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Enhancing Project Management Efficiency through Artificial Intelligence: A Comprehensive Review

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Abstract

This paper presents a structured and comprehensive analysis on the applications of Artificial Intelligence models in Project Management efficiency. It delineates the facets of project management efficiency and correlates them with cutting edge AI technology. The study employs the approach of a systematic literature review, which synthesizes AI advancement with project management practices. This methodology selects data from scholarly articles of high quality that are relevant to the topic. The research is focused to the construction industry, limiting the search to current practices for a period of 10 years. Meanwhile, it has been observed that there is a gap in research focusing on the efficiency aspect in project management using AI technology. Therefore, the paper sets the stage for future investigations, thereby contributing original insights to the field.

Key words:*AI models, Project Management, Efficiency*

Introduction

The construction industry faces many challenges that hinder its growth and efficiency compared to more advanced sectors [1]. Known for its complexity and time-consuming projects, the industry struggles with setbacks and technological difficulties, often hesitating to adopt new technologies. However, Reference [2] predicts that the construction industry sector will soon embrace digital technologies, prioritizing the implementation of emerging technologies[2]. Industry 5.0 is set to revolutionize construction by integrating robots and intelligent machines with human skills, enhancing resilience and productivity.

Artificial Intelligence (AI) has significantly streamlined various construction tasks, from decision-making and error detection to project monitoring and updates. AI reduces human workload and boosts project efficiency by minimizing errors and improving project management. While much literature highlights AI's role in project management, its efficiency benefits are less explored.

Efficiency and effectiveness, though often confused, are distinct: effectiveness improves project value, while efficiency uses minimal resources for excellent outcomes. Projects, defined by a clear start and end, are influenced by external factors and internal management. Traditionally measured by the "iron triangle" of cost, quality, and time, project success now also considers stakeholder management, resource allocation, and safety [3], [4].

Integrating AI into project management accelerates operations and enhances accuracy, crucial in an industry plagued by cost overruns and delays [5]. AI's predictive analytics allow stakeholders to foresee issues and make data-driven decisions, improving project outcomes. Better resource allocation and planning optimization further boost efficiency [6], positioning AI as a transformative force in construction.

Systematic Literature Reviews (SLRs) are a rigorous method for identifying, evaluating, and integrating relevant literature to answer specific research questions [7]. This study uses the SLR approach to explore AI's

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impact on project management efficiency, following a definitive search protocol to finding required results of the study [8]. Hence, a total of about 2245papers were screened using the EPPI Reviewer software, ultimately analyzing 79 papers in-depth. Findings from the study provides significant insights into AI's role in enhancing project management efficiency, contributing to informed decision-making and progress in this field. The aim of the study is to provide clear evidence of how AI models improve Project Management efficiency, having the following objectives;

1. Demonstrate the importance of AI models for PM efficiency.
2. Identify areas for improving PM efficiency and performance.
3. Analyze the necessary aspects to achieve efficiency in PM using AI models.

Methodology

A Systematic Literature Review (SLR) is a methodological approach that involves a thorough examination of existing research, meeting rigorous standards similar to primary research [9]. As a secondary data extraction method, it reviews relevant literature on a specific topic. SLRs are known for their transparency, replicability, and upgradability, which add credibility to the research [10]. They are useful for both exploring established subjects and initiating studies on new topics. An SLR is conducted around a well-defined research question, addressing a hypothesis [11], in which investigating on how AI models improve project management efficiency are deliberated.

The PRISMA framework, which stands for "Preferred Reporting Items for Systematic Reviews and Meta-Analyses," is used to ensure comprehensive and standardized reporting of the SLR. PRISMA provides guidelines for the essential items in systematic reviews and meta-analyses [7], [9].

The use of EPPI-Reviewer 4 softwarewas utilized, in which it is a tool that enhances the efficiency and effectiveness of the SLR processes. It offers various functionalities, including bibliographic management, screening, coding, and synthesis, facilitating the continuous management of the SLR [12]. In addition, the principles of SLR and using the PRISMA framework was followed to achieve the aim of this research, focusing on providing evidence on project management efficiency through AI models.

Research Question

The research investigates findings to answer the question is: "What is the evidence of AI models helping strengthen PM efficiency?". Hence, systematic literature review approach helps to identify significant unanswered questions in research, which creates a highly specific research question to guide the investigation [13].

Keyword Identification & Search String

After carefully identifying the main keywords, a thorough search was conducted to find related synonyms and terms. This process resulted in a refined and comprehensive list of relevant concepts, presented in table 1.

Table 1: Search protocol used for the study review

Artificial Intelligence	Project Management	Efficiency
Expert System Intelligent Retrieval Knowledge Engineering Machine Learning Natural Language Processing Neural Networks Robotics	Management of projects Process based Management Project Administration Project Control Project Governance Project Planning & Execution	Capability Efficacy Efficient Optimization Performance

Subsequently, a complex search string wasdeveloped, following the Boolean method, which is a powerful technique that enabled expansive and systematic

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exploration across multiple databases. Presented herewith is the string implemented specifically for Science Direct, strategically designed to yield a comprehensive and targeted collection of scholarly resources.

Study Description and Search Strategy

The review adopts PRISMA flow diagram model approach. Initial search result was 2245 papers, which are uploaded to EPPI-Reviewer software for carrying out the review. The review process are as follows;

i. Screening process (on title and abstract (T&A) and on full text)
ii. Data Extraction
iii. Quality Assessment
iv. Results Generation

The review further continues after defining in/exclusion criteria, showing consistency in studies carried out by researchers every year. In view of this, the growing interest of research in project management and AI usage continues onwards to date as presented in figure 1. The search using systematic approach was conducted using various databases such as the University of Birmingham library (findit@bham), web of science, Scopus, science direct, ProQuest, Emerald and so on. Sample search string used is as follows;

("Artificial Intelligence" OR "Neural Network" OR "Robotics" OR "Machine Learning" OR "Natural Language Processing" OR "Expert Systems") AND (“Project Management” OR “Project Control” OR “Project Planning”) AND (“Efficiency” OR “Performance” OR “Effectiveness”)

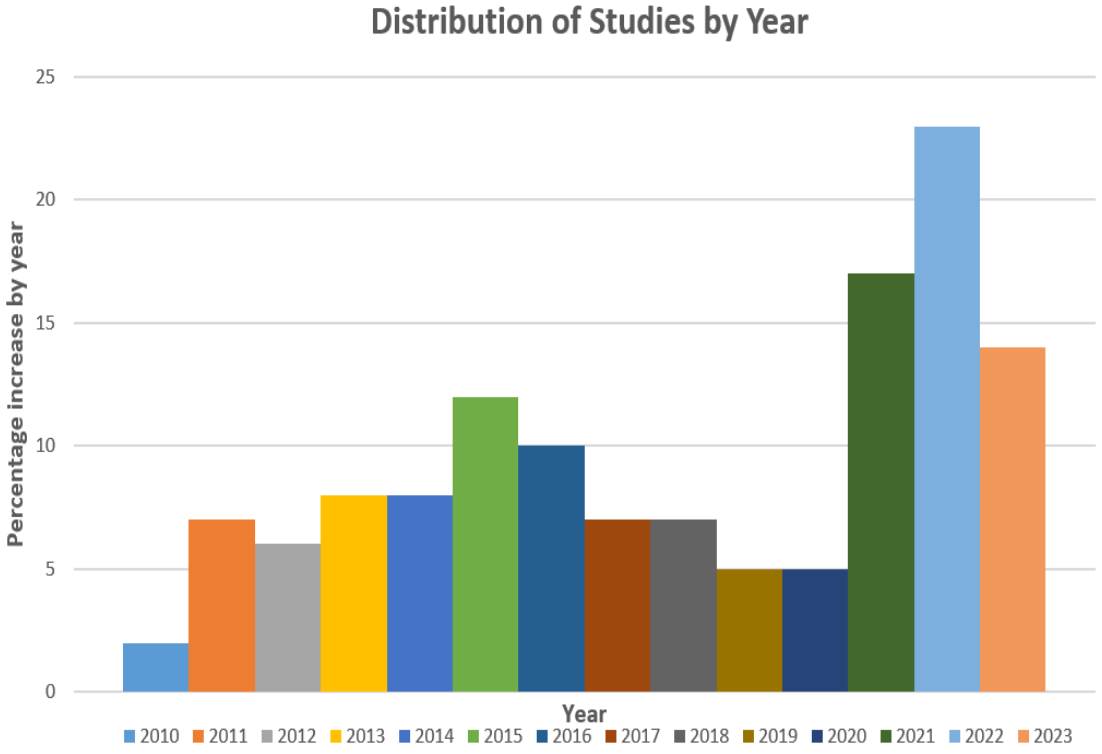

Fig 1: Studies distribution based on year of publication

Inclusion/ Exclusion Criteria

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To choose the right scholarly papers, strict guidelines was created and used for what to include and exclude. These rules helped us focus only on the materials that fit the research goals, leaving out anything that didn't match. This careful approach ensured that the study stayed relevant and true to its context, which helps to add valuable information to the topic. Table 2 depicts criteria for inclusion and exclusion used for the SLR.

Table 2: Study in/exclusion selection criteria

Inclusion	Exclusion
From 2010 - 2023(13years). Papers in English Language Only Only literary data Articles relating to construction industry	Papers before 2010 Papers not in English language Non peer reviewed information Relating to other industries.

Assessing the quality of studies: Weight of evidence criteria

After gathering the relevant papers, each article needs to be carefully evaluated using a technical framework to check its quality and relevance. This framework has three main criteria:

1. The reliability of the study
2. How well the study design addresses the main review question
3. The relevance of the study's focus to the review's scope.

Only studies that score high in at least two criteria and medium in the third are included as presented in table 3, ensuring that only high-quality and relevant studies are used[14].

Table 3: Criteria for article/paper selection

	Soundness of the study	**Appropriateness of study**	**Relevance**
High	Clear interpretation & findings	Answers the question	Closely related to research question
Medium	Some interpretation & unclear findings	Ambiguity in answering the question	Some parts related to the research question
Low	No clear interpretation	Doesn't answer the question	Little connection to the research question

Synthesis of evidence

The primary goal of the search was to find specific long-term studies that detailed how Artificial Intelligence (AI) models are used in Project Management, highlighting their impact on efficiency and other relevant aspects. By carefully selecting studies from the past decade, the study aimed at gaining valuable insights into the development of AI technology. Data were then skillfully combined from these studies using narrative methods to understand how effective AI models are in terms of time, cost, and quality in Project Management. Additionally, the review aimed to identify gaps in the focus on efficiency in these studies, providing guidance for future research in the field [14]. Generally, the study after considering all criteria for in/exclusion and other strategies, 19 studies were found to answer the research question based on developed protocol. The process is using PRISMA model is depicted in flow diagram as presented in figure 2.

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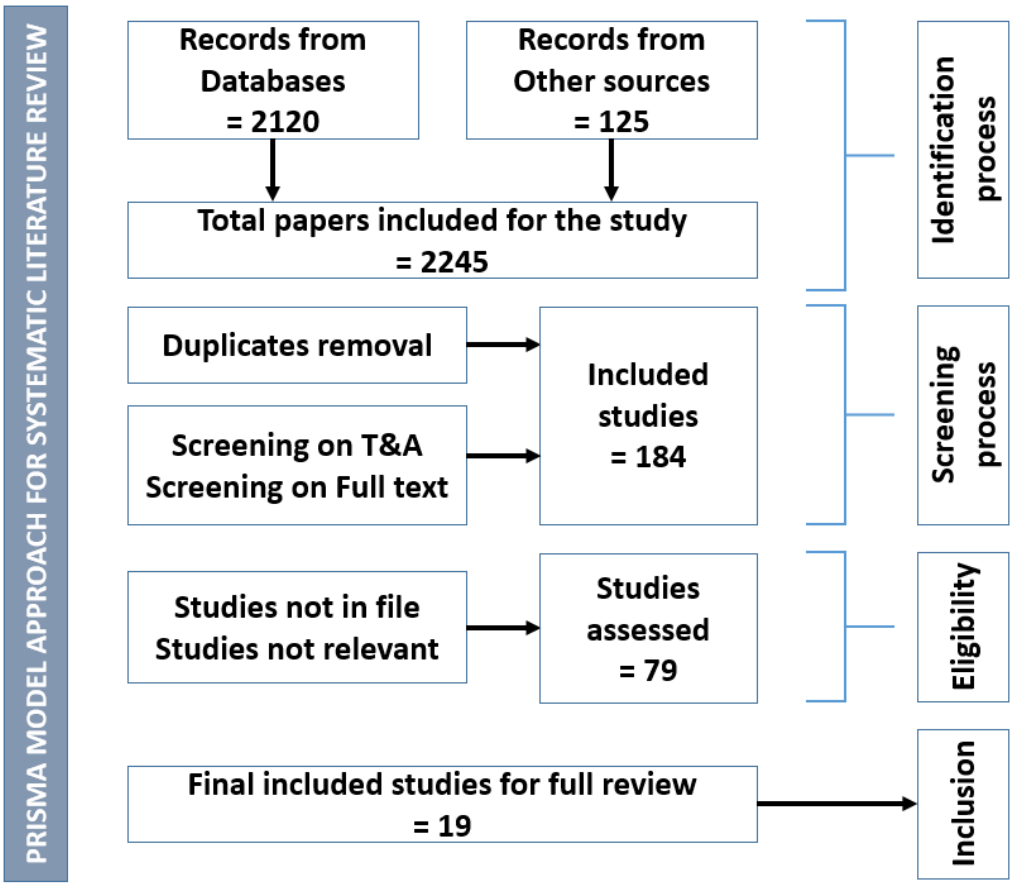

Figure 2: PRISMA model flow chart

Findings from Literature Review

Artificial Intelligence & its Models

The idea of technology taking over jobs traditionally done by humans still makes some people uneasy. Although artificial intelligence (AI) was invented 67 years ago, it has only recently become widely recognized due to its successful use in various industries [15]. Reference [16] defines AI as using computer systems to understand and mimic human intelligence. AI is a complex field with many subfields designed for specific needs. In the construction industry, several AI models have been created to meet its unique demands and challenges, including:

A) Machine Learning Models

According to reference [17], machine learning involves teaching computers to improve their performance based on certain criteria, using either example data or past experiences. As a major part of artificial intelligence, machine learning helps tackle problems in areas like speech recognition, vision recognition, and robotics. IBM (2023) identifies three different types of machine learning models, each designed for specific tasks:

i. ***Supervised Machine Learning***: This method involves teaching algorithms with labeled data, so they can accurately classify information or predict results. For example, supervised machine learning can be used to sort spam emails into a separate folder away from the inbox.
ii. ***Unsupervised Machine Learning***: In this case, machine learning algorithms automatically

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analyze and group unlabeled data, discovering hidden patterns on their own without human help. For example, unsupervised machine learning is used for tasks like recognizing images and patterns.

iii. ***Semi-supervised Machine Learning***: Combining the two approaches above, semi-supervised machine learning handles situations where there isn't enough labeled data for supervised learning. It is also useful when labeling data is too costly.

B) Deep Learning Models

According to reference [18], Deep Learning is a specific area within Machine Learning that uses complex models with many processing layers to understand data at different levels of detail. This capability makes Deep Learning useful in the construction industry for tasks like automatically monitoring equipment, improving building design, and enabling automation [19].

C) Natural Language Processing Models

Within the realm of AI models, Natural Language Processing (NLP) emerges as a distinctive branch that aspires to imbue machines with human-like language comprehension, interpretation, and manipulation capabilities. By harnessing the power of NLP, computers are empowered to grasp the nuances of human language, enabling various applications like knowledge management, document classification and clustering, as well as risk and safety management in the domain of construction [20].

Project Management & efficiency

A project, which starts and ends at specific points, needs a focused approach to ensure everything runs smoothly, including managing deliveries and handling unexpected issues. Effective project management is crucial for dealing with these challenges. Project management involves using knowledge, skills, tools, and techniques to coordinate project tasks according to its requirements, helping to achieve the desired results [21]. It covers a range of goals, from large strategic plans to fixing minor issues in construction. Each project has its own complexities, so a tailored project management approach is necessary for success.

Efficiency in project management is very important because it affects whether a project meets its goals. In the construction industry, where skill, resource, and time wastage are common, being efficient is especially crucial [22]. Efficiency is often confused with effectiveness or performance, but in project management, it means using resources wisely while reducing waste to get good results. According to reference [23], project efficiency is about producing results in a skilled and qualified way, highlighting the need for a clear understanding of this key concept.

The focal point of this paper revolves around the monitoring of efficiency in project management within the construction industry. To gauge efficiency, several key metrics come to the forefront:

1. ***Labour Productivity:*** Given the labor-intensive nature of the construction domain, labor productivity emerges as a critical area that significantly impacts wastage, which may result from the underutilization or misallocation of labor skills. The lack of timely access to materials and relevant information, along with tasks performed out of sequence, contributes to substantial disruptions [24]. Hence, precise labor allocation is pivotal in enhancing efficiency.

2. ***Cost Performance*****:** This metric delves into the efficiency of cost management across the project's lifespan. As expressed by reference [25], it gauges the extent to which general conditions facilitate the project's completion within the estimated budget. Cost performance encompasses factors such as cost variance and legal claims, such as those associated with arbitration or litigation. The Cost Performance Index (CPI) serves as a useful measure to assess cost performance throughout the project.

3. ***Rework Rate:*** Addressing negligence and miscommunication, the rework rate evaluation focuses on monitoring areas prone to defects or

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causing defects, thus contributing to delays in project completion beyond the stipulated contract timeframe. Such delays entail significant financial losses on a daily basis, underscoring the imperative of efficient defect management.

4. ***Stakeholder Satisfaction:*** The ultimate gauge of project success lies in meeting stakeholders' objectives. Commencing even before the project's inception and persisting throughout its lifecycle, stakeholder satisfaction assumes a paramount role in determining project efficiency. Each stakeholder possesses the power to influence and shape the project's efficiency, accentuating their pivotal role in the overall success of the endeavor [21].

AI Models for Project Management Efficiency

AI is very useful in project management because it offers many ways to improve efficiency. AI models can be effectively used in project management through these methods:

1. **Machine Learning for Scheduling and Cost Prediction:** Machine Learning is a powerful tool for improving project schedules because it can quickly understand complex information. By using data from past projects, AI algorithms can find the best scheduling methods. Additionally, AI can handle much more data than humans, which helps in making more accurate predictions and managing project costs better [26].
2. **Natural Language Processing for Document Analysis and Automated Reporting:** In addressing the escalating challenges of identifying and verifying initial requirements, the construction industry encounters frequent errors and deficiencies in design aspects [27]. By harnessing the capabilities of Natural Language Processing, data extracted from drawings can be transformed into structured and formalized structural information, simplifying the reporting process.
3. **Chatbots for Project Communication:** In the domain of project management, consistent updating, analysis, and management of construction-related information assume paramount importance for achieving success [28]. To streamline communication, a well-designed AI-driven chatbot system can offer daily progress reports and swiftly address project-related queries, minimizing the time and effort expended on manual communication tasks.

The thoughtful integration of AI applications into project management empowers stakeholders with enhanced decision-making capabilities and augments overall project efficiency, epitomizing the symbiosis of cutting-edge technology and effective project execution.

Importance of AI in Project Management

AI has become a powerful force due to its speed and wide range of abilities. In construction project management, AI's importance is clear for several reasons:

1. According reference [29], AI helps quickly improve project definition, planning, and reporting. By using big data and machine learning, project managers can better spot risks that might otherwise go unnoticed. AI can also automate the tedious job of collecting and analyzing user stories, making it easier to handle project scope by identifying issues like inconsistencies and missing elements. Additionally, AI's ability to automate tasks helps project managers avoid repetitive work, allowing them to focus on more important tasks and skill development.

2. A study by the Association for Project Management (2022) supports the benefits of AI in project management, showing that AI helps project managers make faster, more informed decisions, even if the solutions aren’t perfect. AI also improves efficiency by assisting with problem-solving and offering strategies to prevent delays.

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3. Research by reference [30] shows that AI enhances team collaboration and stakeholder engagement by providing real-time access to shared information. This leads to better decision-making and strengthens team coordination. AI's automated reminders help keep tasks on track, and predictive analytics help project managers foresee and address potential issues early, reducing wasted resources and unexpected delays.

Using AI in project management speeds up key processes, improves problem-solving, and boosts team collaboration, making it essential for effective and successful project management.

In 2023, AI is crucial due to the growing complexity and scale of construction projects. These projects now involve many global stakeholders and skilled workers, making careful planning and smooth execution vital. AI is a valuable tool for managing these large-scale projects effectively.

AI can handle challenges that once seemed impossible, significantly increasing the chances of project success [31]. By using AI, project managers can focus on strategic decisions while AI handles routine tasks. The combination of human skills and AI technology improves efficiency and opens new possibilities for project management, leading to excellence in the field.

Areas for improvement

Using AI technologies in project management offers a great opportunity to boost overall efficiency. However, it's important to carefully consider potential challenges to ensure successful use. Here are some key ways AI can improve project management and the challenges to be aware of:

i. **Data Collection and Automation:** Machine learning helps review and understand large amounts of contracts and drawings quickly. It also helps allocate tasks smartly and organize documents for easy access. Drones and sensors are used to automatically record data and provide visual updates on construction progress [32].

ii. **Increased Efficiency:** The construction industry often faces issues with resource waste and delays. AI can improve efficiency by optimizing project management. Process mining, as mentioned by reference [33], provides insights into complex construction processes, tracks workflows, predicts changes, finds hidden problems, and shows collaboration patterns, leading to smoother project execution.

iii. **Resource Allocation:** AI and machine learning are better than humans at managing resources because they process large amounts of data quickly. They can find unused capacities that might be missed by humans and address potential system overloads before they become problems [34].

Exploring these AI-driven capabilities can help project management reach new levels of efficiency and improve construction processes. However, it's crucial to address potential challenges carefully to ensure successful use of AI in project management.

Conclusion

The review reveals the project management efficiency can be improved in construction industry using AI technologies. This is done by addressing challenges like cost overruns, delays, and poor resource management. AI technologies, including machine learning, natural language processing, and expert systems, can enhance decision-making, help predict problems, optimize resource use, and streamline project execution. Likewise,the review stresses the need to understand project management efficiency as using resources effectively to reduce waste while achieving organizational goals. Key indicators like labor productivity and cost performance are important for measuring efficiency, and customized project management strategies are needed for the unique challenges of each project.

The gaps in current research, such as the long-term effects of AI on project management and specific AI applications in different areas were highlighted, in which these gaps suggest areas for future study that could offer more

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insights into using AI to address ongoing project management challenges.

In conclusion, the study shows that AI models can significantly boost project management efficiency. By adopting AI methods, project managers can improve outcomes, reduce inefficiencies, and encourage innovation. As project management continues to change, ongoing research and practical use of AI will be key to achieving success and resilience in a complex and competitive field.

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