

Thesis Title:

**Factors Affecting Project Management Based on
Artificial Intelligence in Design & Consultancy
Engineering Projects**

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by
MAJID TALEB ALFLFEL
Saudi Arabia

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MAJID TALEB ALFLFEL



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2 Introduction;

Given the speed at which science and technology are developing in domains such as manufacturing, engineering, and medicine, project managers need to use artificial intelligence (AI) technologies to increase productivity. Project management is a strategic competency that employs knowledge, skills, tools, and techniques to effectively meet project requirements. This systematic approach, as defined by the Project Management Institute's (PMI) PMBOK Guide, is structured around five key process groups: Initiating, Planning, Executing, Monitoring and Controlling, and Closing. These processes ensure that projects are aligned with organizational goals, delivered on time, within budget, and meet or exceed stakeholder expectations. Furthermore, project management encompasses ten knowledge areas: Integration, Scope, Schedule, Cost, Quality, Resource, Communication, Risk, Procurement, and Stakeholder Management. Together, these areas equip project managers with the competencies needed to navigate complex projects and achieve strategic success. PMBOK® (2021).

AI has emerged as a crucial component of design and consulting engineering projects in critical domains like risk assessment, data gathering, improved data insight and analysis, improved decision-making and potentially enhanced project management. AI thereby improves operating efficiency by freeing up project managers to concentrate on important tasks while automating and optimizing processes to save a significant amount of time. Among its most common uses is the incorporation of intelligent AI technology into project management procedures, which stimulates the development into instruments and methods that greatly improve results. In design and consultancy engineering projects, AI has become instrumental in key areas such as data collection, risk identification, enhanced data insight and analysis, and enhanced decision-making processes. AI can optimize resource allocation and automate processes, freeing up project managers to concentrate on strategic goals while reducing human error. Weng (2023), highlights AI's role in optimizing resource allocation and automating tasks, enabling project managers to focus on strategic objectives while minimizing human error." In the context of Saudi Arabia's Vision 2030, AI emerges as a foundational pillar to achieve the vision's ambitious goals. AI makes it easier to forecast potential results of resource allocation, notify project managers of impending problems, assist in project prioritization, and give project managers the information they need to make decisions that best fit the project's overall progress. "With the help of AI it becomes more possible to predict possible outputs of resource allocation, alert project managers to upcoming issues, aid in prioritizing projects, and provide project managers with the necessary information to carry out decisions that best fit the projects' overall progress" (Caniels & Bakens, 2011).

Utilizing AI tools demonstrates immense potential across diverse industries. For example, the finance and banking sectors have successfully implemented AI to automate repetitive tasks, enabling the processing of vast numbers of transactions with minimal errors. El Khatib & Al Falasi (2021) document a case study at Mashreq Bank, where AI automation facilitated over 150,000 error-free transactions in a single day, significantly boosting productivity and eliminating data bias. This innovation has created reliable data pools for better decision-making and future projections.

AI applications in project management are equally transformative, “We found that almost half of the selected works focus on construction PM whereas, the use of AI in IT projects is also pronounced (nearly 22%), while its tools in other specific sectors (i.e., health) is too scarce. Moreover, AI-enabled approaches for generic PM are also remarkable” Taboada et al. (2023) observed.

Building on this discussion, it is evident that AI offers significant potential to enhance project management practices in design and consultancy engineering projects. It provides substantial benefits to both projects and project managers, addressing operational inefficiencies and decision-making challenges. This study aims to explore the application of AI in this domain, addressing existing gaps while raising awareness among project managers and organizations about effectively leveraging AI tools.

3 Research Problem

Artificial Intelligence (AI) in project management remains in its early developmental stages, grappling with significant challenges in the design, standardization, and implementation of tools, particularly in practical applications. While AI offers promising potential, its adoption in project management has been slow, hindered by factors such as insufficient investment from private companies, leaving much of the progress to universities and public research organizations (Ruiz, 2020). Moreover, the application of AI tools is not yet widespread across all areas of project management, with uncertainty surrounding their practical effectiveness and clear outputs in real-world scenarios (Bento, 2022). These challenges are compounded by the limited availability of research and primary data exploring AI's impact on project management information systems (El-Khatib & Al Falasi, 2021). As a result, the field often struggles to move beyond theoretical advancements to achieve actionable and scalable implementations in organizational settings (Taboada et al., 2023). “Although AI-enabled PM seems encouraging, its design, standardization, and implementation in project-based firms are still a challenge. Thus, AI adoption in PM is yet to be noted” (Taboada et al. 2023). Highlights another dimension of this issue, “The slow progress of AI in the field of project management is largely due to the lack of investment from private companies, which means progress is only has been made in the universities and the public research organizations” (Ruiz, 2020). Similarly, observed that “There weren't a sufficient number of research papers in the region about the impact of artificial intelligence on project management information systems as it was mentioned

earlier in the introduction. In addition, the number of managers was less than the predetermined amount. It was expected to get a total of twenty-five managers from different companies, but the primary data collected half that amount” (El-Khatib & Al Falasi, 2021). Further notes that, "Project management is a common field in many industries, and it is not immune to the innovations that artificial intelligence is bringing to the world. Even so, the application of artificial intelligence is not that widespread in companies and especially not in all of project management areas. The reasons are not clear but seem to be related to the uncertainty of the application of artificial intelligence in project management “ (Bento, 2022).

To address this gap, in addition to above mentioned gap highlighted by Taboada et al. 2023, Ruiz, 2020, El-Khatib & Al Falasi, 2021 and Brnto, 2022. we reviewed findings from prior studies on the evolution of AI in project management to identify the challenges and opportunities associated with its practical application. “There appears to be an increase in Project Management activity across industries, some authors perceive that AI in Project Management has been somewhat slower in adapting (Davahli, 2020; Munir, 2019). Such slower adaption may be a reason why project-heavy industries such as Manufacturing and Construction are listed as AI laggards (McKinsey & Company, 2018). Still, the continuously increasing accumulation of data in Project Management is expected to catalyze the benefits of AI in Project Management (Ong & Uddin, 2020), underlining the need for this study “(PAULO, 2021). Also “Although artificial intelligence applied to the project management area is not a novelty, its potentiality in all knowledge areas is still questionable (Pereira et al., 2021, 2022)” (Bento, 2022). “The possibility of project success is a field of research in which researchers are working intensively” (Ruiz, 2020) “In a survey, a group of project management experts were asked to state their insights into AI’s likely effect on project management in the next 10 years. Results clearly illustrated that AI will be an integrated part of future project management practice and will affect project management knowledge areas in the near future” (Fridgeirsson, 2021). While prior research presents varied perspectives, there is consistent agreement regarding the limited adoption of practical AI tools in project management. This recognition motivates the current study to investigate these gaps and propose solutions specific to design and consultancy engineering projects. “In the future, AI will not be a choice but will be an integral part of their strategy for survival.” El Khatib & Al Falasi (2021).

Case Study;

To validate the problem from a practical standpoint, the researcher conducted an exploratory study targeting a convenience sample of experts in design and consultancy engineering projects. This study sought to understand their perceptions of the factors affecting and the outputs derived from using AI in project management. The findings revealed limited adoption of advanced AI tools and identified several key issues, summarized as follows:

1. A significant proportion of respondents indicated the absence of practical AI tools for project management in their organizations.

2. A smaller percentage reported incomplete attempts to use AI tools, hindered by challenges such as incompatibility with existing infrastructure, insufficient training, and lack of managerial support.
3. Some respondents acknowledged the use of AI-supported tools, although their application was primarily limited to automating routine tasks.

As a practitioner in project management within Saudi Arabia, the researcher also observed the absence of advanced AI tools beyond basic automation. However, it is possible that some AI tools are being used in organizations but are not publicly documented. This study therefore aims to identify the challenges and opportunities affecting the use of AI in design and consultancy engineering project management.

For example, retrieving historical data for future projects such as risk identification, cost estimation, or quality records, often requires significant time and effort due to the lack of AI-powered tools. In contrast, organizations with AI tools can retrieve such data quickly and efficiently. However, concerns about data privacy and security deter organizations from adopting AI, as they are reluctant to expose sensitive information externally.

Another notable challenge is data analysis. Human analysts require considerable time to process large volumes of complex data, whereas AI-powered tools can analyze such datasets in seconds, offering faster and more actionable insights.

Additionally, AI adoption comes with substantial costs. Organizations must upgrade infrastructure to ensure compatibility with AI technologies and incur ongoing expenses for training and maintenance. This issue is further exacerbated by the limited availability of skilled professionals with AI expertise.

Lastly, ethical and social challenges also hinder adoption. Resistance to change often arises, fueled by employees' reluctance to leave their comfort zones. Fear of job displacement further exacerbates resistance, making it critical to implement change management strategies to reassure employees and address their concerns while maintaining operational efficiency.

These difficulties highlight the necessity of integrating AI into project management in a thorough and calculated manner, guaranteeing that its advantages are seen while resolving the related obstacles. These challenges underscore the need for a careful and strategic approach to incorporating AI into project management, ensuring that its benefits are realized while addressing the associated challenges.

Building on this discussion and addressing the identified research gap, this study seeks to answer the following major question:

Q.1: What are the factors that affect the use of artificial intelligence tools in project management?

Accordingly, the subsequent question will answer the research gap at each independent variable as below;

Q1.1: How do data privacy and security affect the use of artificial intelligence tools in project management of design and consultancy projects?

Q1.2: How does resistance to change and adaptation affect the implementation of artificial intelligence tools in project management of design and consultancy projects?

Q1.3: What is the impact of the costs associated with AI implementation on its use in project management of design and consultancy projects?

Q1.4: How does the compatibility of artificial intelligence tools with existing infrastructure affect their use in project management of design and consultancy projects?

Q1.5: How do resource availability and training skill development affect the use of artificial intelligence tools in project management of design and consultancy projects?

Q1.6: What role do ethical considerations play in the adoption of artificial intelligence tools in project management of design and consultancy projects?

4 Research Objectives

This study aims to achieve the following objectives:

1. Identify and Measure the most important factors affecting project management in the Saudi design & consultancy engineering project.
2. Assess the direct impact of the factors affecting the use of artificial intelligence tools on project management in the Saudi design & consultancy engineering project under investigation.
3. Examine the direct effects of the factors affecting the use of artificial intelligence tools on the expected outputs of these tools in the Saudi design and consultancy companies under investigation.
4. Analyze the indirect effects of the factors affecting project management when mediated by the adoption of artificial intelligence tools..
5. Determine whether significant differences exist among the study sample elements regarding factors and outputs based on organization size, sector type, and the demographic characteristics of managers in the Saudi engineering companies under investigation.
6. Develop actionable recommendations based on the findings to help project managers in the companies under investigation maximize the benefits of artificial intelligence tools in their field.
7. Investigate the key factors affecting project management performance when utilizing artificial intelligence tools in Saudi design and consultancy engineering projects.

5 Research Importance

5.1 Scientific Importance:

This study distinguishes itself by focusing on identifying and measuring the factors affecting project management through the utilization of AI. By addressing the scarcity of research on AI tools in project management, it fills a critical gap in the academic literature, particularly in the context of design and consultancy engineering projects. The limited availability of studies in this area, as highlighted by several researchers, underscores the importance of conducting such focused investigations.

Similarly, many studies have predicted the future evolution of AI in project management, “Looking to the future 25 years from now, it is likely that there will exist an AI capable of managing the entire project, albeit with some form of human supervision” Ruiz (2020) notes. Despite these predictions, there is little quantitative research examining the moderating impact of AI tools on project management. This study will address this gap by quantifying the effects of applying AI in project management and measuring its impact on key variables. Such an investigation will contribute significantly to understanding the factors that affect project management through AI, specifically in design and consultancy engineering projects.

5.2 Practical Importance:

To achieve strategic objectives and enhance project value, companies must prioritize the practical adoption of artificial intelligence in project management. Leveraging AI has become essential for staying competitive amidst rapidly evolving technologies. Organizations looking to optimize AI's benefits in project management techniques must comprehend the elements that lead to its successful and long-lasting deployment.

Understanding the factors that contribute to the successful and sustainable implementation of AI is critical for organizations seeking to maximize their project outputs in project management practices. By exploring both challenges and opportunities, this study aims to provide actionable insights that will enable organizations to integrate AI effectively, ensuring its long-term value in design and consultancy engineering projects.

6 Theoretical Background

6.1 Independent Variables:

Independent variables are the factors that a researcher changes to see how they affect another factor, known as the dependent variable. For example, in a study on how light affects plant growth, the amount of light is the independent variable. Here are some of the independent variables that we intend to measure the its effect to the dependent variables;

6.1.1 Data Privacy and Security:

Protecting data privacy and security in project management is essential for safeguarding sensitive information and maintaining stakeholder trust. Achieving this involves obtaining clear consent for data use, applying anonymization techniques, and securing data storage with encryption and controlled access. Access to data is one of the main obstacles to deploying AI. Poor quality causes data to be compartmentalized and inconsistent. AI is only capable of carrying out tasks that have been planned or programmed. Implementing, fixing, rebuilding, and creating it all requires a lot of time “One of the major implementing AI barriers is data availability. Data is inconsistent and siloed due to poor quality. AI can perform only those types and tasks that are programmed or designed. It takes lots of time to implement, repair, rebuild, and also to create.” Khayyat & Alshaikhi (2021).

The complexity of data privacy challenges further extends to data comprehension and integration with AI technologies, Since practitioners might not be aware of what data is entered and kept in a model, privacy presents an additional data difficulty. The necessity for transparency through so-called explainable AI has increased due to the inability to comprehend AI outputs “Privacy is a further data challenge since practitioners may lack knowledge of what data is inputted and stored in a model. Contemporary AI, such as deep neural networks (DNNs), that function on unstructured data, mainly render opaque decisions. The lack of comprehension from AI outputs has raised the need for transparency through so-called explainable AI” Paulo (2021).

AI technologies rely on large volumes of data to operate effectively, which raises significant concerns about data security. Data collected, stored, or processed by AI systems must be consistent and of high quality to avoid operational inefficiencies and risks. Project teams frequently handle sensitive data, therefore maintaining the data's integrity and confidentiality becomes crucial. When AI tool is used for project management, data is sent between the AI tool and project management software, which could expose private information to outside parties “With project teams often handling sensitive information, protecting the confidentiality and integrity of this data becomes paramount. Applying ChatGPT to project management involves exchanging information between the AI tool and project management software, potentially exposing sensitive data to third parties.” Weng (2023). This risk applies broadly to most AI tools, as the data exchanged may include project-specific details, client information, and financial data, all of which could be exposed without adequate safeguards.

Organizations must adopt robust measures to enhance data privacy and security. Cybersecurity specialists should be engaged to address vulnerabilities and ensure compliance with data protection standards, To create best practices and rules for

utilizing AI tools, project managers need also to collaborate closely with their cybersecurity and IT departments. Organizations should also continue to be open and honest with their stakeholders regarding the usage of AI and the security and privacy precautions adopted. “Project managers should also work closely with their IT departments and cybersecurity teams to establish best practices and guidelines for using AI tools like ChatGPT. Additionally, organizations should maintain transparency with their stakeholders about the use of AI and the measures taken to protect data privacy and security” Weng (2023). Data privacy and security are critical considerations in AI-driven project management, particularly in design and consultancy engineering projects. As organizations increasingly adopt AI-powered technologies, ensuring robust data security practices is essential to protect sensitive information and build stakeholder trust. This research explores how concerns about data privacy and security affect the adoption and success of AI tools in project management, providing actionable insights into mitigating these risks.

6.1.2 Adaptation and Change Resistance

Adopting AI in project management is critical as it offers enhanced efficiency, accuracy, and decision-making capabilities. AI tools automate routine tasks, such as scheduling, resource allocation, and data analysis, allowing project managers to focus on strategic aspects of their work. This integration ultimately leads to more successful projects, delivered on time and within budget, while minimizing human error and resource wastage. highlight the main justifications for adapting AI in project management, Various justifications for adapting AI in project management are related to the need for enhance data accuracy, enhance decision-making skills, enhance risk identification process, increased productivity, and the requirement to enhance overall project performance. “The first three reasons for adopting AI in Project Management are linked to the need in increased productivity which will free up project managers allowing them to focus on more important decisions (53%), followed by better decision-making capabilities (52%) and necessity to improve overall project performance and reporting (51%). As a conclusion to these answers, respondents indicate the time gained for strategy-related issues as an important benefit.” Bodea et al. (2020).

Despite these significant benefits, organizations often encounter substantial challenges and resistance when implementing AI tools. Key barriers include difficulties integrating new technology with existing systems, training employees, and updating processes to accommodate AI capabilities. Employee resistance is often fueled by fears of job automation, satisfaction with current systems, or a lack of understanding of AI's benefits. Overcoming the acceptance obstacles related to AI technologies is a major difficulty when implementing ChatGPT in project management. Lack of knowledge and awareness of AI's potential uses in project management is a significant obstacle. Many stakeholders and project managers might not completely understand the potential advantages of AI-driven project management solutions, or they might have preconceived notions about what AI tools and technologies are capable of. This ignorance may lead to resistance to change and a

hesitancy to embrace AI-powered solutions. “One significant challenge in applying ChatGPT to project management is overcoming the adoption barriers associated with AI tools. A major barrier is the lack of understanding and awareness of AI capabilities and potential applications in project management. Many project managers and stakeholders may not fully grasp the potential benefits of AI-driven project management solutions or may have misconceptions about the capabilities of AI tools like ChatGPT. This lack of understanding can result in resistance to change and reluctance to adopt AI-driven solutions” Weng (2023).

The rapidly evolving nature of AI technology further complicates adaptation efforts. Organizations must continuously adjust processes and strategies to keep pace with emerging trends and best practices, adaptation requirements, flexibility, and awareness of existing infrastructure needs are necessary for the successful integration of AI. “Successful integration of AI requires strategic planning, adaptability, and careful task selection” Bharati (2024).

To overcome micromanagement concerns and lessen opposition to AI deployment, change management training is crucial, to properly use of AI, project staff must have practical skills and technical automation tool expertise, and change management skills. “Change management training is essential to mitigate resistance to AI adoption and address micromanagement issues. Practical skills development, including AI literacy, data literacy, technical proficiency in automation tools, and change management, is necessary for project personnel to effectively leverage AI ” Bharati & Sandbrink (2024).

Organizational reluctance to adopt AI tools is often linked to the need for significant changes to existing infrastructure or the abandonment of legacy systems. This hesitance can prevent organizations from realizing the efficiency and decision-making benefits of AI-driven solutions. Effective change management is essential to overcome these barriers. This includes identifying potential problems early, involving stakeholders, providing proper training, and tracking adoption rates to ensure a smooth transition. The quality of the data is enhanced by pre-planning and teamwork. The majority of businesses encountered numerous challenges in successfully deploying and operating AI. The main cause is a lack of preparation and teamwork. The group in charge of putting AI into practice must communicate with the stakeholders frequently. “Pre-planning and collaboration across the board improve the quality of data. Another manager discussed some of the cases in companies where AI was used to collect and manage data. Most companies, it faced many problems in implementing AI and run it smoothly. The primary reason is lack of collaboration and pre-planning. The team responsible for the implementation of AI needs to interact with the stakeholders on a regular basis. In one case, it took them more than four months to implement a simple task because the employees were not ready and briefed about the changes” El Khatib & Al Falasi (2021). Similarly, The majority of organizations face a number of difficulties when attempting to successfully deploy and operate AI. The main issue is a lack of planning and collaboration. The group responsible for implementing AI needs to keep stakeholders informed on a regular basis. “Most businesses encounter several challenges in implementing and running AI smoothly. The fundamental problem is a lack of teamwork and forethought. The team in charge of Artificial Intelligence deployment must communicate with stakeholders frequently. One example lasted over four months to complete a straightforward

mission since the staff were not prepared for the changes and were not informed of them.” Tubman (2022).

Adaptation and change resistance are key factors affecting the adoption of AI in project management. This study explores how these challenges impact the successful integration of AI tools in design and consultancy engineering projects, with a focus on strategies to overcome resistance and foster collaboration. By addressing these issues, the research aims to provide actionable insights for organizations navigating the complexities of AI adoption, ultimately maximizing its benefits and ensuring long-term success.

6.1.3 Cost associated with AI implementation

The cost of implementing AI tools in project management can vary significantly depending on factors such as the complexity of the project, the specific AI tools or platforms used, the level of customization required, and the size of the organization. The high implementation costs of AI make its adoption and use difficult. By reaching a judgment or resolving an issue, artificial intelligence (AI) mitigates some uncertainty and offers the advantages of cost-benefit analysis. “Adoption and implementation of AI are not so easy to develop due to expensive operation costs and equipment. AI gives the benefits of cost-effectiveness, reliability, and permanency, and addresses some issues of uncertainty by drawing a conclusion or solving a problem” Khayyat & Alshaikhi (2021). Despite these benefits, the initial investment required to adopt AI often poses a barrier, particularly for organizations with limited financial resources.

AI adoption entails several layers of costs, which collectively create financial challenges for organizations. The initial expense includes purchasing or licensing specialized AI software, which can carry a significant price tag depending on the level of functionality and customization required. For instance, integrating ChatGPT into project management systems involves not only the cost of software but also expenses related to compatibility adjustments and process restructuring. Noting that, The cost of implementing AI solutions in project management is another obstacle to acceptance. The cost may vary from small to big organization, for smaller businesses with tighter resources, the expenses of incorporating AI tools into current project management procedures and tools might be high. Furthermore, companies might have to pay for continuous upkeep, upgrades, and training for AI-powered project management software. “Another adoption barrier is the financial investment required to implement AI solutions in project management. The costs associated with integrating ChatGPT into existing project management systems and processes can be substantial, particularly for smaller organizations with limited budgets. Additionally, organizations may face ongoing costs related to maintenance, updates, and training for AI-driven project management tools” Weng (2023).

Beyond software and implementation costs, organizations must invest in data integration and employee training. Data integration often involves consolidating diverse data sources to ensure compatibility with AI systems, which can be a resource-intensive process. Training team members to effectively use AI tools also incurs significant costs, as employees must acquire new skills to work alongside

advanced technology. Additionally, organizations may need to allocate budgets for change management efforts to facilitate a smooth transition to AI-driven processes.

Broader economic challenges related to AI adoption, The substantial financial obstacles posed by AI to institutions and organizations deal with the necessary technological investments and adjustments to modern working procedures. Research in the healthcare sector demonstrates that pressure from competitors to use AI technology increases businesses' costs, which leads to higher pricing being passed on to customers. "AI's significant economic challenges to organizations and institutions address the required investments for technology and changes in contemporary working practices. Studies in the healthcare industry show that competitive pressures to adopt AI technology raise the financial burden of companies so that prices are rolled off to consumers " PAULO (2021). Bughin et al. (2018) further argue that AI adoption risks widening the gap between developed and developing economies, as poorer nations may lack the financial capital to compete in technological investments, thereby falling behind in competitiveness.

Ongoing costs for maintenance and technical support further add to the financial burden of AI adoption. These expenses are necessary to keep AI systems functional, secure, and up-to-date. Without sufficient budgeting for these recurring costs, organizations risk undermining the long-term sustainability of their AI initiatives. The financial challenges of adopting AI tools in project management are a critical factor affecting their successful implementation. This study examines how cost considerations impact the adoption of AI in design and consultancy engineering projects, providing insights into effective budgeting strategies. By understanding these cost components and weighing them against potential benefits, organizations can better mitigate financial risks and maximize returns, ensuring that the transformative potential of AI is fully realized.

6.1.4 Compatibility with existing Infrastructure:

Compatibility with existing infrastructure refers to how effectively AI systems integrate into an organization's current hardware, software, and operational frameworks. Successful AI adoption often hinges on the seamless alignment of AI technologies with legacy systems, ensuring minimal disruption to workflows and reducing implementation costs and time. Companies may be hesitant to use AI solutions if they necessitate giving up on old systems or making major adjustments to their current project management infrastructure. Even while AI-driven project management systems have a lot to offer in terms of efficiency and decision-making help, this may cause reluctance to adopt them. "Organizations may be reluctant to adopt AI tools if they require significant changes to their current project management infrastructure or the abandonment of legacy systems. This can result in hesitance to embrace AI-driven project management solutions, even if they offer significant benefits in terms of efficiency and decision-making support." Weng (2023).

Integration challenges can arise in several areas, such as data quality, interoperability, and scalability. AI systems often rely on large, structured datasets, which are typically scattered across different systems and formats. Since new technologies are emerging and relying on outdated tools and procedures won't work for complicated projects, incorporating artificial intelligence into project management is crucial. "Including

artificial intelligence is an essential involvement in managing projects as new technologies are arising, and depending on old-style tools and techniques will no longer work for new complex projects” Mahmood et al. (2023).

To ensure compatibility, organizations must carefully evaluate their current infrastructure. They need to determine whether new AI tools can operate efficiently within existing systems or if building a new AI-specific infrastructure would be more effective. While upgrading infrastructure may incur additional costs, it can enhance system accuracy and scalability, enabling organizations to fully harness AI's capabilities. Organizations must weigh the costs and benefits of integrating AI with legacy systems versus investing in modern AI-compatible infrastructure. The compatibility of AI tools with existing infrastructure is a critical factor affecting their successful adoption in project management. This study explores how infrastructure challenges impact the integration of AI in design and consultancy engineering projects, providing insights into strategies for ensuring interoperability and scalability. By addressing these issues, the research aims to help organizations make informed decisions about optimizing their infrastructure for AI-driven solutions.

6.1.5 Unavailable Resources & Training Skills Development:

Effective training and skill development are critical to leveraging AI technologies successfully in project management. As AI continues to evolve, organizations must commit to ongoing education and adaptation to ensure their workforce can effectively utilize these advanced tools. Without sufficient training, organizations risk failure in adopting AI technologies, as project managers and teams may lack the necessary technical expertise to fully integrate these tools into their workflows. The requirement for education and training is one facet of change management that enterprises need to handle. Project managers and team members need to learn new skills in order to use AI tools and technologies as they become more integrated into project management procedures. In order to ensure that their staff is capable of utilizing AI-driven project management solutions, organizations must make investments in professional development and training. “One aspect of change management that organizations must address is the need for training and education. As AI tools like ChatGPT become more integrated into project management processes, project managers and team members must develop new skills to effectively leverage these tools. This requires organizations to invest in training and professional development, ensuring that their workforce is equipped to harness the potential of AI-driven project management solutions.” Weng (2023).

The lack of adequate training and skill development can have severe consequences for organizations. It's observed that, a lack of leadership and interpersonal skills is one of the main reasons why firms have not used or implemented AI for data management or decision-making. Numerous firms were able to overcome this obstacle and change the way they think about their own growth. “The primary reason why organizations had failed to utilize or implement AI for decision-making or data management is due to lack of leadership and interpersonal skills. Several organizations overcame this barrier and shifted the paradigm of their organization growth.” El Khatib & Al Falasi (2021).

This highlights the importance of leadership in driving training initiatives and fostering a culture of continuous learning.

A well-trained technical workforce is essential for the successful adoption of AI in project management. AI adoption won't be successful if the skilled workforce are in short supply. To run and integrate AI in the company, technical personnel with the necessary training and expertise are needed. The business won't be able to obtain a long implementation period if they are unable to function. "The adoption of AI will not work properly if there is no availability of the technical staff and shortages of skills. Technical staff with well-trained and experienced is required to operate and implement the AI in the business. If they cannot operate, the company will not be able to get lengthy implementation time." Khayyat & Alshaikhi (2021). Additionally, organizations face challenges such as integration with legacy systems and interoperability with other platforms, which require skilled professionals to address.

Upskilling employees to meet the demands of AI-driven project management is a necessity. Companies may need to spend money on upskilling their staff to meet the objectives and obstacles of this new project management approach because the field is relatively new. "As the field is quite new in the area of project management, companies may have to invest in upskilling their employees to meet the demands and challenges of this new mode of project management." Belharet (2020). Furthermore, notes how AI can enhance human capital optimization by identifying the right skills for the right jobs, pinpointing training needs, and predicting resource excess or shortages, ultimately addressing one of the primary causes of project failures—insufficient team capabilities. Despite its importance, many organizations fail to provide adequate training for AI adoption. It reported that even though AI is crucial for organizational effectiveness, it needs a reassessment of the available resources to determine the gap and the area of improvement because participants possess various AI knowledge and experience, thus some of the participants have little to no knowledge or experience with AI. "Despite AI's importance for organizational efficiency, 62% of the participants rated their companies at 4 or below (on a scale of 1 to 10) in providing AI training to their employees, which correlates with the finding that 65% of participants possess no or only a basic level of AI knowledge and experience" Müller (2024). This gap underscores the critical need for training and highlights the challenges organizations face in developing a skilled workforce capable of adapting to AI technologies. The unavailability of resources and lack of adequate training are significant barriers to the adoption of AI tools in project management. This study examines how these factors affect AI integration in design and consultancy engineering projects, identifying strategies to overcome these challenges. By addressing gaps in skills development and training, this research aims to provide actionable recommendations to help organizations build a workforce capable of leveraging AI technologies effectively.

6.1.6 Ethical Consideration:

The implementation of AI in project management brings numerous benefits, but it also necessitates careful attention to ethical considerations. These include ensuring fairness, avoiding bias in AI algorithms, maintaining transparency, and ensuring

accountability in AI-driven processes. Addressing these issues is crucial for safeguarding data integrity, supporting regulatory compliance, and building stakeholder trust. The ethical importance of AI is highlighted by a number of factors. Such as biases in data input and discrimination. Therefore, it is recommended that the current legislative framework be quickly modified to address the current AI concerns. “Various aspects highlight the ethical criticality in AI. First, intelligent agents may exhibit discrimination caused by biases in programming or data input. Second, many AI algorithms cannot reason upon their outputs. Third, the long-term impacts of the technology are yet polarizing. Hence, the current regulatory framework is advocated to swiftly adapt to current AI challenges.” Paulo (2021). Bias in training data can lead to unfair outputs, underscoring the need for transparency and fairness in AI systems. Any biases in the training data could be reinforced in the AI-generated outputs because AI models learn from the data they are fed. This may result in skewed judgment or erroneous forecasts for project management software, which could have a negative effect on project results. “Since AI models learn from the data they are fed, any biases present in the training data may be perpetuated in the AI-generated outputs. For project management applications, this can lead to biased decision-making or inaccurate predictions that could adversely impact project outcomes” Weng (2023). Addressing these biases involves integrating ethical guidelines at every stage of AI development, from data collection to model training and deployment.

The ethical challenges extend beyond data integrity to broader societal implications, AI raises concerns about job displacement and its broader societal impact, As artificial intelligence surpasses human skills, it will also unavoidably replace other occupations that currently require humans. “Other roles which currently require humans will also inevitably be replaced by Artificial Intelligence as they exceed human capabilities. Research has predicted that this will occur within the next couple of decades” Ong (2020). Similarly, the responsibility of organizations to ensure a just transition for their workforce, noting that “As AI-powered tools become more adept at performing tasks that were once exclusive to human project managers, there is a growing concern about job displacement and the potential devaluation of human expertise” Weng (2023).

To address these challenges, organizations must establish ethical governance frameworks that promote transparency, fairness, and inclusivity. The importance of explainability and interpretability in AI decision-making, The concepts of justice, openness, and responsibility in AI decision-making are expanded upon by explainability and interpretability. AI decision-making must be rational, particularly if the results directly harm someone. “Explainability and interpretability build on the principles of fairness, transparency, and accountability in AI decision-making. Decisions made by AI shall be reasoned, especially if outcomes are to the direct detriment of someone” Paulo (2021). Ensuring these principles are followed can prevent harm and foster trust in AI-driven decision-making processes. In the context of Saudi Arabia, the government has taken proactive steps to regulate AI ethically and responsibly. The National Strategy for Data and AI (NSDAI), launched by the Saudi Data and Artificial Intelligence Authority (SDAIA) in 2020, emphasizes robust data governance frameworks, privacy protections, and ethical guidelines for AI use. These efforts align with Saudi Vision 2030, aiming to position the country as a leader in AI-driven innovation while adhering to strict ethical standards.

The ethical considerations surrounding AI adoption in project management are critical for ensuring that its benefits are realized without compromising societal values or stakeholder trust. This study examines these ethical challenges in the context of design and consultancy engineering projects, exploring strategies to promote fairness, accountability, and transparency. By addressing these issues, the research aims to contribute to the development of responsible AI systems that enhance project outputs while supporting ethical and societal goals.

6.2 Mediated Variables:

The method or technique via which an independent variable enhance a dependent variable is explained by mediators, also known as mediated variables. When the mediator is affected by the independent variable and subsequently affects the dependent variable, mediation takes place. This idea is especially useful for comprehending intricate relationships, and it is frequently examined using statistical techniques such as regression analysis to examine mediation routes.

6.2.1 Project Management based on Artificial Intelligence:

The integration of artificial intelligence (AI) into project management introduces transformative potential, addressing several challenges while creating new opportunities. AI tools are increasingly being utilized to automate processes, analyze data, identify risks, and enhance decision-making. Project management has some challenges evaluating large amounts of data without adequate human resources and time, enhancing rule-based scheduling with artificial intelligence, and leveraging AI to create sub-projects or networks to increase efficiency. AI speeds up and simplifies the entire process. “There are three main issues that project management faces, which are: analyzing many data without sufficient human resources and time available; rule-based scheduling enhanced by AI; and establishing sub-projects or networks using AI to improve efficiency. AI makes the entire process faster and easier” Khayyat & Alshaikhi (2021).

AI also supports dynamic project management processes by leveraging machine learning, data science, and automation technologies. Sahadevan (2022) and الغامدي & ضرمان (2023) note that AI applications in project management are categorized into integration and automation, chatbot assistance, machine-learning-based solutions, and autonomous management. Among these, machine-learning-based tools are considered the most beneficial. For example, AI-powered risk detection tools can analyze large datasets to identify potential risks early, enabling project managers to adopt proactive measures that save time, resources, and money.

AI tools also enhance defect resolution and scope management, which are critical for project success. By analyzing real-time and historical data, AI systems can quickly identify the root causes of defects and suggest corrective measures. AI can detect and manage scope creep by monitoring project progress and identifying scope changes before they lead to budget overruns or delays. By continuously tracking developments and offering insights to effectively manage stakeholder expectations, AI tools can help project managers control scope creep. “AI tools can assist project managers in

controlling scope creep by constantly monitoring progress and providing insights to manage stakeholder expectations effectively ” Sahadevan (2023).

The ability of AI to enhance project team collaboration and empower decentralized decision-making is another significant benefit. AI-driven tools like chatbots and collaborative platforms enable team members to communicate seamlessly, regardless of location or time zone, reducing the reliance on centralized management (Korke et al., 2023). By evaluating team performance and pinpointing areas for development, these tools also efficiently distribute duties, which eventually results in more independent and productive teams. Adopting AI in project management is not without its difficulties, though. Its broad acceptance is still hampered by problems including data security, change aversion, inadequate training, and excessive implementation costs. These tools also allocate responsibilities effectively by analyzing team performance and identifying areas for improvement, ultimately leading to more autonomous and efficient teams. However, the adoption of AI in project management is not without challenges. Issues such as data security, resistance to change, lack of training, and high implementation costs continue to hinder its widespread adoption (Weng, 2023). Ethical concerns, such as biases in AI algorithms and potential job displacement, further complicate the integration process. For instance, the necessity for striking a balance between AI insights and human judgment is highlighted by the possible over-reliance on AI tools in project management, which raises worries about undervaluing human skills. “The potential over-reliance on AI tools like ChatGPT in project management raises concerns about undervaluing human expertise, highlighting the need for a balance between AI insights and human judgment” Weng (2023).

The integration of AI into project management serves as a crucial mediator that links independent factors like cost and infrastructure compatibility to dependent outputs such as enhanced efficiency and decision-making. By examining how AI transforms traditional project management processes, this study aims to uncover its role in enhancing project outputs, mitigating challenges, and supporting strategic goals in design and consultancy engineering projects. This understanding will provide actionable insights into leveraging AI as an enabler for achieving organizational success.

6.3 Dependent Variables:

In an experiment or study, the output or response that researchers measure is called a dependent variable. It is referred to as "dependent" since it is assumed that it is reliant on the affect of other variables, also called independent variables. In order to determine the impact of the independent variables, the researcher observes changes in the dependent variable, which is what they are trying to explain or forecast. For instance, test scores would be the dependent variable in a study looking at how study time (an independent variable) affects test results (a dependent variable).

6.3.1 Enhancing Decision Making:

A dependent variable represents the output or response measured in a study. In the context of project management, enhancing decision-making is a critical dependent variable affected by AI's capabilities in data analysis, predictive analytics, and automation. These capabilities enable organizations to make faster, more accurate, and data-driven decisions, improving efficiency and overall project outputs. AI significantly supports proactive decision-making by offering insights into future outputs, identifying risks, and optimizing strategies. Because it helps facilitate decision-making, enhance risk identification, and other aspects as well. AI is becoming a crucial part of project management. AI lowers the possibility of human error while enabling project managers to concentrate on more strategic, higher-level duties by automating repetitive ones. "Artificial intelligence has increasingly become an essential component of project management, as it can help streamline workflows, optimize resource allocation, and improve decision-making. By automating repetitive tasks, AI allows project managers to focus on higher-level strategic activities while also reducing the likelihood of human error" Weng (2023).

Project Management Information Systems (PMIS) play a pivotal role in AI-driven decision-making, because PMIS make it easier to manage complicated data by facilitating the effective management of complex data. PMIS are essential to AI-driven decision-making, PMIS is advantageous to project managers overseeing projects since it facilitates quicker decision-making and project success. "PMIS is considered beneficial to project managers managing single and complex projects because it contributes to timelier decision making and project success" El Khatib & Al Falasi (2021). Additionally, incorporating AI into PMIS allows organizations to maintain control, verify actions, and monitor system stability, which improves decision accuracy and efficiency. Moreover, "integrating AI into PMIS enables organizations to monitor system stability, verify actions, and maintain control, leading to improved efficiency and accuracy in decisions" (Raymond & Bergeron, 2008).

AI's ability to process large volumes of data enhances decision-making quality by identifying trends, patterns, and risks that might otherwise go unnoticed. In that stream of data, AI could spot steadily escalating tendencies that are important but difficult to notice. "AI could identify slowly ramping trends in that stream of data that are significant but hard to see." (El Khatib & Al Falasi, 2021). This capability is especially critical in risk assessment, where AI helps decision-makers anticipate and mitigate potential issues, as in the banking sector, where it identifies high-risk customers.

In addition to decision-making, AI contributes to urban planning and other specialized applications. Mahmood et al. (2023) describe how AI tools like the Tangible User Interface (TUI) system have been used in urban planning projects, including in Riyadh, to ensure energy efficiency, walkability, and daylighting. By simulating various scenarios, the system improves planning accuracy and enables informed decision-making. Such tools demonstrate AI's value in addressing complex project variables and delivering high-quality outcomes. The use of AI in project management also enhances collaboration and reduces errors through data analysis and automation. Tubman (2022) reports on AI applications in the financial industry, such as Mashreq Bank's implementation of AI to manage over 150,000 error-free transactions in a

single day. These advancements underscore the potential of AI to improve data reliability and inform future decisions effectively.

AI-powered tools provide project managers with real-time recommendations and proactive insights, enabling faster and more accurate decisions. Project managers may make quicker and more accurate decisions thanks to AI-powered solutions that offer proactive insights and real-time recommendations. For example, ChatGPT-4 has been identified as a transformative tool for improving efficiency and decision-making in project management (Weng, 2023). Such tools integrate lessons learned and best practices to optimize project outcomes while maintaining data privacy and security.

The ability of AI to enhance decision-making is a key output in this study, as it demonstrates how AI tools can transform traditional project management practices. By analyzing historical and real-time data, AI supports faster, more accurate decisions, allowing project managers to address challenges proactively. This research examines how AI-driven decision-making affects project outputs, helping organizations enhance efficiency and achieve strategic goals in design and consultancy engineering projects.

6.3.2 Improving Project Output:

Artificial Intelligence (AI) significantly enhances project outputs by leveraging predictive analytics, automation, and real-time insights to optimize decision-making, risk management, and resource allocation. These capabilities streamline workflows, enhance communication, and enable project managers to make timely, informed decisions, leading to more efficient and successful project completions. A smooth connection with existing systems and procedures is essential to maximizing the advantages of AI-driven project management solutions. Businesses can overcome this difficulty by creating unique plugins and integrations for well-known project management programs, guaranteeing that AI tools can efficiently enhance current tools and procedures. “To fully leverage the benefits of AI-driven project management solutions, seamless integration with current systems and processes is crucial. Organizations can address this challenge by developing custom integrations and plugins for popular project management software, ensuring that ChatGPT can effectively complement existing tools and workflows” Weng (2023).

AI contributes to the planning and execution phases of projects by ensuring accuracy in scheduling, resource allocation, and cost estimation. Since new technologies are emerging and relying on outdated tools and procedures won't work for complicated projects, incorporating artificial intelligence into project management is crucial. “Including artificial intelligence is an essential involvement in managing projects as new technologies are arising and depending on old-style tools and techniques will no longer work for new complex projects.” Mahmood et al. (2023). AI helps project managers update budgets, adjust schedules, and align resources efficiently, reducing human error and enhancing project planning. Automation tools like chatbots and robotic process automation (RPA) also play a pivotal role in improving project efficiency. El Khatib & Al Falasi (2021) highlight an example from Mashreq Bank, which implemented AI to manage over 150,000 error-free transactions in a single day. This automation not only increased transaction volumes but also enhanced data quality, ensuring reliable information for decision-making.

In construction project management, AI-powered tools and techniques such as process mining and computer vision have proven transformative in monitoring crucial workflows, anticipating deviations, locating bottlenecks, and deriving patterns of cooperative behavior are just a few of the beneficial tasks. By avoiding pointless tasks, these insights increase operational efficiency. “Process mining enables several useful activities, including the monitoring of essential workflows, forecasting deviations, identifying bottlenecks, and extracting patterns of collaborative behavior. These insights help avoid unnecessary steps and improve operational efficiency.” Korke et al. (2023). Similarly, computer vision technologies automate damage detection and structural component recognition, reducing the need for manual inspections and improving safety on construction sites. AI-driven tools also enhance collaboration and task optimization, empowering project teams to work more effectively. AI-powered robots, for example, are increasingly used to handle repetitive tasks like bricklaying and welding, allowing human workers to focus on more complex activities (Korke et al., 2023). These tools operate continuously, ensuring consistent quality and productivity without breaks, ultimately boosting project outputs.

AI’s ability to address cybersecurity concerns and automate repetitive processes contributes further to enhanced project outputs. Sahadevan (2023) notes that AI-powered security tools can monitor systems in real time, detect threats, and respond faster than human teams. Meanwhile, tools like chatbots free employees to focus on more critical tasks, enhancing overall productivity.

AI’s potential to enhance project outputs is evident in its ability to optimize planning, automate routine processes, and provide actionable insights for project managers. This study examines how AI technologies contribute to enhanced project performance in design and consultancy engineering projects. By exploring real-world applications and overcoming implementation challenges, the research aims to identify strategies for leveraging AI to maximize project success and organizational competitiveness.

6.3.3 Data Collection Accuracy:

AI significantly enhances data collection accuracy by automating processes, minimizing human error, and analyzing large volumes of data in real-time. Through validation, cleaning, and standardization, AI ensures that data is accurate from the outset. Additionally, AI-driven systems are capable of detecting complex patterns and anomalies that may be overlooked manually, making them indispensable for improving data quality in various industries, including project management, healthcare, and finance. More precision is achieved when AI is used in data collection. AI may reveal gradually increasing patterns in that amount of data that are significant yet hard to see or simple for people to ignore even if they do. The use of AI in data collecting and analysis enhances data accuracy. “AI might uncover gradually escalating tendencies in that quantity of information that are substantial but difficult to perceive or easy for people to dismiss even if they do perceive them” Tubman (2022).

The role of AI in project management extends to real-time data analysis and integration, helping project managers make timely and informed decisions. During the

project planning stage, when managers must organize and allocate tasks and resources to better accomplish project objectives, artificial intelligence will be a huge assistance. AI's capacity to forecast length and expenses utilizing large data can help with the problem of inaccurate estimation, which is frequently brought on by human error. "AI will be a big help in project management throughout the project planning phase where project managers will need to plan and assign activities and resources to better achieve project goals. The challenge of incorrect estimation, often caused by human oversight, can be addressed by AI's ability to predict duration and costs using big data." Mahmood (2023). Tools like Building Information Modeling (BIM) further enhance data collection and sharing in construction project management. BIM offers a platform for sharing, trading, and evaluating data in real time in addition to collecting enormous amounts of data on every aspect of the project. This ensures accuracy and efficiency by facilitating smooth communication and collaboration among project stakeholders. "BIM provides a platform for not only gathering vast volumes of data about all parts of the project but also for sharing, exchanging, and analyzing data in real time. This facilitates seamless communication and cooperation among project stakeholders, ensuring accuracy and efficiency." Korke et al. (2023). The integration of AI with BIM transforms traditional paper-based methods into automated digital processes, enabling real-time responses to changes and optimizing project workflows.

AI's applications also extend to improving customer engagement and task automation. Organizations frequently utilize AI chatbots to automate data collecting and consumer interactions. These automated systems decrease human error while improving data quality and archive a massive amount of data in the organization's historical repository. "AI chatbots are widely used by firms to automate customer interactions and data collection. These automated systems enhance the quality of data while reducing errors caused by human intervention." Tubman (2022). Additionally, drones and sensors employed in construction projects autonomously gather data, offering a comprehensive view of the site without manual involvement, further improving accuracy and efficiency (Korke et al., 2023). AI-driven tools are instrumental in processing, automating, and securing data across industries. By utilizing these tools, Organizations can enhance data analysis, security, and productivity through capabilities like computer vision, natural language processing, and machine learning. "These tools possess capabilities like computer vision, natural language processing, and machine learning, enabling businesses to achieve better data analysis, enhanced security, and higher productivity." Mahmood (2023). This ensures that organizations can manage complex datasets effectively, driving enhanced outputs.

One important element affecting the effectiveness of AI-driven project management systems is the accuracy of data collecting. By analyzing their function in enhancing decision-making, decreasing errors, and streamlining processes, this study explores how AI technologies improve data accuracy in design and consulting engineering projects. The research attempts to give businesses practical insights to improve data-driven decision-making and project outcomes by tackling issues and investigating AI's applications.

6.3.4 Enhancing data analysis and insights:

AI has revolutionized data analysis by processing vast datasets at unparalleled speeds, uncovering patterns, and generating actionable insights with exceptional precision. These advanced capabilities enable organizations to identify trends and correlations that traditional methods might overlook. AI's strength in analyzing unstructured data, such as text, images, and audio, broadens the scope of insights available. This enhanced analytical power empowers businesses to make data-driven decisions, respond proactively to changes, optimize operations, and refine strategies across various sectors, including project management, healthcare, and finance. Organizations are improving their capacity to use AI in data administration and collecting, as well as in using the data to make smarter decisions. AI will be a necessary component of their survival strategy in the future rather than an option. "Organizations are developing their capabilities to embrace AI in data collection, data management and utilize the data for better decision-making. In the future, AI will not be a choice but will be an integral part of their strategy for survival" El Khatib & Al Falasi (2021).

AI transforms project management by automating complex data analysis and providing comprehensive insights. Development teams can now process enormous volumes of data at a never-before-seen speed thanks to advanced AI algorithms, which provide insightful results. These systems give a comprehensive picture of projects by tying together different subsystems, including marketing, engineering, and sales. "Advanced AI systems allow development teams to process massive amounts of data at an unprecedented pace, yielding valuable insights. These systems connect various subsystems, such as marketing, engineering, and sales, providing a holistic view of projects " Sahadevan (2023). This integration enhances decision-making across the entire project lifecycle.

AI tools further enhance data analysis by identifying previously hidden patterns and risks. For example, AI-based solutions can overcome the limitations of traditional construction management by analyzing large amounts of data with machine learning algorithms and revealing information that was previously unknown. "AI-based solutions can overcome the limitations of conventional construction management by using machine learning algorithms to analyze vast amounts of data, uncovering previously unknown information." Korke et al. (2023). These insights enhance risk identification, resource allocation, and operational efficiency, contributing to overall project success.

Despite its strengths, AI-driven solutions must complement human judgment rather than replace it. To highlight the importance of balancing, Project managers must apply a balance between relying on AI advice and applying their own expertise and intuition, even while AI-generated insights can enhance decision-making. "While AI-generated insights can enhance decision-making, project managers must strike a balance between relying on AI recommendations and leveraging their own expertise and intuition." Weng (2023). Establishing guidelines for the appropriate use of AI ensures that these tools support human decision-making rather than supplant it.

AI has a clear edge in improving data analysis and insights because of its capacity to swiftly and accurately examine massive datasets. In order to improve decision-making

and risk management, this study investigates how AI-driven tools improve analytical capabilities in design and consulting engineering projects. The goal of this research is to give businesses practical ways to use AI to improve project outcomes by looking at how AI technologies are integrated.

6.3.5 Risk Identification Accuracy:

AI significantly enhances the accuracy of risk identification by leveraging predictive models, machine learning algorithms, and data-driven insights to detect potential risks early and with greater precision. By analyzing historical data, identifying patterns, and forecasting risk scenarios, AI can uncover hidden anomalies and emerging threats that manual methods might miss. This capability allows organizations to implement preventive measures proactively, minimizing disruptions and improving resilience in industries like finance, healthcare, construction, and project management. Risk management gives decision-makers a methodical way to recognize, evaluate, and reduce risks. Additionally, it makes it possible for decision-makers to make better-informed choices. However, from the standpoint of decision-making, human judgment and knowledge are typically necessary for the risk management process to be successful. “Risk management provides decision-makers a systematic approach to identify, assess, and mitigate risks. It also enables decision-makers to make more informed and effective decisions. However, within the decision-making perspective, the success in the risk management process generally depends on human expertise and judgment.” Alada (2023).

In project management, AI supports risk identification by analyzing extensive datasets to predict threats and recommend mitigation strategies. While identifying potential project dangers to plan preventive steps or redevelop stronger mitigation plans, using AI to predict risks through historical data analysis and issue logs can save time, money, and effort. El Khatib & Al Falasi (2021) highlight how AI can assist project managers in industries like banking, where identifying and notifying decision-makers of high-risk clients can prevent financial losses.

AI’s application in construction project management demonstrates its capability to address uncertainties and enhance risk mitigation. By mimicking the knowledge of experts, providing predictive insights on important problems, and facilitating early troubleshooting to avoid unfavorable failures, AI methods can solve complex issues. “AI methods can solve complex issues by imitating the expertise of professionals, offering predictive insights on significant challenges, and enabling early troubleshooting to prevent unfavorable failures.” Korke et al. (2023). Techniques like probabilistic models, fuzzy theory, and neural networks are used to capture interdependencies between causes and outputs, improving safety and efficiency on construction sites.

Risk identification accuracy also benefits from AI’s integration with real-time data collection and scenario analysis. AI-powered tools can merge historical and real-time data to forecast challenges, assess risks, and evaluate potential alternatives effectively Tubman (2022). For example, in construction sites, drones and sensors autonomously gather data to monitor environmental and project conditions, reducing reliance on error-prone manual inspections (Korke et al., 2023).

The role of AI in risk management is particularly significant, enabling organizations to predict and mitigate potential threats. By planning for preventive actions or creating better mitigation strategies, using AI for risk prediction through historical data analysis and issue logs can save effort, resources, and costs. “Adopting AI for risk prediction through historical data analysis and issue logs can save effort, resources, and costs by planning for preventive actions or developing better mitigation strategies.” Mahmood et al. (2023). By analyzing large datasets, AI helps project managers proactively address risks, reducing the likelihood of project failures. AI’s contributions extend beyond risk management to optimizing operational processes in various industries. Ong (2020) discusses how AI supports project management by automating data analysis tasks like data preparation, exploration, and visualization. This automation reduces the time and effort required to extract insights, enabling faster and more informed decisions.

In the healthcare sector, AI’s role in risk management underscores the importance of human-AI collaboration. Healthcare projects often involve multiple layers of stakeholders, requiring interpersonal communication to ensure proper decision-making. He states, “AI can support decision-making by forecasting challenges, but the execution phase of healthcare projects necessitates human-to-human interaction, especially when patient care is involved.” Tubman (2022). BELHARET (2020) agrees, emphasizing that AI may not replace human judgment but serves as an indispensable tool for supporting it.

AI’s potential for risk identification extends beyond individual projects to organizational strategies. Weng (2023) advises organizations to adopt a multi-layered approach, combining thorough risk assessments with AI-driven insights to implement robust security measures. This proactive strategy ensures that project managers can address risks efficiently while maintaining stakeholder transparency and trust.

This study examines how AI-driven technologies improve the process of risk identification in design and consulting engineering projects, which is a crucial component of project management. The study looks at AI’s capacity to evaluate past data, forecast hazards, and suggest mitigation techniques in order to find workable ways to use AI to improve risk management, cut expenses, and maximize project results.

6.3.6 Saving Time for Project Manager (Operation Efficiency):

AI technologies empower project managers to save significant time by automating repetitive and administrative tasks, such as scheduling, data entry, reporting, and monitoring. This shift allows project managers to focus on high-level decision-making, strategic planning, and team management, enhancing project outputs and improving organizational efficiency. By eliminating the need for manual execution of routine tasks, AI enables managers to address complex challenges, engage deeply with stakeholders, and drive innovation within their projects.

The capacity of project management professionals to successfully coach, guide, and communicate with other stakeholders is what really makes them valuable, even when AI can automate many of the daily duties they undertake. In order to be truly

effective, these higher-level abilities require human interaction, solid and flexible judgment, empathy, and a connection to teams and stakeholders. “While many of the daily tasks project managers perform can be automated through the use of AI, the true value behind Project Management Professionals lies in their ability to effectively mentor, guide, and communicate with other stakeholders. These are the higher-level skills where human interaction, sound and flexible judgment, empathy, and connection to teams and stakeholders need the ‘Human-ness’ in order to be truly effective” BELHARET (2020).

AI’s potential to save time is particularly evident in areas like predictive analytics and automated scheduling. AI streamlines project planning with auto-scheduling features, making plans more robust while reducing the need for redundant information. AI tools such as bots can step up and handle less demanding tasks, reducing busy work time by half and allowing project managers to concentrate on the dynamic processes that underpin their strategic management. “80% of daily work, such as data collecting, reporting, and tracking, can be eliminated by AI, allowing project managers to integrate their expertise with AI capabilities.” Khayyat & Alshaikhi (2021). Similarly, “AI bots are capable of stepping up and handling less intensive tasks, cutting time spent on busy work in half, enabling project managers to focus on the dynamic processes behind their strategic management.” BELHARET (2020).

The integration of AI-driven tools also enhances data analysis and decision-making. According to Korke et al. (2023), advanced analytics provide managers with actionable insights, allowing them to recognize project difficulties promptly in a data-driven manner. This integration ensures managers can utilize historical data to predict potential outcomes, simulate scenarios, and make informed decisions faster. BELHARET (2020) elaborates on this, stating that predictive analytics helps project managers answer “what-if” questions to simulate potential project changes and outcomes, enabling more proactive management.

AI’s role in time-saving extends beyond individual tasks to overarching project management strategies. In the future, project managers will move into roles that combine their experience with data-driven insights from AI, while AI will make all the decisions and manage resources in an efficient and timely manner. “In the future, AI will make all the decisions and manage resources in an optimal and timely manner, while project managers will transition into roles that blend their expertise with data-driven insights from AI” Ruiz (2020). Weng (2023) adds that integrating AI tools like ChatGPT allows project managers to maintain data privacy while utilizing AI’s efficiency gains, ensuring trust and compliance while achieving project goals.

By automating coordination, reporting, and monitoring tasks, AI enables project managers to allocate their time to more impactful activities, such as stakeholder engagement and risk mitigation. BELHARET (2020) explains that this shift allows managers to foster a more relaxed work atmosphere where employees feel valued and supported. Furthermore, AI-powered systems enhance resource allocation, ensuring project teams can focus on tasks that truly matter while optimizing their efficiency.

This report emphasizes how AI is revolutionizing time management for project managers working on design and consulting engineering projects in Saudi Arabia.

Project managers can focus on strategic goals and intricate decision-making processes by using AI solutions to automate administrative activities, which improves project performance and overall efficiency. Organizations hoping to successfully utilize AI's time-saving potential must comprehend these dynamics.

6.3.7 Effective Collaboration & Communication:

AI tools significantly enhance collaboration and communication by automating routine tasks, streamlining information flow, and providing access to real-time data across teams. Tools such as AI-powered chatbots, virtual assistants, and collaborative platforms enable teams to stay connected, resolve issues promptly, and make informed decisions regardless of geographical location. This facilitates enhanced alignment of efforts, reduces misunderstandings, and enhances teamwork efficiency. By breaking down communication barriers and fostering transparency, AI supports a culture of seamless information exchange, leading to more coordinated and successful project execution. The cyclical process of collaboration involves individuals or organizations exchanging information, learning from one another, and coming to an agreement to accomplish shared objectives. Businesses that collaborate to accomplish a common goal or gain benefits from one another are said to be in integrated relationships, which are defined by dedication and trust. One of the most important influencing factors in project-based businesses is collaboration between various players. “Collaboration is a cyclical process in which organizations or people share information, learn, and establish an agreement to achieve common goals. Integrated relationships are businesses working together to achieve a similar purpose or acquire mutual advantages, characterized by trust and commitment. Collaboration between diverse actors is a major influential factor in project-based companies.” Tubman (2022).

AI also bridges communication gaps by automating documentation, translating languages, and providing tailored insights. This capability enhances productivity and ensures inclusivity in multinational projects. AI can help with email drafting, progress report, other weekly or monthly reports, and real-time language translation, removing barriers to communication and promoting more productive teamwork. “AI can assist in drafting emails, creating reports, and providing real-time language translation, breaking down communication barriers and facilitating more effective teamwork” Weng (2023).

AI-powered tools may minimize the impact of schedule delay cost overrun on project timelines and budgets by offering project managers recommendations for corrective actions and efficient stakeholder communication, by enabling users to participate in the process online or through other communication channels, AI engages and involves more people in decision-making processes. This guarantees that choices are made with the improvement of companies in mind. Moreover, AI tools encourage proactive communication by suggesting corrective measures based on historical data, reducing scope creep and aligning stakeholder expectations. “AI-powered tools may provide project managers with suggestions for corrective measures and effective communication with stakeholders, minimizing the impact of scope creep on project timelines and budgets.” Sahadevan (2023). Furthermore, “AI engages and involves more people in decision-making processes by providing them with the ability to

participate in the process online or through other forms of communication. This ensures that decisions are made for the betterment of organizations.” Tubman (2022).

Transparency and accountability are also bolstered through AI’s ability to provide decision-makers with complete, accurate, and unbiased information. By giving decision-makers access to all pertinent information, artificial intelligence (AI) improves transparency and accountability in decision-making processes and guarantees that decisions are made effectively and efficiently. “AI increases transparency and accountability in decision-making processes by providing decision-makers with the ability to access all relevant information, ensuring decisions are made efficiently and effectively.” Tubman (2022). This transparency reduces the likelihood of conflict and enhances cooperation among stakeholders, especially in multi-partner projects.

AI’s ability to optimize organizational culture is another pivotal contribution to collaboration. AI facilitates communication within a group and enhances the flow of information. Knowledge sharing and cross-border cooperation are made possible by a project's positive organizational culture. “AI improves information flow and removes communication barriers inside a group. A good organizational culture inside a project



allows knowledge exchange and cross-border collaboration” Tubman (2022). By fostering knowledge sharing and enabling self-organization, AI ensures a smoother flow of information and enhanced collaboration across project teams.

AI's ability to improve teamwork and communication is crucial for bringing project teams together and accomplishing organizational goals in the context of Saudi design and consulting engineering projects. Project managers may improve stakeholder interactions, strengthen teamwork, and guarantee more efficient project execution by utilizing AI solutions to automate repetitive operations, provide real-time updates, and offer remedial recommendations.

7 Literature Review:

The following table explains the details of the previous studies and identifies the Gap in the previous studies;

Name of the Literature	Methodology	Tools & Techniques	Year	Author Name	Purpose	Result	Study Summary & GAP Analysis
1. Putting Intellectual Robots to Work - Implementing Generative AI Tools in Project Management White Paper By Conor Weng	semi-structured interviews	using thematic analysis techniques	2023	Jiaxiong Weng	The primary objective is to provide a comprehensive guide for project managers on the effective use of ChatGPT-4 in their project management practices. The paper highlights the benefits and challenges of integrating ChatGPT-4 into project management processes, with a focus on data privacy, security, ethical considerations, adoption barriers, and change management.	The study identifies several key areas for future development and enhancement in ChatGPT-4's capabilities, including integration with other project management methodologies (e.g., Agile methods, Kanban), possibilities for customized development, and providing training and support for non-technical staff.	Weng conducted a study (Weng, 2023) titled "Putting Intellectual Robots to Work: Implementing Generative AI Tools in Project Management," with the objective of providing a comprehensive guide for project managers on the effective use of ChatGPT in their project management practices. The study highlights both the advantages and challenges of integrating ChatGPT, focusing on critical areas such as data privacy, security, ethical implications, adoption barriers, and change management. Weng's findings identified several key areas for future enhancements in ChatGPT's capabilities, including better integration with project management methodologies (e.g., Agile, Kanban), opportunities for customized development, and enhanced training and support for non-technical staff. The current study differs from Weng's research in its focus on identifying the factors affecting project management through AI in industrial engineering projects, proposing a unique model and methodology

							within specific spatial boundaries.
2. The Application of Artificial Intelligence in Project Management Research; A Review	مراجعة الأدبيات literature review	1. review a large number of learning techniques. 2. presenting a brief study of the different artificial intelligence techniques. 3.	2020	1. Jesús Gil Ruiz 2. Javier Martínez Torres, 3. Rubén González Crespo	The objective of this work is to review the new proposals emerging in the field of AI in the various areas, and to ascertain which techniques could be the most effective for ensuring the success of the projects.	AI tools are highly useful to the project manager in terms of controlling and monitoring the project; however, many of the reviewed models involve weaknesses and limitations, which indicates that project managers should continue to use their experience when making evaluations according to the results.	Ruiz conducted a study (Ruiz et al., 2020) titled "The Application of Artificial Intelligence in Project Management Research; A Review," aiming to explore emerging AI techniques in project management and identify the most effective methods for ensuring project success. The study reviews various AI applications, highlighting the benefits AI offers to project managers in areas such as project monitoring and control. However, it notes that many AI models have limitations, suggesting that project managers should still rely on their expertise alongside AI tools. The study forecasts a future where AI will manage resources and decision-making, while project managers will take on data scientist roles to interpret AI-driven insights. The current study diverges from Ruiz's research in its specific focus on identifying factors that impact project management through AI in industrial engineering projects, using a different proposed model, geographic focus, and applied methodology.
3. Effects of Artificial Intelligence on Decision Making in Project Management	literature review	Primary Data (formal interview) Secondary Data	2021	Mounir El Khatib Ahmed Al Falasi	The objective of this paper is to examine the effect of AI on decision-making in project management. More specifically, the paper looks into the quality, integrity, and volume of the data collected by AI systems which is then displayed for the project manager to carry out project decisions.	the drawn conclusion was that AI application enhances data quality and integrity leading to enhanced speed and effectiveness of decision making in both single and multiple project environments.	El Khatib and Al Falasi examined (El Khatib & Al Falasi, 2021) "Effects of Artificial Intelligence on Decision Making in Project Management" with the objective of understanding how AI impacts decision-making processes in project management, focusing specifically on data quality, integrity, and volume. Their study analyzed both primary and secondary data, concluding that AI enhances data quality and integrity, which in turn enhances the speed and accuracy of decision-making in single and multi-project environments. The current study differs from El Khatib and Al Falasi's research in its aim to investigate the integration of AI in project management within Saudi Arabia's industrial engineering sector. While El Khatib and Al Falasi focused on AI's impact on decision-making, the current study assesses factors affecting AI adoption and its effects on project outputs, providing a different perspective on AI's role in enhancing project management practices.
4. Artificial Intelligence in Project Management;	literature	Websites for search	2022	1. Sofia Bento 2. Renato	The purpose of this paper was to acknowledge the potentialities and	Looking to what as emerge from this research, organisations can find	Bento conducted a study (Bento et al., 2022) titled "Artificial Intelligence in Project Management:

Systematic Literature Review	review			Lope Da Costa 3. Rui Alexandre Henriques Goncalves 4. Alvaro Lopes Dias 5. Leandro Ferreira Pereira	limitations of artificial intelligence in the specific area of project management by doing a systematic literature review ..	practical implications of this work by having paths to where they can find relevant work to explore, that will provide them relevant insights on how to use artificial intelligence in project management. With this work we believe that organisations will have important guidelines about advantages, challenges, business areas and techniques, to help their research of how to apply AI in project management.	Systematic Literature Review," with the goal of identifying the potential benefits and limitations of AI in project management through a systematic literature review. The study provides organizations with practical insights on leveraging AI, highlighting guidelines on advantages, challenges, tools, and technologies to aid AI implementation in project management. Findings suggest that AI is effective in optimizing rule-based tasks like scheduling and risk assessment but remains less suitable for areas requiring empathy, such as human resource management. The current study differs from Bento's in its focus on integrating AI within project management practices specific to engineering firms in Saudi Arabia, with unique objectives, spatial boundaries, and methodological approach.
5. An Authoritative Study on the Near Future Effect of Artificial	1. The research was exploratory, since it investigates a topic on which little data is available and where there is still a lack of scientific research and theoretical literature. The study was also prospective, as it focused on the possible effect that AI could have on project management in the foreseeable future [Schmelzer, R. AI in		2021	Fridgeirsson, T.V.; Ingason, H.T.; Jonasson, H.I.; Jonsdottir, H.	The purpose of this study is to explore how Artificial Intelligence (AI) might augment the project management profession in each of the 10 categories of project management knowledge areas, as defined in the Project Management Body of Knowledge (PMBOK) of the Project Management Institute (PMI)	The average scoring result shows that the participants believe that AI will likely have the highest effect on project cost management, 58% thought AI would have a very high or high effect on project cost management. 51% of respondents thought AI would have a very high or high effect on project schedule management, and 47% on project risk management in the next 10 years. The respondents believe that AI would have a medium to high effect on project quality management or 61%, and 60% on project procurement management. According to the results, AI would likely have the least effect on project stakeholder management in the next 10 years. For the other areas of knowledge, project integration management, project scope management, project resource management, project communication management, the result was very similar.	Fridgeirsson conducted a study (Fridgeirsson et al., 2021) titled "An Authoritative Study on the Near Future Effect of Artificial Intelligence on Project Management Knowledge Areas," with the objective of examining how AI might impact the 10 knowledge areas in project management as outlined by the Project Management Body of Knowledge (PMBOK). The study used a quantitative, cross-sectional method to assess expert insights, finding that AI is expected to have the most significant effects on cost management, schedule management, and risk management, while having minimal impact on stakeholder management and processes requiring human leadership. The current study differs from Fridgeirsson's research in its focus on exploring the integration of AI within Saudi Arabia's industrial engineering sector, with unique objectives, a different model, and spatial boundaries specific to the region's engineering challenges.

	Project Management. 2019. Available online: https://www.forbes.com/sites/cognitiveworld/2019/07/30/ai-in-project-management/#56aa04f5b4a0 (accessed on 23 April 2020).]. 2. The method used for the study was a quantitative cross-sectional study. The quantitative method follows standardized forms that seek to quantify the results of the research and are represented analytically. A cross-sectional study is a research design where data is collected at one point in time, so as to get an overview of the study c						
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	[Schmelzer, R. AI in Project Management. 2019. Available online: https://www.forbes.com/sites/cognitiveworld/2019/07/30/ai-in-project-management/#56aa04f5b4a0 (accessed on 23 April 2020).].					
6. Data Science and Artificial Intelligence in project Management, The past, Present and Future			2022	Stephen Ong; Shahadat Uddin	This article discusses and uncovers the current state of Data Science and Artificial Intelligence in relation to the Project Management sector. Drawing from this context, the possible future applications and uses are then delineated.	Throughout various applications, it is evident that Artificial Intelligence in project management aims to simplify and generate efficiency in project processes. Generally beneficial, its applications and processes can range in sophistication and include those of risk management, estimation, resource management, KPIs, prediction and experimentation. Various data scientist roles will inevitably be introduced especially during the process of technology development. These higher-level roles will eventually replace more traditional roles as they become fulfilled by technology. Ong and Uddin conducted a study (Ong & Uddin, 2020) titled "Data Science and Artificial Intelligence in Project Management: The Past, Present, and Future," aiming to explore AI's applications in project management, from risk management to resource optimization and KPI tracking. Their study highlights the transformative role of AI in automating complex project tasks and discusses how future developments may lead to new roles in data science while traditional roles are increasingly replaced by AI-driven solutions. The current study differs from Ong and Uddin's research in its focus on assessing the factors that affect AI adoption in Saudi Arabia's industrial engineering projects. While Ong and Uddin provide an overview of AI applications and their implications, the current study targets AI's integration and its impact on project management outputs within a specific industry and geographic context.
7. Role of Artificial Intelligence in Construction Project Management			2023	Pavankumar Kork, Gobinath R, Manisha Shewale, Bhagyashree Khartode	This research presents a discussion of the numerous methodologies that have been researched by the researchers along with a review of the artificial intelligence that is used in the construction industry, specifically Construction Project Management. Additionally, this research offers a review of the artificial	most important findings, as uncovered by this exhaustive investigation, are as follows: i. Most academics will be focusing their efforts on the construction phase, which is the stage in which fewer digital tools and methods will be discovered. Kork conducted a study (Kork et al., 2023) titled "Role of Artificial Intelligence in Construction Project Management," aiming to investigate AI's impact on improving construction project outputs through optimization, risk management, and automation. The study examines AI applications such as process mining, computer vision, and AI-driven robotics to enhance efficiency and mitigate risks on construction sites. It

					intelligence that is utilized in the construction business.	ii. The use of BIM and ML approaches occurs most frequently in CPM since research in this area focuses heavily on data analytics and visualization. iii. Even though approximately half of the research is devoted to two distinct areas, construction performance management and construction supply chain management and resource optimization, less than half of the entire volume of research that has been published is focused on these two issues.	highlights AI's potential to automate repetitive tasks, perform real-time project monitoring, and apply predictive insights for early-stage problem-solving, ultimately reducing time, cost, and safety risks in construction management. The current study differs from Kork's in its focus on AI integration within Saudi Arabia's industrial engineering sector, specifically in understanding factors affecting AI adoption. While Kork et al. emphasize AI's transformative potential for construction management, the current study explores AI's impact on broader project management practices in engineering, identifying unique challenges and opportunities within a specific regional context.
8. An investigation into the Impact of Artificial Intelligence on the Future of Project Management			2021	Asma Alshaikhi, Mashael Khayyat	The purpose of the study is to investigate the impact of Artificial Intelligence on the future of project management. This study provides detailed conceptual information about Artificial Intelligence and different perspectives.	As to the initial research question about the possibility of reducing the need for a human resource with AI, based on the investigation in this research, the expectation of performance AI in automating project management tasks and activities will be hard to meet the requirements of ambitious terms such as: Automated project manager. The results show that technology and AI cannot replace the human mind. Machine and other AI robots can automate tools and tasks, but at the end of the day, machines need human help to operate and monitor.	Khayyat and Alshaikhi conducted a study (Khayyat & Alshaikhi, 2021) titled "An Investigation into the Impact of Artificial Intelligence on the Future of Project Management," aiming to assess AI's potential in automating project management tasks and the implications for human roles. The study finds that while AI can automate certain project tasks, it cannot replace human expertise entirely. Human involvement remains essential for operating, guiding, and monitoring AI tools due to limitations in data quality, technical integration, and the complexity of project management decision-making. The current study diverges from Khayyat and Alshaikhi's research by focusing on the factors affecting AI adoption specifically within Saudi Arabia's industrial engineering projects. While Khayyat and Alshaikhi emphasize AI's impact on reducing human resource dependency, the current study explores AI's integration and its broader impact on project outputs and operational efficiency within the industrial sector.
9. The Last State of Artificial Intelligence in Project Management			2021	Mohammad Reza Davahli	This paper reports on a systematic review of the published studies used to investigate the application of AI in PM. This systematic review identified relevant papers using Web of Science, Science Direct, and Google Scholar databases.	The results indicated that the application of AI in PM was in its early stages and AI models have not applied for multiple PM processes especially in processes groups of project stakeholder management, project procurements management, and project communication	Davahli conducted a study (Davahli, 2020) titled "The Last State of Artificial Intelligence in Project Management," with the objective of assessing the current state of AI applications within various project management processes. The study found that AI's application in project management remains in early stages, with limited implementation in stakeholder management, procurement, and communication

						management. However, the most popular PM processes among included papers were project effort prediction and cost estimation, and the most popular AI techniques were support vector machine, neural networks, and genetic algorithms.	processes. However, AI techniques such as support vector machines, neural networks, and genetic algorithms are increasingly used for project effort prediction and cost estimation. The current study differs from Davahli's research by focusing on the integration of AI within Saudi Arabia's industrial engineering projects, specifically examining the factors affecting adoption and its impact on project management outputs. While Davahli's work provides an overview of AI's adoption across various project management areas, the current study aims to apply these insights within a targeted regional and industrial context.
10. The current state of and Trends of AI in Project Management			2021		SAO PAULO	The purpose of this thesis is to present a bibliometric analysis to identify the intellectual structure, the research trends, and the conceptual building blocks of the research discipline AI in Project Management. The study presents an extensive literature review on AI technical building blocks, challenges, and industry adoption. Based on 467 documents retrieved from Web of Science and Scopus, the bibliometric analyses methods of Co-Citation, Bibliographic-coupling and Co-Word are applied.	The intellectual structure of AI in Project Management is identified, from which the knowledge fields of Software Effort Estimation, Project Risk Modeling, and Construction Cost Estimation emerge. Furthermore, the bibliographic-coupling analysis identifies four emerging trends in the discipline, namely (i) increased automation, explainability, and data robustness in cost estimation models, (ii) intelligent Project Control systems based on Earned Value Management, (iii) risk mitigation scenario modeling, and (iv) optimization of input factors for effort estimation models. Paulo conducted a study (Paulo, 2021) titled "The Current State and Trends of Artificial Intelligence in Project Management," with the objective of analyzing AI adoption trends, challenges, and technical building blocks within project management. The study utilized bibliometric analysis of 467 documents, identifying data integration, economic costs, and organizational challenges as significant barriers. Paulo also highlighted emerging AI trends like explainable AI for greater transparency, ethical considerations, and industry adoption patterns across various sectors. The current study differs from Paulo's work by focusing specifically on the factors affecting AI integration within industrial engineering projects in Saudi Arabia. While Paulo's study offers a broad bibliometric analysis of AI applications in project management, the current study aims to contextualize these insights within a specific industry and region, addressing unique local adoption challenges and their impact on project outputs.
11. How AI can leverage PMIS and data driven decision making in Project Management	This research paper aims to identify the core benefits of AI in Project Management aspects and find how using AI can help improve		2023	Alia Mahmood ¹ , Aysha Al Marzooqi ¹ , Mounir El khatib ² , Hessa AlAmeemi ¹		This article focuses on the opportunities of utilizing Artificial intelligence in project management in general. Special emphasis to project management data driven decision making and the relevant tools represented in processes, tools and techniques of PMIS. The results showed that with the creation of big data, AI can now be more than just technology and is capable of performing more complex tasks using advanced techniques and algorithms. AI helps more effectively through integrating project management phases and the entire project lifecycle process. Bringing AI to the project management domain across the	Mahmood et al. conducted a study (Mahmood et al., 2023) titled "How Artificial Intelligence can Leverage Project Management Information System (PMIS) and Data-Driven Decision Making in Project Management" with the objective of exploring AI's potential to enhance PMIS functions and support data-driven decisions within project management. The study utilized a qualitative approach, including case studies and interviews with Smart Dubai, to examine AI's role in integrating big data, improving project phase management, and enhancing decision-making processes. Results

the way project management is handled. The data used to support this research is collected from primary and secondary sources to emphasize the research paper results. The approach used in data collection was a qualitative method where an interview was conducted with an employee in Smart Dubai to discuss AI implementation, benefits and challenges involved. As a result, this choice was made to give a better understanding of the effectiveness of implementing AI in project management in real life and to find ways to better make use of it. In addition to the					world can provide a sustainable world for future generations. It also assists in faster and smarter decisions. It is recommended to monitor AI until users are satisfied and can trust the systems output. AI will have a tremendous growth as projects in smart cities are growing bigger, complex and demanding. The demonstrated case studies show that there is a need for AI in the implementation of new business management. The case studies indicated that much more is yet to come by the beginning of 2021 following the UAE Vision 2021. Previously or maybe even now, most people are thinking that artificial intelligence is about robotic system and they are programmed to do certain activities. However, with the creation of big data, AI can now be more than just technology and is capable of performing more complex tasks using advanced techniques and algorithms. AI helps more effectively through integrating project management phases and the entire project lifecycle process.	highlighted AI's ability to enable faster, more accurate decisions by automating data analysis, facilitating real-time adjustments, and supporting project managers in critical planning and execution phases, especially as projects in smart cities grow in complexity. The current study differs from Mahmood et al.'s by focusing on AI adoption within Saudi engineering projects, investigating broader adoption dynamics such as cultural readiness, infrastructure maturity, and organizational strategy. While Mahmood et al. concentrated on how AI strengthens PMIS functionality and data handling, the current study examines how these systems can be adapted to Saudi project management settings, considering regional and sector-specific challenges that affect AI implementation beyond technical integration alone.
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	interview, Google Scholar and HBMSU Library databases were both used to find					
12. The Use of Artificial Intelligence in International Decision-Making Processes in Project Management	This study used purposeful sampling to identify and select cases that contain essential information about the phenomenon under investigation. Non-random sampling is preferred in case-study research because no sample can represent a larger population (Halkias & Neubert, 2020; Tubman & Neubert, 2021). Ten companies that use AI in project management were selected: Alibaba, Alphabet, Amazon,	2022	Alliyah Tubman	This qualitative multiple-case study aims to explore the perceptions of subject matter experts (SME) about the use of artificial intelligence in international decision-making processes. This research study looks at the effect of artificial intelligence (AI) on project managerial decision-making. The article looks at the value, consistency, and capacity of data composed by Artificial Intelligence technologies, then provided to the project administrator to help them make project results.	Artificial intelligence is becoming increasingly essential for information management and decision-making. AI has played an important role in industries, particularly in project management, monitoring, and gathering data. One of the most important benefits of adopting AI is the excellent accuracy of data management. Artificial intelligence has a favorable affect on making good decisions. For example, AI has been shown to manage a greater volume of data than any other source previously employed by enterprises. The United States will have the most significant GDP contribution from AI among Middle Eastern countries, amounting to around 14 percent by 2030. Some organizations tend to disregard the usage of AI because they believe it is too tricky (Kouloukoui et al., 2018). Lack of leadership and interpersonal skills is why firms have unsuccessful use or integrate AI to make decisions or manage data. Several organizations surmounted this hurdle and transformed their organizational growth paradigm.	Tubman conducted a study (Tubman, 2022) titled "The Use of Artificial Intelligence in International Decision-Making Processes in Project Management," aiming to explore how AI enhances decision-making and collaboration across global project management. Using case studies of ten major companies, the research identified that AI enhances data quality, enables more accurate decision-making, and fosters efficient cross-team collaboration by enhancing data accessibility and transparency. Despite AI's potential, challenges such as data quality issues, the need for skilled human oversight, and organizational resistance remain significant. The current study diverges from Tubman's work by focusing specifically on the adoption of AI within the Saudi industrial engineering sector, examining the unique factors that affect AI implementation in project management. Tubman's study broadly addresses the role of AI in global collaboration and decision-making, whereas the current study narrows its scope to regional challenges, such as skills shortages and infrastructure limitations, within Saudi project management.

	Apple, Baidu, Facebook, IBM, JD.com, Microsoft, and Tencent. We chose these businesses because artificial intelligence plays a vital role in project management. Table 1 describes the samples that we selected.					
13. Project Management in the Era of Artificial Intelligence	literature review	interpreting vast amount of data from various sources.	2023	Sivasubramaniyan Sahadevan	The objective of this study is to help project managers understand how incorporating Artificial Intelligence (AI) can both benefit and challenge project management.	In conclusion, artificial intelligence is rapidly changing the field of project management, posing both new opportunities and difficulties for businesses. By incorporating AI technologies into project management workflows, proactive risk detection, quicker defect analysis, and resolution, better scope creep and expectation management, predicting and experimenting, and team empowerment are all made possible. Resources may be allocated more efficiently, and communication, cooperation, and decision-making are all improved by AI solutions. However, enterprises must overcome several obstacles before implementing AI in project management, including poor data quality and accessibility, reluctance to change, ethical and social concerns, and talent scarcity. Sahadevan reached to (Sahadevan. 2023) titled "Project Management in the Era of Artificial Intelligence," the research aimed to help project managers understand how integrating artificial intelligence (AI) can benefit project management while acknowledging some challenges. The study concluded that AI can significantly enhance project management processes. AI-based solutions can support project managers in making better decisions, fostering teamwork, reducing project risks, and improving project efficiency and quality. The current study differs from Sahadevan's study in its objectives, proposed model, spatial boundaries, and methodology.

						To attain their goals and add value to project management processes, companies must design a comprehensive AI approach that encourages a culture of constant learning and innovation. The collaboration between project managers, data scientists, IT professionals, and business leaders is essential to integrate AI into project management. Project management professionals need to keep alongside the latest developments and innovations to take full advantage of the capabilities of AI in project management. Overall, the use of AI in project management delivers countless opportunities for companies to enhance project delivery, improve performance, and drive business success. Study reveals that AI can significantly enhance PM processes. AI based solutions can support project managers (PMs) to make better decisions, enhance teamwork, lessen project risk, and improve efficiency and quality projects (Collins et al., 2021; Bhbosale et al., 2020; Munir, 2019; Kunnathur, 2020; Elrajoubi, 2020).	
14. Comparison of Artificial Intelligence Techniques for Project Conceptual Cost Prediction			2020	Haytham Elmousalami	The article focuses on investigating 20 AI techniques which are conducted for conceptual cost modeling, such as fuzzy logic model, artificial neural networks, multiple regression analysis, case-based reasoning, hybrid models, such as genetic fuzzy model, and ensemble methods such as scalable boosting trees (XGBoost) and random forest.	This article presented a comparison of AI techniques to develop a reliable conceptual cost prediction model. A total of 20 ML models were developed utilizing tree-based models ensemble methods, fuzzy systems, CBR, ANNs, SVM, and transformed regression models. The accuracy of the developed models was tested from two perspectives: MAPE and adjusted	Elmousalami conducted a study (Elmousalami, 2020) titled "Comparison of Artificial Intelligence Techniques for Project Conceptual Cost Prediction," with the objective of evaluating 20 AI techniques for their effectiveness in predicting conceptual project costs. The study found that XGBoost, an ensemble method, was the most accurate for cost predictions, achieving a mean absolute percentage error (MAPE) of 9.091% and an adjusted R^2 of 0.929. The research highlighted ensemble methods' capability to improve prediction accuracy and handle data inconsistencies, despite limitations in interpretability.

					Out of 20 AI techniques, the results show that the most accurate and suitable method is XGBoost with 9.091% and 0.929 based on mean absolute percentage error and adjusted R2, respectively.	R2. The results showed that the most accurate and suitable method was XGBoost with 9.091% and 0.929% for MAPE and adjusted R2, respectively. The study emphasized the importance of ensemble methods for improving the prediction accuracy, and handling noisy and missing data. However, the key limitation of the ensemble method was an inability to interpret the producing results.	The current study differs from Elmousalami's study by focusing on AI's broader impacts on project management in Saudi engineering projects, aiming to understand factors that affect AI adoption beyond cost prediction. Elmousalami's research emphasizes comparative performance among AI models, while the current study expands to analyze AI's potential in various project management functions, including scheduling, risk management, and decision-making.
AI IN PROJECT MANAGEMENT: EXPLORING THEORETICAL MODELS FOR DECISION-MAKING AND RISK MANAGEMENT	EXPLORING	This paper delves into two powerful AI tools - Machine Learning and Deep Learning - and explores how they can be harnessed to enhance decision-making and planning within complex projects	2024	Opeyemi Abayomi Odejide & Tolulope Esther Edunjobi	The paper discusses the future potential of AI in shaping personalized marketing experiences. However, responsible implementation will be paramount in ensuring a positive future for both brands and consumers. Enhanced version of the abstract incorporating additional insights, this paper delves into the transformative power of Artificial Intelligence (AI) in personalized marketing. It explores how AI algorithms can analyze a multitude of customer data points, including purchase history, website behavior, and social media interactions.	the paper acknowledges the ethical considerations that accompany AI implementation. By identifying potential bottlenecks and proactively mitigating risks, AI helps avoid unnecessary delays and resource waste. Advanced Risk Prediction, AI models are constantly evolving, incorporating new data sources and becoming more sophisticated. By identifying potential threats early in the project lifecycle, project managers can implement proactive mitigation strategies minimizing their impact on the project timeline and budget. AI can facilitate communication and collaboration within project teams and with external stakeholders. By generating real-time reports and facilitating data sharing, AI can promote transparency and streamline project execution. This will make AI capabilities readily accessible to project managers and further simplify the adoption of AI practices.	Opeyemi Abayomi Odejide & Tolulope Esther Edunjobi, (2024), "AI in Project Management: Exploring Theoretical Models for Decision-Making and Risk Management." The study explores the transformative role of Artificial Intelligence (AI), particularly Machine Learning (ML) and Deep Learning (DL), in enhancing decision-making, risk management, and planning within complex projects. The paper emphasizes AI's ability to identify potential risks early in the project lifecycle, enabling project managers to implement mitigation strategies proactively, thus minimizing delays and budget overruns. The study also highlights AI's role in promoting communication and collaboration by generating real-time reports, facilitating data sharing, and enhancing transparency across project teams and stakeholders. It acknowledges the ethical considerations of AI adoption and underscores the importance of responsible implementation for positive outputs. By making AI capabilities more accessible, the study envisions a streamlined and efficient future for project management, emphasizing adaptability and continual improvement in AI models. The current study differs from Opeyemi Abayomi Odejide & Tolulope Esther Edunjobi's study in its focus on identifying the factors affecting project management through AI in industrial engineering projects, proposing a unique model and methodology within specific spatial boundaries.

16. A Study on the Impact of Artificial Intelligence on Project Management			2020	Adel BELHARET, Urmila BHARATHA N, Benjamin DZINGINA, Neha MADHAVAN, Charul MATHUR2, Yves-Daniel B. TOTI,	Artificial intelligence and machine learning have found a wide range of business applications, but their impact is only just starting to be seen in project management. In this report, we share our findings to aid in understanding the impacts of Artificial Intelligence on projects and how they will reshape project management in the future based on suitable AI inputs.	We show Healthcare, Transportation and Finance as three key industries more amenable to implementing A. A key finding of the report where one of the conclusions we draw is that the areas least susceptible to change enforced by AI are going to be the ones which require personal relationships and human interaction. we share our position that the “humanness” aspect to project management is one thing that AI cannot seem to achieve. However, AI and the project manager will inevitably be interdependent; so, the project manager who wishes to remain relevant must take necessary steps to develop the right skill sets to be able to manage and complement AI capabilities. Given that smart machines increasingly assume and absorb aspects of PMO work, existing PMOs will tend to amalgamate into one function concerned with change, strategy, product evolution and organizational governance by 2030.	Belharet et al. conducted a study (Belharet et al., 2020) titled "Report on the Impact of Artificial Intelligence on Project Management," with the objective of exploring AI's potential to enhance project management through improvements in resource allocation, risk management, and automation of routine tasks. The study identified that AI can significantly optimize project efficiency by automating data processing and predictive analytics, which allows project managers to focus more on strategic decision-making. However, Belharet et al. noted that AI cannot fully replace human intuition, especially in creative and team-oriented tasks, and that data quality and integration challenges remain substantial barriers. The current study differs from Belharet et al.'s by specifically examining the adoption of AI in project management within Saudi engineering projects, focusing on factors that affect AI implementation in this regional and industry-specific context. While Belharet et al.'s study emphasizes AI's functional contributions to project management efficiency, the current study seeks to understand broader adoption dynamics, including organizational readiness and cultural acceptance of AI, extending beyond operational benefits to include strategic and contextual considerations in Saudi Arabia's engineering sector.
17. Investigating AI Applications in Construction Industry: A Systematic Review			2023	Tayibe Seyman Güray	This study aims to examine the contributions of AI to handling construction industries challenges by performing both bibliometric and scientometric analysis using the PRISMA protocol. In this regard, this study presents the current state of adapting AI in the construction industry and its future directions	The findings of the research pointing out that there has been a dramatic increase in number of publications in the research area. China and USA are the leading countries having highest number of publications respectively. The findings showed that there is a strong linkage between BIM, digital twin, ML and DL as the most cited article is on semantic construction digital twin by Boje et.al (2020). Following next two highest cited articles are about	Tayibe Seyman-Güray reached to (Seyman-Güray, 2023) titled "Investigating AI Applications in Construction Industry: A Systematic Review," the goal was to explore the potential of AI tools in addressing labor, resource allocation, and planning issues in the construction industry. The study highlights AI's transformative impact on construction by improving data accuracy, enhancing project workflows, and optimizing labor allocation strategies. It also identifies challenges such as resistance to technology adoption, high implementation costs, and skill deficits. The study emphasizes the need for improved training programs and compatibility with older systems. The current study differs from Seyman-Güray's in its focus on industry-specific challenges, objectives, spatial scope, and methodology.

						safety issues that indicates an area of research interest in the domain. On the other hand, review papers are quite popular in the research area. Construction industry traditional problems known to all such as delays, cost overruns, quality issues, uncertainty, high risk and safety have become hard to solve in the world of Industry 4.0 and upcoming Industry 5.0 as bringing smarter, higher technology, taller and bigger construction and buildings with sustainability point of view. Therefore, AI as a disruptive technology for many sectors, contain potentials for the construction industry to provide solutions to its unique problems.	
18. Artificial Intelligence Adoption in Project Management			2020	Constanta-Nicoleta BODEA, Cosmin MITEA, Oana STANCIU	The paper aims to identify the characteristics of Artificial Intelligence adoption in project management, based on the theoretical frameworks related to the technology adoption. The authors also present findings of a global survey conducted by IPMA and PwC Romania during March-August 2020.	Looking ahead, the survey results suggest that digitization and certain foundational practices are critical to creating value from AI and enabling progress. The implications related to adoption of AI are significant, but for many companies, they involve transformation-level changes to the very business processes at the core of the company and new ways in which people, with different capabilities, will work	Bodea et al. conducted a study (Bodea et al., 2020) titled "Artificial Intelligence Adoption in Project Management" with the objective of identifying primary motivations for adopting AI within project management. Their survey of project management professionals found that over half of respondents highlighted increased productivity (53%), enhanced decision-making capabilities (52%), and improved project performance and reporting (51%) as the top drivers for AI adoption. Respondents emphasized the strategic advantage of AI, noting that automation can free up time for managers to concentrate on higher-level strategic tasks. The current study expands upon Bodea et al.'s work by examining AI adoption specifically within Saudi engineering projects, addressing both the motivating factors and unique regional challenges affecting AI integration. While Bodea et al. focused on general productivity and decision-support advantages of AI, the current study investigates broader adoption barriers and facilitators in the Saudi context, including regulatory,

							economic, and cultural factors that affect how AI adoption impacts project management strategies in engineering-focused environments.
19. A FRAMEWORK FOR LEVERAGING ARTIFICIAL INTELLIGENCE IN Project Management	Literature review, case study	Machine learning, Natural Language Processing (NLP), chatbots	2021	Rea Todorovic	To integrate AI for efficiency in project management by reducing time for administrative tasks and enhancing predictive capabilities for resource optimization.	Enabled predictive analysis, increased efficiency in resource allocation, and improved timelines for project managers.	Todorovic conducted a study (Todorovic, 2021) titled "A Framework for Leveraging Artificial Intelligence in Project Management," aiming to explore how AI can enhance project management efficiency by reducing administrative workload and improving resource optimization through predictive analytics. The study utilized both a literature review and case study to examine the impact of AI applications, such as machine learning and NLP-powered chatbots, in streamlining project management processes. Key findings indicate that AI integration can improve project timelines and resource allocation but is limited by existing skill gaps and inadequate technological support. The current study diverges from Todorovic's work by focusing specifically on the factors affecting AI adoption within Saudi engineering projects. While Todorovic addresses general efficiency improvements and predictive capabilities of AI, the current study evaluates additional regional barriers and enablers, such as regulatory and economic factors, to create a more comprehensive framework for successful AI implementation in Saudi Arabia's construction and engineering sectors.
20. Artificial Intelligence in Project Management; Bibliometric Analysis	Bibliometric Analysis	VOSviewer, Web of Science database	2022	Vusumuzi Maphosa, Mfowabo Maphosa	To analyze the application of AI in PM, realizing the importance of artificial intelligence in transforming most fields, such as PM. This study provides a baseline for researchers and scientists to plan and research the integration of these two fields	The study demonstrates the state of AI application in PM, highlighting publication trends, geographic distribution, and research themes, such as decision-making, scheduling, and risk management."	Maphosa & Maphosa, (2022) conducted a bibliometric analysis titled 'Artificial Intelligence in Project Management Research: A Bibliometric Analysis,' to explore AI applications in PM, focusing on trends, research hotspots, and challenges. The study identified gaps in AI's adoption in PM, such as limited integration in developing regions and the lack of proactive AI tools for 'what-if' analysis. Unlike other studies, this work provided a systematic mapping of global trends in AI-PM research." The current study diverges from Maphosa and Maphosa work by focusing specifically on the factors affecting AI adoption within Saudi engineering projects. While Todorovic focusing on trends, research hotspots, and challenges. The study identified gaps in AI's adoption in PM, such as limited integration in developing regions

							and the lack of proactive AI tools for 'what-if' analysis. Unlike other studies, this work provided a systematic mapping of global trends in AI-PM research
21. Intelligent Purchasing: How artificial intelligence can redefine the purchasing function			2021	Oihab Allal-Chérif, Virginia Simón-Moya, Antonio Carlos Cuenca Ballester	This article analyzes to what extent AI can improve the performance of the purchasing department. First, a review is undertaken of how AI is used in purchasing. Thereafter, the research follows an exploratory, inductive, and qualitative approach based on a multiple case studies	this study provides a better understanding of how AI can improve the purchasing function, achieve higher performance, and handle new missions	Allal-Chérif et al. (2020) conducted a study titled "Intelligent Purchasing: How Artificial Intelligence Can Redefine the Purchasing Function" to analyze AI's affect on purchasing, including its role in decision-making, supplier management, and collaboration. The study identifies gaps, such as limited data exploitation and resistance to change, while highlighting AI's transformative potential for strategic innovation. Unlike other research focusing broadly on AI's impact, this study narrows down its scope to purchasing functions, providing practical insights into AI's role in redefining organizational interfaces. The current study diverges from Allal-Chérif et al. (2020) work by focusing specifically on the factors affecting AI adoption within Saudi engineering projects.
22. An Authoritative Study on the Near Future Effect of AI on Project Management Knowledge Areas			2021	Thordur Vikingur Fridgeirsson, Helgi Thor Ingason, Haukur Ingi Jonasson and Hildur Jonsdottir	The purpose of this study is to explore how Artificial Intelligence (AI) might augment the project management profession in each of the 10 categories of project management knowledge areas, as defined in the Project Management Body of Knowledge (PMBOK) of the Project Management Institute (PMI).	Results clearly illustrated that AI will be an integrated part of future project management practice and will affect project management knowledge areas in the near future. According to these findings, the management of cost, schedule, and risk, in particular, will be highly affected by AI. The research indicates that AI is very useful for processes where historical data is available and can be used for estimation and planning. In addition, it is clear that AI can monitor schedules, adjust forecasts, and maintain baselines	Fridgeirsson et al. (2021) conducted a study titled "An Authoritative Study on the Near Future Effect of Artificial Intelligence on Project Management Knowledge Areas" to examine how AI might enhance project management across the ten knowledge areas defined by the PMBOK framework of the Project Management Institute (PMI). The study found that AI is set to become an integral part of project management, particularly affecting cost management, scheduling, and risk management. The research highlights that AI is especially effective for processes utilizing historical data for estimation and planning. Additionally, AI demonstrates potential in monitoring schedules, adjusting forecasts, and maintaining project baselines, emphasizing its transformative role in future project management practices. The current study diverges from Fridgeirsson et al. (2021) by focusing specifically on the factors affecting AI adoption for design and consultancy engineering projects in Saudi Arabia.
23. Prediction of Risk Delay in Construction Projects Using a Hybrid Artificial Intelligence			2020	Zaher Mundher Yaseen, Zainab Hasan	The aim of this current study is to develop a hybrid artificial intelligence model called integrative Random Forest classifier	The achieved results of the developed hybrid RF-GA model revealed a good resultant performance in terms of accuracy,	Yaseen et al. (2020) conducted a study titled "Prediction of Risk Delay in Construction Projects Using a Hybrid Artificial Intelligence Model" to address delay prediction in construction projects through the development of a

Model				Ali , Sinan Q. Salih,* and Nadhir Al-Ansari	with Genetic Algorithm optimization (RF-GA) for delay problem prediction.	kappa and classification error. Based on the measured accuracy, kappa and classification error, RF-GA attained 91.67%, 87% and 8.33%, respectively. Overall, the proposed methodology indicated a robust and reliable technique for project delay prediction that is contributing to the construction project management monitoring and sustainability	hybrid AI model, the Random Forest classifier integrated with Genetic Algorithm optimization (RF-GA). The study demonstrated the model's strong performance, achieving 91.67% accuracy, 87% kappa, and an 8.33% classification error. The findings underscore the robustness and reliability of the RF-GA model as a predictive tool, contributing to enhanced monitoring, risk management, and sustainability in construction project management. The current study diverges from Yaseen et al. (2020) by focusing specifically on the factors affecting AI adoption for design and consultancy engineering projects in Saudi Arabia.
24. Artificial Intelligence-Based Knowledge Management Processes in Construction Projects: An Applied Study in Saudi Arabia.	Descriptive Analytical and Deductive Approach	Questionnaire	2022	Salwa Al-Ghamdi & Fahd Abdullah Al-Darman.	The study aimed to explore and analyze the application of knowledge management processes in construction projects through AI software from the perspective of contractors in Saudi Arabia.	The application of knowledge management processes, represented by knowledge sharing and knowledge application through artificial intelligence software, has a statistically significant impact on construction investments. There is a correlation between knowledge management processes using artificial intelligence software and construction projects..	Al-Ghamdi, Salwa & Darman, Falah, (2022), "AI-Based Knowledge Management Processes in Construction Projects: An Applied Study in the Kingdom of Saudi Arabia." The study investigates the role of Artificial Intelligence (AI) in knowledge management processes within construction projects in Saudi Arabia. Using a descriptive analytical and deductive approach, the research focuses on how AI software facilitates knowledge sharing and application among contractors. It concludes that the integration of AI in knowledge management significantly impacts construction investments, fostering efficiency and effectiveness in project outcomes. Furthermore, the study identifies a strong correlation between AI-driven knowledge management processes and the success of construction projects. The current study differs from Al-Ghamdi & Darman's work by emphasizing the broader implications of AI on project management across various industries, particularly industrial engineering, and proposing a unique framework to explore adoption factors and challenges beyond knowledge management.
25. Using an Artificial Neural Network for Improving the Prediction of Project	In this paper, we present a dynamic project	Machine learning	2022	Itai Lishner and Avraham Shtub	This paper presents a new dynamic ML tool for improving the prediction accuracy of project duration. The tool is based on an artificial neural network	The results show that the proposed tool significantly improved the prediction accuracy for both organizations despite the major	Lishner, I. & Shtub, A., (2022), "Using an Artificial Neural Network for Improving the Prediction of Project Duration."

Duration	duration prediction (DPDP) method				(ANN) which is automatically adapted and optimized to different types of prediction methods and different datasets.	differences in the size, type, and structure of their datasets. A dedicated model designed for a specific project or type of dataset can potentially produce better results than the presented tool but will require an additional effort and redesign to fit other types of data, which is not always practical for an organization.	This study introduces a Dynamic Project Duration Prediction (DPDP) method, leveraging Artificial Neural Networks (ANNs) to enhance the accuracy of project duration forecasts. The method is adaptable to various prediction approaches and datasets, making it a versatile tool for diverse organizational needs. The research demonstrates that the proposed ANN-based tool significantly improves prediction accuracy across different dataset types, sizes, and structures. While a customized model tailored to a specific project may yield better results, such approaches often require extensive effort and redesign, limiting their practicality for widespread use. The current study differs from Lishner & Shtub's work by expanding the application of AI beyond project duration prediction, focusing on particularly industrial engineering, and proposing a unique framework to explore adoption factors and challenges beyond knowledge management.
26. The Reality of Artificial Intelligence in Project Management in the Government Sector in the Kingdom of Saudi Arabia	Descriptive Analytical and Deductive Approach	Questionnaire	2023	Khaled Abdullah Al-Shehri, Kholoud Ali Basuwaid, Mohammed Abdullah Gharawi, Dr. Waleed Suleiman	The study aimed to understand the current state of artificial intelligence usage in managing government projects in Saudi Arabia. It also proposed recommendations to improve project management efficiency and effectiveness, enhance decision-making abilities, support strategic planning, and anticipate challenges and obstacles.	The study concluded that AI can play a significant role in project management within the government sector in Saudi Arabia. It contributes substantially to the development and improvement of projects, fosters continuous improvement, and ensures the provision of technological capabilities needed by relevant entities to achieve this. Additionally, the study emphasized the need for specialized managers to handle AI-related technologies effectively.	Al-Shehri et al. reached to (Al-Shahri et al. 2023) titled "The Reality of Artificial Intelligence in Project Management in the Government Sector in Saudi Arabia," the research aimed to understand the current state of AI usage in government project management in Saudi Arabia at that time and to propose suggestions that could improve the efficiency and effectiveness of project management. The study sought to enhance the ability to make accurate decisions, strategic planning, and forecasting potential challenges and dilemmas. The study concluded that artificial intelligence can play a significant role in project management within the government sector in Saudi Arabia, significantly contributing to the development and improvement of projects, continuous improvement, and providing the relevant authorities with the necessary technological capabilities to achieve this. It also emphasized the importance of having specialized managers to handle AI-related technologies. The current study differs from this one in its research objectives but aligns with it in its research methodology.
27. Intelligent Decision Support System for Building Project	This type of decision support	1. Decision Support System	2023	Jianqiao Wang	Therefore, this article proposes the theoretical framework and architecture of a construction project decision support	This article conducts theoretical research on establishing a construction project decision support	Wang reached to (Wang. 2023) titled "Intelligent Decision Support System for Building Project Management Based on Artificial Intelligence," the article

Management Based on Artificial Intelligence.	system can be structurally divided into two categories: expert decision support systems and intelligent decision support systems.	Based on Data Warehouse 2. Construction of Deep Confidence Networks			system based on data warehousing.	system and uses examples to illustrate the specific application issues. This article studies the architecture of a construction project decision support system based on a data warehouse. Specific examples include the establishment of engineering project data warehouses, online analytical processing, and the application of data mining in project decision support, explaining the supporting principles of the system and its significance in project management. This article also proposes using DBN to evaluate the practicality of the system, and the results show that the proposed method has high accuracy.	proposes using a Deep Belief Network (DBN) as a theoretical research framework for creating a decision support system for construction projects. It uses examples to illustrate specific tool problems. This study examines the architecture of a construction project decision support system based on a data warehouse. Specific examples include the creation of engineering project data warehouses, online analytical processing, and the tools of data mining in project decision support. The article explains the supporting principles of the system and its significance in project management. The results show that the proposed method has high accuracy. The current study differs from Wang's study in both methodology and objectives. While Wang's research focuses on developing a decision support system using DBN and evaluating its practical tool, the current study aims to integrate AI into project management and examine the affecting factors.
28. Artificial Intelligence and Project Management: Empirical Overview, State of the Art, and Guidelines for Future Research	we synthesize key findings from a comprehensive survey of 2,314 professionals across 129 countries, providing insights into the current state of AI adoption		2024	Ralf Müller ¹ , Giorgio Locatelli ² , Vered Holzmann ³ , Marly Nilsson ⁴ , and Temisan Sagay	we synthesize key findings from a comprehensive survey of 2,314 professionals across 129 countries, providing insights into the current state of AI adoption	Empirically, the integration of AI into project management is a transformative trend that is reshaping the industry.	Müller et al. (2024) conducted a study titled "Artificial Intelligence and Project Management: Empirical Overview, State of the Art, and Guidelines for Future Research," which aimed to provide a comprehensive empirical assessment of AI adoption in project management. Drawing from a global survey of 2,314 professionals across 129 countries, the study offers valuable insights into the current state of AI utilization and its transformative affect on project management practices. Key areas where AI has shown to enhance efficiency, accuracy, and decision-making include data collection and reporting, performance monitoring, and project scheduling and time management. The study further highlighted a significant skills gap, as 62% of participants rated their companies below average in terms of AI training support, while 65% of professionals possessed only basic AI knowledge. This finding underscores the critical need for more robust training initiatives and targeted research on effective AI training methods within the project management industry. In contrast, the current study expands on Müller et al.'s work by focusing specifically on AI integration within Saudi engineering projects, examining both

							organizational and regulatory factors unique to the region. While Müller et al. emphasize global adoption trends and general efficiency improvements, this study explores AI's role in advancing project management in Saudi Arabia, considering factors such as regional training needs, infrastructure, and regulatory constraints.
29. Evaluation of success factors of utilizing AI in digital transformation of health and safety management systems in modern construction projects	Qualitative literature review approach to identify 25 contributors to success.	A comprehensive Questionnaire distributed among a representative sample of construction industry experts.		Ahsan Waqar, Andri, Abdul Hannan Qureshi, Hamad R. Almujibah, Liza Evianti Tanjung, Citra Utami d	This study aims to address the gap concerning the essential factors for successful implementation by meticulously analyzing the key elements that contribute to the success of AI integration into the digital transformation of health and safety management systems within cutting-edge construction projects.	The study's findings underscore the paramount importance of six critical constructs in determining the success of AI implementation in construction health and safety management systems: Adaptability, Operation, Management, Reliability, Integration, and Knowledge. These findings provide valuable insights for enhancing safety measures in the construction industry through AI-driven solutions.	Waqar reached to (Waqar. 2023) titled "Evaluation of Success Factors of Utilizing AI in Digital Transformation of Health and Safety Management Systems in Modern Construction Projects," the research aims to address the gap related to the key factors for successful implementation by thoroughly analyzing the critical elements that contribute to the successful integration of artificial intelligence in the digital transformation of health and safety management systems within modern construction projects. The study's findings emphasize the paramount importance of six critical constructs in determining the success of AI implementation in construction health and safety management systems: adaptability, operability, management, reliability, integration, and knowledge. These results provide valuable insights for enhancing safety measures in the construction industry through AI-driven solutions. The current study differs from Waqar's study in the methodology and scope of AI tools. While Waqar's research focuses on integrating AI into health and safety management systems, the current study focuses on integrating AI into project management and examining the affecting factors.
30. Using AI to develop a framework to prevent employees from missing project deadlines in software projects - case study of a global human capital management (HCM) software company	The mixed methods research with both qualitative and quantitative design was opted for this research. A	1. systematic literature review (SLR) was carried out initially. 2. Focus group interviews were then carried out.	2022	Yugeshwaree Sheoraj, Roopesh Kevin Sungkur	This research will aim to eliminate the missed deadlines issues faced by employees when working on their projects through Artificial intelligence (AI). The research aim of this project is to identify the issues faced by employees to meet their project deadlines and to propose a framework to which will include solutions for all the issues faced by the employees to facilitate their tasks to meet their project deadlines more	The proposed AI framework was then evaluated and 72.7% participants rated the framework as effective and was keen to integrate AI at their workplace for smooth transition of tasks.	Sheoraj and Sungku reached to (Sheoraj and Sungku. 2022) titled "Using AI to Develop a Framework to Prevent Employees from Missing Project Deadlines in Software Projects - Case Study of a Global Human Capital Management (HCM) Software Company," the research aims to eliminate issues related to missed deadlines faced by employees in their projects through the use of artificial intelligence (AI). The research objective is to identify the problems employees encounter in meeting project deadlines and propose a framework that provides solutions to these issues,

					effectively. .		enabling employees to meet their project deadlines more effectively. The proposed AI framework was evaluated by 72.7% of participants as effective, and they advocated for the integration of AI in their workplace to facilitate a smoother task transition. The current study differs from Sheoraj and Sungku's in both methodology and the scope of AI tools. While their study focuses on the challenges faced by a global software company and developing an AI framework to address these issues, the current study aims to integrate AI into project management within engineering companies in Saudi Arabia and examines the affecting factors.
31. The Role of Artificial Intelligence in Project Management			2023	MUHAMMA D ODEH	This article discusses the role of artificial intelligence (AI) in project management.	Project managers need to transform from the traditional approach in project management to utilizing the right skills and taking advantage of what AI applications can offer. Transformation must be recognized as a journey rather than an improvised task. The journey includes a roadmap of initiatives and projects that involve people, processes, and technology	Odeh (2023) published an article titled "The Role of Artificial Intelligence in Project Management" in the IEEE Engineering Management Review, highlighting the transformative potential of AI in project management. The article emphasizes the need for project managers to transition from traditional methodologies to leveraging AI applications effectively. This transformation is described as a strategic journey, requiring a well-defined roadmap that integrates people, processes, and technology. The study underscores that adopting AI in project management demands a deliberate and structured approach to maximize its benefits. The current study diverges from Odeh (2023) by focusing specifically on the factors affecting AI adoption for design and consultancy engineering projects in Saudi Arabia.
32. AI and Its Impacts on Project Management			2023	Sindhu Reddy Nagireddy	The primary reason for doing this research was due to the fast-paced nature of the technology sector and the significant progress that has been made in project management. This study reviews existing literature on AI and project management, analyzes case studies of AI adoption in project management, and provides insights into how AI can be integrated into project management practices.	The study concludes that AI has the potential to improve project planning, resource allocation, risk management, and decision-making but also highlights the need for project managers to address the ethical and social implications of AI. Overall, this dissertation offers a comprehensive analysis of the intersection of AI and project management, providing valuable insights for practitioners and researchers.	Nagireddy (2023) authored a study titled "AI and Its Impacts on Project Management," which explores the intersection of AI and project management in response to the rapid technological advancements in the field. The study reviews existing literature, analyzes case studies of AI adoption, and examines strategies for integrating AI into project management practices. It concludes that AI offers significant benefits, including enhanced project planning, resource allocation, risk management, and decision-making. However, the study also highlights the importance of addressing the ethical and social implications of AI adoption. This research provides valuable insights for both practitioners and researchers in understanding and leveraging AI in project management.

							The current study diverges from Nagireddy (2023) by focusing specifically on the factors affecting AI adoption for design and consultancy engineering projects in Saudi Arabia.
33. A Qualitative Study on Artificial Intelligence and Its Impact on the Project Schedule, Cost and Risk Management Knowledge Areas as Presented in PMBOK	The chosen method is a qualitative cross-sectional study based on interviews.	online questionnaire Interviews	2023	1. Thordur Vikingur Fridgeirsson, 2. Helgi Thor Ingason , 3. Haukur Ingi Jonasson 4. Helena Gunnarsdottir	The aim of this paper is to study the main areas in which artificial intelligence (AI) will impact the field of project management in relation to cost, risk and scheduling.	AI can significantly impact project management by automating tasks, optimizing resource allocation and providing data-driven insights. It can enhance decision-making, risk analyses and project forecasting, ultimately increasing efficiency, reducing costs and improving project outputs. AI can analyze historical project data to predict future project outcomes, helping with resource allocation and risk management.	Fridgeirsson et al. reached to (Fridgeirsson et al. 2023) titled "A Qualitative Study on Artificial Intelligence and Its Impact on the Project Schedule, Cost, and Risk Management Knowledge Areas as Presented in PMBOK," the paper aims to examine the key areas where AI will impact project management concerning cost, risk, and scheduling. The study found that AI has the potential to significantly affect project management by automating tasks, improving resource allocation, and providing data-driven insights. AI can enhance decision-making processes, risk analysis, and project forecasting, ultimately leading to increased efficiency, reduced costs, and improved project outcomes. Additionally, AI can analyze historical project data to predict future project outcomes, aiding in resource allocation and risk management. The current study differs from Fridgeirsson et al.'s study in both methodology and the scope of AI tools. While Fridgeirsson et al.'s research focuses on the impact of AI on cost, schedule, and risk management in project management, the current study aims to integrate AI into project management more broadly and examines the affecting factors.
34. Artificial Intelligence in Project Management & Its Future			2023	1. Rajesh Dominic Savio, 2. Jafar M. Ali	this study examines the current applications of artificial intelligence in project management and its future.	The search on the relevant databases led to identifying twenty-one relevant articles. Three of the included sources addressed the topic of the evolution of artificial intelligence in project management. Six reports also evaluated the various successful instances of AI integration into PM, while five others examined the shortcomings organizations face when using AI for project management. The rest of the papers (n=7) highlight the potential for artificial intelligence to deal	Savio & Ali reached to (Savio & Ali. 2023) titled "Artificial Intelligence in Project Management & Its Future," the research explores the current tools of artificial intelligence in project management and its future prospects. The researchers identified a set of opportunities and challenges for the evolution of AI in project management through a review of relevant databases. Additionally, various successful cases of AI integration with project management were evaluated. The current study differs from this one in its research objectives and methodology. While Savio & Ali's study focuses on exploring current tools and future opportunities and challenges of AI in project management, the current study aims to integrate AI into project management and examine the affecting factors.

						with the current gaps in project management activities.	
35. Implementation of Artificial Intelligence in Project Management and its effect in working personnel			2023	Panteleimon Kelepouris	This thesis project examines the implementation of Artificial Intelligence (AI) in Project Management, focusing on its impact on the working personnel. This thesis aims to explore the implementation of AI in project management with a focus on the impact on working personnel. The study analyzes the benefits and challenges of AI implementation, the impact on the role of project managers and team members, and the ethical considerations of using AI in project management	The findings suggest that the integration of AI in project management can significantly benefit working personnel by reducing workload, increasing accuracy, and providing better insights. However, the implementation of AI requires careful consideration of ethical issues and proper training of personnel.	Kelepouris (2023) conducted a thesis titled "Implementation of Artificial Intelligence in Project Management and Its Effect on Working Personnel," at KTH Royal Institute of Technology. The research investigates the integration of AI into project management, with a particular focus on its impact on project managers and team members. It analyzes the benefits, such as reduced workload, improved accuracy, and enhanced insights, alongside the challenges, including ethical concerns and the necessity for personnel training. The study emphasizes the need for careful planning and ethical considerations to ensure successful and sustainable AI adoption in project management. The current study diverges from Kelepouris (2023) by focusing specifically on the factors affecting AI adoption for design and consultancy engineering projects in Saudi Arabia.
36. The Implementation of Artificial Intelligence in Project Management			2024	Aditi Bharati, Christoph Sand brink	This thesis explores the impact of Artificial Intelligence (AI) on project management, specifically focusing on its effects on employees. It aims to understand how AI adoption can enhance project management processes, improve certain areas of PM, and boost productivity, while also addressing ethical concerns.	This investigation explores the integration of automation and artificial intelligence (AI) into project management (PM), highlighting diverse stakeholder perceptions ranging from enthusiasm to concerns. It emphasizes the need for adaptability, lifelong learning, and strong leadership to navigate these transitions successfully. The analysis identifies key areas within PM, such as project planning and decision-making, poised to benefit from AI integration, despite its limitations in understanding human dynamics. Strategies for embedding automation into daily operations include leadership endorsement, skill development, incremental integration, and consistent review mechanisms. Overall, the research underscores the importance of informed strategies to fully embrace	Bharati & Sandbrink (2024), in their study "The Implementation of Artificial Intelligence in Project Management," delve into the transformative impact of AI on project management, focusing on both productivity enhancements and employee experiences. The research highlights AI's potential to improve key areas of project management, such as planning, decision-making, and operational efficiency, while acknowledging its limitations in comprehending human dynamics. The study emphasizes strategies for effective integration, including leadership endorsement, skill development, incremental adoption, and continuous evaluation. Ethical challenges, such as algorithmic bias, data privacy, and transparency, are critically examined, with a focus on mitigating stakeholder concerns and resistance through proper training and support. The research underscores the importance of adaptability, strong leadership, and ethical frameworks to fully leverage AI's transformative potential while maintaining the well-being of project teams. This work contributes to the growing discourse on AI in project management by offering insights and strategies for its sustainable and responsible implementation.

						the transformative potential of automation and AI, propelling project management towards innovation and efficiency. Moreover, the study underscores the importance of addressing ethical issues like algorithmic bias, data privacy, and decision-making transparency associated with AI adoption. It emphasizes the need for providing proper training and support to team members to ensure successful AI utilization and mitigate potential opposition or anxiety among project stakeholders. Overall, this research contributes to the ongoing discourse on AI's role in project management by emphasizing its benefits for employees. It aims to provide insights into AI integration to guide future strategies while prioritizing ethical considerations and ensuring the effectiveness and well-being of project management teams.	The current study diverges from Bharati & Sandbrink (2024) by focusing specifically on the factors affecting AI adoption for design and consultancy engineering projects in Saudi Arabia.
37. Assessing the Accuracy of ChatGPT Use for Risk Management in Construction Projects			2023	Hande Aladağ	Artificial Intelligence (AI) is considered promising digital technology that has important opportunities for enhancing project oversight and delivering improved decision-making in the risk management domain. However, there is a limited amount of research that has evaluated AI tools' performance in risk management. Therefore, with the intention of sustaining more accurate riskbased decision-making process in the construction industry, this paper investigates the accuracy of ChatGPT in risk management for different project types.	there is a limited amount of research that has evaluated AI tools' performance in risk management. Therefore, with the intention of sustaining more accurate risk-based decision-making process in the construction industry, this paper investigates the accuracy of ChatGPT in risk management for different project types The findings indicate that ChatGPT has a moderate level of performance in managing risks. It provides more accurate knowledge in risk response and risk monitoring rather than risk	Aladağ (2023), in the study "Assessing the Accuracy of ChatGPT Use for Risk Management in Construction Projects," explores the application of ChatGPT as an AI tool for enhancing risk management processes in the construction industry. Recognizing the limited research evaluating AI performance in this domain, the study aims to assess ChatGPT's accuracy across various project types. The findings reveal that ChatGPT demonstrates moderate effectiveness in managing risks, excelling particularly in risk response and monitoring, while showing less accuracy in risk identification and analysis. This research contributes valuable insights into the potential and limitations of AI tools like ChatGPT in supporting risk-based decision-making processes in construction project management. The current study diverges from Aladağ (2023) by

						identification and risk analysis sub-processes.	focusing specifically on the factors affecting AI adoption for design and consultancy engineering projects in Saudi Arabia.
38. Artificial Intelligence Enabled Project Management; A Systematic Literature Review	A Systematic Literature Review		2023		this paper examines the role of artificial intelligence in emerging project management through a systematic literature review; the applications of AI techniques in the project management performance domains are presented.	The results show that the number of influential publications on artificial intelligence-enabled project management has increased significantly over the last decade. The findings indicate that artificial intelligence, predominantly machine learning, can be considerably useful in the management of construction and IT projects; it is notably encouraging for enhancing the planning, measurement, and uncertainty performance domains by providing promising forecasting and decision-making capabilities.	Taboada et al. reached to (Taboada et al. 2023) titled "Artificial Intelligence Enabled Project Management: A Systematic Literature Review," the research aimed to provide a comprehensive understanding of emerging AI tools in project management and categorize them by project management areas to discover solutions for the digital transformation towards Industry 5.0. The findings reveal that the number of impactful publications on AI-supported project management has significantly increased over the past decade. The results indicate that AI, particularly machine learning, can be highly beneficial in managing construction and IT projects. This is especially encouraging for enhancing planning performance, measurement, and uncertainty through promising predictive and decision-making capabilities. The current study differs from Taboada et al.'s study in the methodology and scope of AI tools. While Taboada et al.'s research focuses on a comprehensive understanding of the literature and categorizes it by project management areas, our study emphasizes integrating AI into project management and examining the influencing factors.

8 Study Hypotheses:

Based on the research problem and the objectives we aim to achieve, this study tests the validity of the following major hypotheses:

H1: There is a significant effect of the factors affecting the use of artificial intelligence tools on the outputs of project management.

Accordingly, the study will test the validity of the following subsequent hypotheses at each independent variable as below;

Data Privacy and Security:

H1.1: There is a significant effect of data privacy and security concerns on the adoption and outputs of artificial intelligence tools in project management.

Adaptation and Change Resistance:

H1.2: There is a significant effect of resistance to change and adaptation on the effectiveness of artificial intelligence tools in project management.

Cost Associated with AI Implementation:

H1.3: There is a significant effect of costs associated with AI implementation on the adoption and outputs of artificial intelligence tools in project management.

Compatibility with Existing Infrastructure:

H1.4: There is a significant effect of compatibility with existing infrastructure on the successful adoption and outputs of artificial intelligence tools in project management.

Unavailable Resources and Training Skills Development:

H1.5: There is a significant effect of resource availability and training skill development on the outputs of artificial intelligence tools in project management.

Ethical Considerations:

H1.6: There is a significant effect of ethical considerations on the adoption and outputs of artificial intelligence tools in project management.

9 Proposed Conceptual Framework:

The **Proposed Conceptual Framework** aims to investigate how various factors affect the utilization of Artificial Intelligence (AI) tools in project management, specifically within design and consultancy engineering projects in Saudi Arabia. The framework also explores how these factors indirectly affect project outputs by mediating through project management processes.

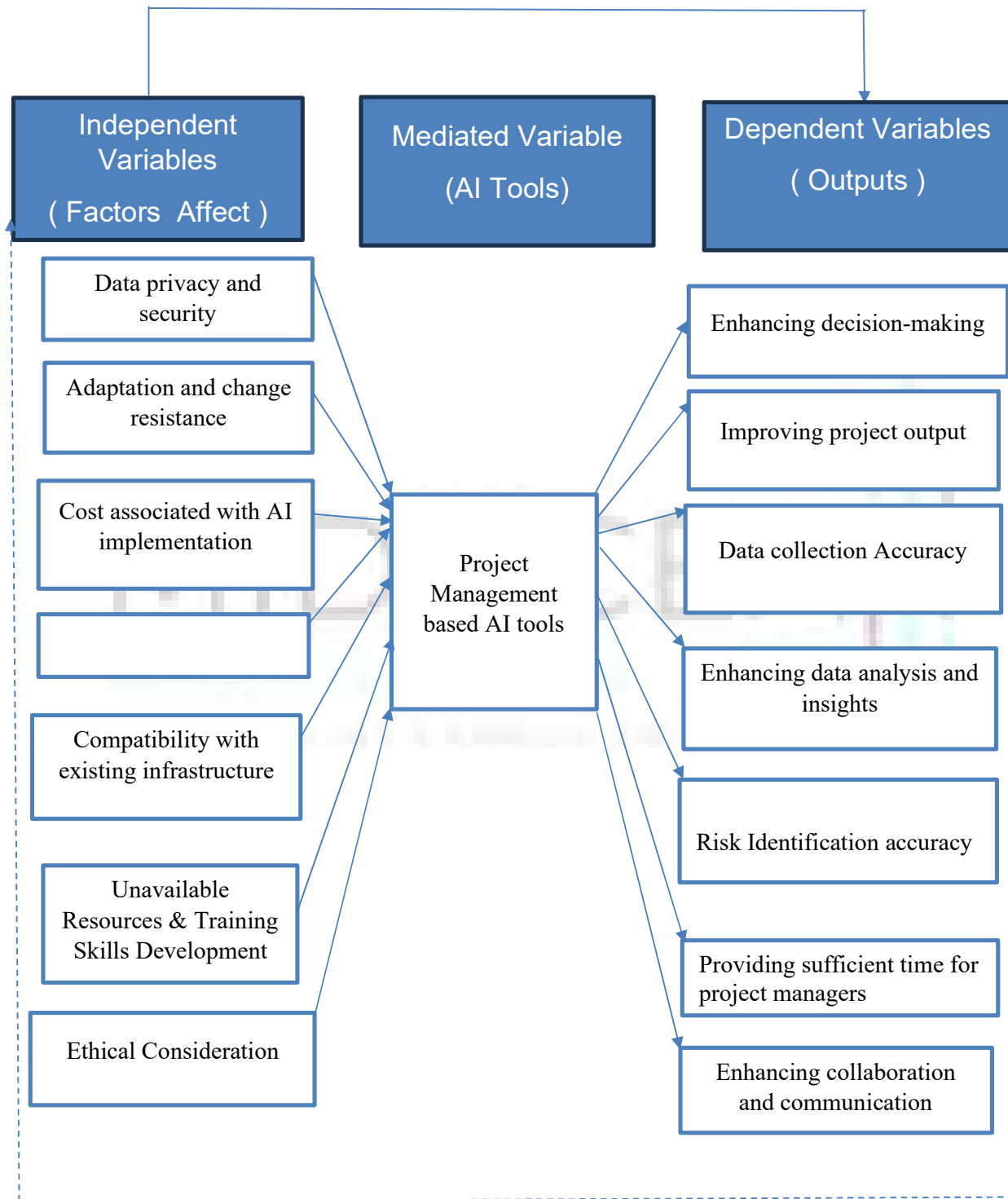
Key Elements of the Framework

The framework is structured around the following components:

1. **Independent Variables (IVs):** Factors affecting AI Utilization, These factors represent the challenges and enablers that impact how AI tools are adopted and integrated into project management processes. Each factor is essential in understanding barriers and facilitators of AI adoption.
2. **Mediating Variable (MV):** Project Management based on AI, The mediating variable focuses on how the integration of AI transforms project management processes. AI serves as an enabler, optimizing workflows, enhancing decision-making, and improving efficiency.
3. **Dependent Variables (DVs):** outputs of AI Utilization, The outputs of AI utilization are measured through its impact on project success and efficiency.

9.1 proposed model

The following figure illustrates the proposed model, which provides a conceptualization of the expected relationships between the included variables.



The conceptual framework hypothesizes relationships between the independent variables, the mediating variable, and the dependent variables. For example:

Independent variables, such as data privacy and security or cost considerations, directly affect the successful adoption of AI tools.

Dependent variables, also have an indirect impact on project outputs, mediated by the integration of AI into project management processes.

The framework posits that a well-implemented AI system, when supported by robust data security, organizational adaptation, and ethical practices, will lead to significant improvements in decision-making, collaboration, and overall project efficiency.

The conceptual framework is grounded in the local context of Saudi Arabia's Vision 2030, which emphasizes technological advancement and AI adoption as key drivers for economic diversification. By incorporating factors such as regulatory compliance (e.g., the National Data Governance Framework, SDAIA) and examples of AI adoption in projects like those by Saudi Aramco, the framework ensures relevance to Saudi Arabia's unique environment.

The proposed conceptual framework is designed to provide:

1. Practical Insights: Helping project managers and organizations understand the conditions necessary for successful AI adoption.
2. Theoretical Contributions: Offering a structured approach to studying the impact of AI on project management in a regionally relevant context.
3. Policy Implications: Informing policymakers about the enablers and barriers to AI adoption in Saudi Arabia's engineering and consultancy sectors.

9.2 Description of the Components

9.2.1 Independent Variables (IVs)

The IVs are the driving factors that affect the adoption and integration of AI in project management. These variables are:

1. Data Privacy and Security
2. Adaptation and Change Resistance
3. Cost Associated with AI Implementation
4. Compatibility with Existing Infrastructure
5. Unavailable Resources and Training Skills Development
6. Ethical Considerations

Each IV is connected to the Mediating Variable (MV) via a direct arrow. This indicates that these factors affect how AI is implemented and utilized within project management practices.

9.2.2 Mediating Variable (MV)

The MV represents Project Management based on AI and acts as the central element of the framework. This variable captures how AI transforms project management processes by automating workflows, enhancing decision-making, and improving efficiency.

The MV is the bridge between the IVs and DVs, mediating their impact.

1. Arrows from IVs to MV: These arrows represent how each influencing factor shapes the integration and effectiveness of AI in project management. For instance:
 - If Adaptation and Change Resistance is not addressed, AI adoption may be incomplete or ineffective.
 - If Cost is prohibitive, organizations may only implement partial AI solutions, reducing the potential benefits.
2. Arrows from MV to DVs: These arrows represent how effective project management based on AI translates into measurable outputs (the dependent variables).

9.2.3 Dependent Variables (DVs)

The DVs are the outputs of AI utilization in project management, measuring its success and value addition. These include:

1. Enhancing Decision-Making
2. Improving Project Output
3. Data Collection Accuracy
4. Enhancing Data Analysis and Insights
5. Risk Identification Accuracy
6. Saving Time for Project Managers
7. Effective Collaboration and Communication

Each DV is connected to the MV via an arrow, indicating that the effectiveness of project management based on AI directly affects these outputs.

10 Population and Sampling:

10.1 Study Population:

The large design & consultancy engineering companies in Saudi Arabia, in total 1,123 companies according to the statistics of the Saudi Council of Engineers as of April 2024.

10.2 Study Sample:

The sample size was calculated using the formula by Steven K. Thompson (2012), as follows:

$$n = \left\lceil \frac{N \times p(1-p)}{[N-1 \times (d^2 \div z^2)] + p(1-p)} \right\rceil$$

where:

- n = required sample size
- N = population size (1,123)
- p = expected proportion of the characteristic present (e.g., 0.5 to maximize the sample size)
- d = acceptable margin of error (e.g., 0.05)

Assuming an expected proportion $p = 0.5$ and a margin of error $d = 0.05$, the sample size is calculated as follows:

$$n = \frac{1123 \cdot 0.5 \cdot (1 - 0.5)}{(1123 - 1) \cdot 0.05^2 + 0.5 \cdot (1 - 0.5)}$$

Let's compute the sample size using these values:

$$n = \frac{1123 \cdot 0.5 \cdot 0.5}{1122 \cdot 0.0025 + 0.25}$$

$$n = \frac{280.75}{2.805 + 0.25}$$

$$n = \frac{280.75}{3.055}$$

$$n \approx 91.86$$

To ensure accurate data, the sample size can be rounded to **92** companies.

If it is necessary to ensure good representation and avoid potential errors, the sample size may be increased based on the study's needs and potential data collection challenges.

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