difficult to formalise (Carayannis et al., 2024; Lim et al., 2023) or that rely on human intuition and tacit knowledge (Barcaui and Monat, 2023; Karnouskos, 2024).
- **ML for optimisation:** refers to a class of algorithms that allow systems to learn from historical data and improve performance without being explicitly programmed (Ong and Uddin, 2020). In PM, ML has primarily been used for optimisation purposes, including resource scheduling, cost and risk forecasting, and performance prediction.
- **Automation:** includes robotics and Internet of Things tools as well as computer vision technologies. It aims to streamline repetitive tasks, reduce operational costs, and improve execution speed (Wijayasekera et al., 2022). In PM, automation can support monitoring and control activities, data extraction, quality inspections, and even procurement processes (Jauhar et al., 2023). Computer vision specifically enables the interpretation of visual data, turning images or videos into actionable insights.

Table 4 provides an overview of which AI tools are more suitable for each knowledge area, according to the dominant type of knowledge required to complete certain tasks and their own capabilities.

5. Discussion

5.1. Integration of AI tools into PM

Implementing AI in PM represents a significant challenge and will change how projects are performed (Niederman, 2021). It offers new opportunities for project managers causing better-informed decisions that will guide projects to success (Bork et al., 2023; Gupta et al., 2022). Using specialised tools, such as optimisation models and GenAI, project managers can faster predict what might happen next, complete tasks faster, fostering efficiency (Enholm et al., 2022). However, the adoption and the use of AI in PM still poses significant challenges and the existent literature lacks clarity in these processes (Sarafanov et al., 2024).

Table 4
PM knowledge areas and suitable types of AI tools.

Knowledge area	Dominant knowledge type	Most suitable types of AI tools	Examples of AI capabilities
Integration management	Formal Data-driven Tacit	GenAI	Decision-making support based on real-time tracking and deviation alerts.
Scope management	Data-driven Tacit	GenAI	Drafting work breakdown structures, clarifying deliverables.
Schedule management	Formal Data-driven	ML for optimisation	Timeline generation, rescheduling.
Cost management	Formal Data-driven	ML for optimisation	Budget forecasting, variance analysis.
Quality management	Formal Data-driven	ML for optimisation Automation	Quality monitoring, anomaly detection.
Resource management	Formal Data-driven	ML for optimisation	Resource allocation, workload balancing.
Communication management	Formal Tacit	GenAI	Summarising meetings, drafting reports, language translation.
Risk management	Data-driven Tacit	GenAI ML for optimisation	Identifying emerging risks, probabilistic impact analysis.
Procurement management	Formal	Automation	Contract analysis, vendor selection.
Stakeholder management	Formal Tacit	GenAI	Drafting engagement plans, analysing feedback, conflict resolution assistance.

This paper, through the analysis of the current literature, provides a structured synthesis of the relationship between the most suitable types of AI tools and each knowledge area, considering the dominant knowledge types involved (Fig. 2). This figure was developed following the SLR's results analysis and aims to answer both the research objectives of this research: (1) identify the key knowledge areas of PM where AI is or may be applied, and (2) identify the current key types of AI tools that can be used in PM.

Fig. 2 facilitates a deeper understanding of how AI tools can be strategically deployed according to the required dominant knowledge characteristics inherent in each knowledge area.

It is possible to draw many conclusions from this conceptualization. First, it is evident that the three dominant knowledge types (tacit, data-driven, and formal knowledge) are equally important overall, as they are evenly distributed across the various PM knowledge areas. Notably, integration management is the only PM knowledge area drawing on all three types of knowledge, illustrating its holistic nature, since it involves tasks and processes of monitoring, control, and decision-making. Most other areas rely on two dominant types of knowledge. Procurement management, however, stands out for its exclusive reliance on formal knowledge, highlighting its structured and standardised processes. The listed knowledge areas are considered to be amenable to being replaced or complemented by AI, depending on the type of knowledge required for the specific activities within each knowledge area (Uchihira et al., 2020).

Secondly, when examining the types of AI tools, it becomes clear that GenAI is the most versatile, as it can support all three types of knowledge, making it particularly well-suited for more nuanced or human-centric areas of PM (Karnouskos, 2024). ML algorithms for optimisation, by contrast, are exclusively applicable to data-driven knowledge, and automation tools support both formal and data-driven knowledge.

Third, the relation between knowledge areas, types of knowledge, and the applicability of AI tools shapes which tools are best suited to each knowledge area. Tacit knowledge, by nature, can only be addressed through Generative AI, since it is categorised by being deeply personal, intuitive, experiential, and it is difficult to codify or transfer (Boiral, 2002; Nonaka, 1994). This reinforces the suitability of Generative AI for areas such as integration, scope, communication, risk, and stakeholder management, where unstructured, intuitive, and interpersonal knowledge is essential (Van Berkel et al., 2022). In these domains, GenAI tools can synthesise contextual information, generate decision-making scenarios, and augment human creativity (Barcaui and Monat, 2023; Felicetti et al., 2024). These capacities help project managers by automating routine communications and offering informed decision support (Enholm et al., 2022).

Conversely, formal knowledge, with its clear and standardised characteristics, enables high compatibility with automation tools since these tools are compatible with systematic, organised, and reduced ambiguity tasks (Barcaui and Monat, 2023). This makes procurement management a prime domain for automation tools, nevertheless, oversight by Generative AI can complement standardised approaches by managing exceptions or novel cases (Carayannis et al., 2024). Quality management might also be enhanced by automation, for example with real-time checks and anomaly detection. Accordingly, the use of dark grey lettering in quality management on Fig. 2, denotes this association with automation.

Data-driven knowledge is compatible with all three types of AI tools (GenAI, ML algorithms for optimisation and automation), but presents a central role in areas that can be more enhanced by ML algorithms for optimisation, such as schedule, cost, quality and resource management, for processing large volumes of data, identify patterns, predict outcomes and optimising resource allocations or timelines (Bork et al., 2023; Sklias et al., 2024). Risk management, despite being complemented by GenAI, for example, in risk identification and analysis, can be highly enhanced by ML for optimisation when dealing with quantitative risk analysis, being the reason, it is highlighted on Fig. 2 with the same blue

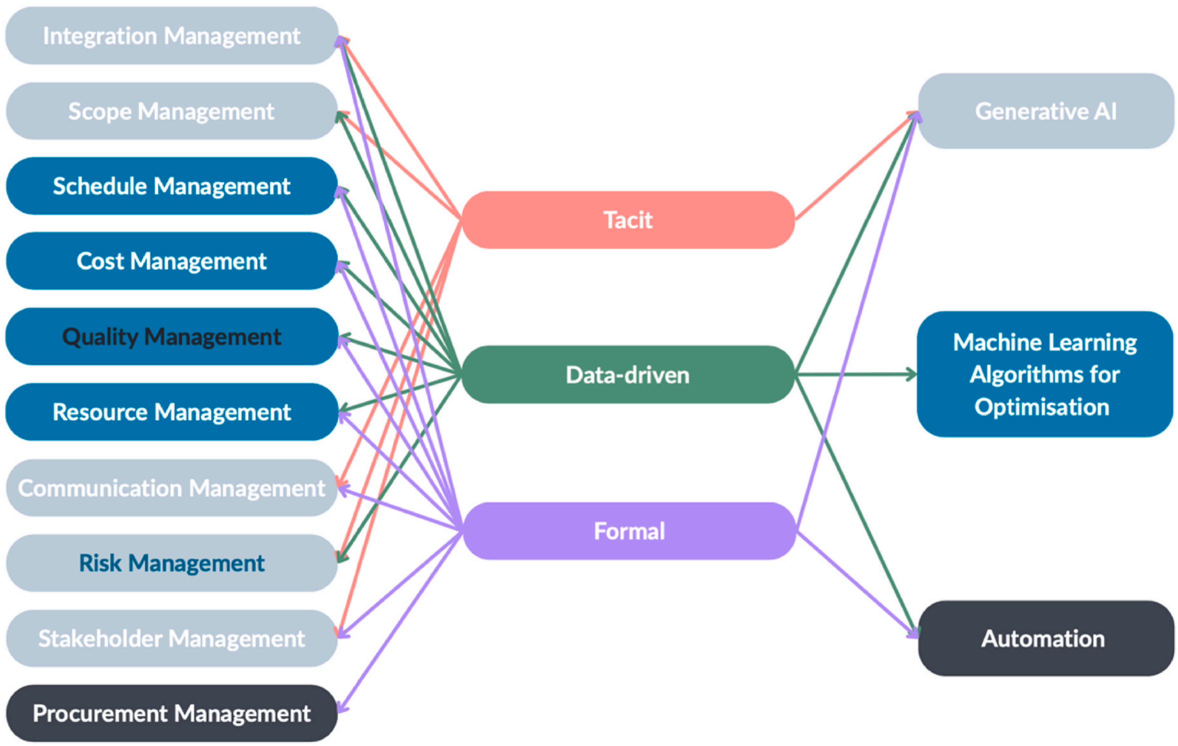

Fig. 2. Conceptual framework for integrating AI tools into PM.

letters used for ML optimisation algorithms.

Ultimately, this conceptual framework illustrates that AI integration in PM must be tailored to the specific context and needs of each knowledge area. Activities that rely heavily on formal or data-driven knowledge may, in some cases, be automated or optimised, reducing costs and increasing efficiency. However, domains dominated by tacit knowledge require a complementary approach, where AI acts as an augmentation tool rather than a replacement (Karnouskos, 2024). In these cases, human judgment, creativity, and contextual understanding remain irreplaceable, with AI offering insights rather than decisions (Bushuyev et al., 2024; Nemati et al., 2002; Seeber et al., 2020; Uchihira et al., 2020).

In summary, besides acknowledging that AI is a promising tool, it is important to recognise that not every project or task necessarily needs its application. In some cases, a more conventional and dependable method that has been established within enterprises for a long time may be more suitable and efficient within certain domains and circumstances (Sarafanov et al., 2024; Weber et al., 2023), it is not a good idea to replace one complexity with another. In those cases, introducing AI into PM might result in higher costs of the project and, sometimes, lower quality. A major part of the existing literature appears to be very AI-enthusiastic. Many studies focus primarily on the benefits of using AI in PM, often portraying it as a transformative force while overlooking its limitations and challenges, leading to overestimation of AI's current capabilities, potentially creating a gap between the theoretical potential and practical implementation.

5.2. Future research

Future research on this subject holds significant potential for advancing both the understanding and practical implementation of AI in PM. The SLR led to the identification of key directions for further research identified in Table 5, which should not be considered as a complete list of future directions, since each topic could be further explored, and further studies might suggest different or additional paths to follow.

6. Conclusion

This SLR has explored the landscape of the integration of AI tools in PM. The review identified several key knowledge areas where the transformative potential of AI is enhancing PM practice across various industries, such as integration, scope, communication, risk, and stakeholder management.

Several types of AI tools amenable to use in PM are identified for enhancing task efficiency, resource allocation, and decision-making within project environments. These tools have demonstrated their ability to automate routine tasks, optimise project timelines, and mitigate risks, thereby improving project success rates and enhancing their efficiency.

This study contributes to the field of PM by offering a structured understanding of how AI can be integrated into PM, based on the dominant type of knowledge (formal, data-driven, or tacit) required in each knowledge area. It establishes clear links between specific AI tools and PM knowledge areas. The conceptual framework developed in this study offers not only theoretical insights but also practical guidance for PM professionals seeking to integrate AI into their workflows. For example, project managers can use generative AI tools to assist with drafting reports, stakeholder communication, or meeting summaries, which are tasks typically driven by tacit knowledge. Meanwhile, ML algorithms can be applied to improve cost forecasting and resource allocation based on historical project data. In risk management, predictive models can support early risk identification by detecting patterns or deviations in data or aid project managers in data-oriented risk evaluation. Automation tools can support more routine and structured tasks, especially in areas such as procurement. For instance, AI systems can analyse vendor contracts, automate invoice processing, and identify discrepancies, reducing manual workload and improving performance. In quality management, automation can also enable real-time anomaly detection and streamline compliance checks. Overall, organisations may apply this framework as a diagnostic tool to assess which knowledge areas in their PM processes can benefit more from each AI tool. This can support more targeted adoption strategies, helping teams to prioritize AI

Table 5
Overview of future research directions.

Research directions	Current limitations and/or arising opportunities	Research questions
Human-AI interaction		
Human–AI interaction in project environments	There is the need to explore how people, especially project managers, team members, and stakeholders, interact with AI tools, perceive their usefulness, and respond emotionally or behaviourally to their integration.	How does the use of AI in PM impact decision-making and outcomes from the perspective of human users? What are the perceived benefits and challenges of AI integration in PM according to different stakeholders? What concerns or reservations do stakeholders express regarding the integration of AI in PM processes?
Evolving competencies and training for AI-enabled PM	AI integration changes the skill requirements for project managers. There should be a focus on identifying new technical and soft skills, such as, critical thinking, digital literacy and adaptability, that practitioners need to develop. It includes how training programs, certifications, and academy should evolve to prepare the future project workforce for AI-enabled environments.	What new skills and competencies are required for project professionals to work effectively alongside AI systems? How can AI tools be developed to support and enhance human soft skills such as problem-solving, critical thinking, and adaptability? What are the key competencies required in a transformation workforce responsible for AI adoption and organisational change?
Governance, Ethics and Regulation		
Ethics, governance, and regulatory compliance in AI adoption	As AI systems are increasingly embedded into project integration management, this area addresses the need for clear governance structures, ethical frameworks, and regulatory compliance. Future research should include topics as data privacy, transparency, and the legal implications of using AI in different project contexts.	How can organisations balance the need for large-scale, high-quality data with ethical and legal requirements for data privacy in AI systems? What are the ethical considerations and implications of using AI in PM, and how do users perceive these issues? Under what circumstances should AI systems be involved in decisions that have fairness implications? How will the EU's AI regulation affect AI adoption compared to regions without such regulation?
Organisational Impact and Performance		
Organisational transformation through AI integration	By embedding AI tools in organisations, it will influence broader organisational elements as culture, structure, workflows, and financial performance. Thus, there is the need to study in what extent will organisations be impacted by these changes, explore whether and how AI adoption leads to sustainable business value and what KPIs are appropriate to measure success.	How does the integration of AI tools reshape organisational culture? In what ways does AI implementation affect organisational structures, roles, and workflows? What is the impact of AI-enabled decision-making structures on organisational agility? In what ways does AI contribute to innovation capabilities within organisations?
	Research should focus on how AI can directly enhance knowledge areas such as scheduling, resource allocation, risk assessment, and stakeholder communication. It includes evaluating the effectiveness of AI versus human project managers and examining the role of AI across different project types.	How does the performance of GenAI tools compare to human project managers? What are the long-term impacts of AI tool adoption on PM outcomes such as efficiency, effectiveness, stakeholder satisfaction, and project success rates? What are the most effective collaboration models between human project managers and GenAI tools?
Embedding AI in Organisations	AI adoption may be shaped by cultural, professional, and generational attitudes. This includes examining how industry norms, national regulations, organisational cultures, and generational perspectives influence how AI is perceived and implemented in project environments.	How do perceptions of AI differ among project/program/portfolio managers versus project sponsors or owners? How do organisations adapt their AI strategies based on evolving understandings of AI's role in their business models? How does organisational culture affect the readiness and willingness to adopt AI in PM? What are the critical factors for AI adoption in PM?
LLMs in PM		
Application of LLMs to PM	With tools like ChatGPT and Gemini becoming widely available, there is the need to explore how LLMs can support or automate tasks in PM. It focuses on performance evaluation, prompt engineering, fine-tuning of LLMs.	What metrics can be developed to assess the competency of LLMs in PM contexts? How does prompt engineering influence the quality, reliability, and depth of LLM-generated responses in PM tasks? What are the effects of fine-tuning LLMs on the model's ability to produce credible PM outputs? How can the value of human–LLM collaboration be measured in practical PM decision-making and execution?
Data Infrastructure and Platform Dependence		
Risks of platform dependency and AI infrastructure centralisation	As AI depends heavily on data and computing power, the risks and implications of relying on a few dominant tech providers (such as, Microsoft, Google) should be investigated. It raises concerns about access inequality, digital control, and organisational vulnerabilities in the case of infrastructure failure or geopolitical restrictions.	What risks are introduced when PM relies on centralized AI infrastructure controlled by major tech providers? How does the control of data availability by a limited number of providers affect AI adoption? What kind of vulnerability is introduced when computing power becomes unavailable, and what are the implications for PM?

investments according to the nature of their key tasks and needs.

By analysing the existing literature, this study also places the foundation for future research. Key directions include conducting empirical studies across industries to validate and refine the results of this study and undertaking longitudinal research to assess how AI adoption influences project outcomes over time, including the evolving role and responsibilities of project managers. Future studies should also address the ethical, legal, and organisational implications of AI in PM, particularly in terms of accountability, transparency, and human-AI collaboration.

Given the increasing relevance of GenAI, especially LLMs, future research should also focus on their potential applications in PM. LLMs might turn into a central support for project managers. Exploring how LLMs can be fine-tuned for specific project environments and integrated into existing PM systems represents a promising research avenue.

This study presents some limitations that should be acknowledged. The rapidly evolving rhythm of AI means that new tools and technologies are always arising, so the discussed ones may become outdated quickly. Additionally, the conclusions may vary across different businesses and project types due to the many impacts of AI integration. Addressing these limitations in future research may also provide a better understanding of AI's role in PM and enhance the practical applicability of this findings.

CRediT authorship contribution statement

Pedro M. Almeida: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Gabriela Fernandes:** Conceptualization, Methodology, Writing – review & editing. **José M.R.C.A. Santos:** Conceptualization, Methodology, Writing – review & editing

Declaration of competing interest

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.

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Data availability

No data was used for the research described in the article.

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