

Thesis Title:
**Factors Influencing AI-Based Project Management
and Its Outcomes in Industrial Engineering Projects**
“Design and Consultancy Engineering Projects”

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List of Shortcuts:

AI	Artificial Intelligence
ANN	Artificial Neural Network
CV	Computer Vision
DL	Deep Learning
LLMs	Large Language Models
ML	Machine Learning
NLP	Natural Language Processing
NSDAI	National Strategy for Data and Artificial Intelligence
PMBOK	Project Management Body Of Knowledge
PMI	Project Management Institute
PMIS	Project Management Information System
RL	Reinforcement Learning
SDAIA	Saudi Data and Artificial Intelligence Authority
CEO	Chief Executive Officer

1 Methodological Framework of the Research:

2 Theoretical Framework (Related Literature Review)

3 Research Methods and Procedures (Methodology)

3.1 Research Methodology (Approach)

This study employs a mixed-method research design, integrating quantitative survey data with qualitative insights from expert interviews. This approach is justified by the need to explore both the factors influencing the utilization of AI-based project management and the measurable outcomes resulting from its integration in design and consultancy engineering projects. The quantitative phase provides statistically validated evidence on the relationships among influencing factors, AI utilization, and project outcomes. Meanwhile, the qualitative phase adds depth by capturing real-world insights, challenges, and enablers from industry experts. Together, these methods ensure a comprehensive and empirically grounded understanding of the dynamics shaping AI-based project management in the Saudi consultancy and design

Justification of Methodology Choice:

This research applies a mixed-method approach, integrating both quantitative and qualitative data collection and analysis. The rationale behind this choice stems from the complex nature of the research objectives, which aim to identify factors influencing AI utilization, measure its effect on project outcomes, and analyze the mediating role of AI-based project management in design and consultancy engineering projects.

Furthermore, the mixed-method approach is chosen to bridge the gap between theoretical insights and practical applications in AI-based project management. This dual approach ensures that the study captures both perceptions and measurable effects, offering a holistic analysis.

The quantitative component involves the distribution of structured questionnaires to a wide sample of professionals in Saudi Arabia's engineering consultancy sector. This allows the collection of statistically analyzable data on the relationship between the identified variables.

The qualitative component is based on semi-structured interviews with subject-matter experts and decision-makers in AI-Based project management. This provides in-depth insight into contextual factors, real-world challenges, and practical strategies, supporting a deeper understanding of the adoption process and interpretation of survey results.

This dual approach ensures that the findings are both statistically valid and contextually grounded, enhancing the reliability and relevance of the research conclusions.

This methodology is justified based on the need to:

- Address "what" the influencing factors are and "how" they statistically affect outcomes (quantitative),
- And understand "why" such factors exist and how they are experienced by practitioners in real scenarios (qualitative).

This research employs a mixed-method design in which structured quantitative data forms the basis for hypothesis testing, while qualitative interviews offer contextual support and interpretation. The study makes a theoretical contribution by proposing and validating a model that links influencing factors, AI-based project management practices, and project outcomes through mediation analysis. On the practical level, it delivers actionable recommendations tailored to the specific context of Saudi Arabia's design and consultancy engineering sector

3.2 Study Population and Sampling:

3.2.1 Study Population:

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

The study population consists of professionals involved in design and consultancy engineering firms in Saudi Arabia, which form the core environment where AI adoption in project management is emerging. According to data from the Saudi Council of Engineers (April 2024), there are 1,123 registered firms operating within this sector, ranging in size and specialization.

These firms typically include project directors, managers, engineers, and department leaders who are either decision-makers or directly engaged in utilization of AI-based project management tools.

3.2.2 Quantitative Study Sample:

Participants will be selected from design & consultancy engineering firms in Saudi Arabia, including project directors, managers, engineers, department leaders and decision-makers with direct AI utilization experience. To ensure that the research reflects diverse organizational perspectives, a structured and balanced sampling approach will be used.

The criteria include:

- Firm size: (small, medium, large)
- AI maturity levels: (early adopters, in-progress adopters, advanced users)

- Sector specialization: (architecture, engineering consultancy, project supervision, etc.)

Participants will be selected from the key managerial and operational roles, including but not limited to:

- Project Directors
- Project Managers
- Project Engineers
- Engineering Leads
- Departments Leads
- Decision-Makers

Additionally, the questionnaire will include a dedicated section to capture the demographic characteristics of the participants, allowing for a deeper analysis of how factors such as experience level, job role, and organizational background influence utilization of AI-Based project management and its outcomes.

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

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

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** firms.

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.

The minimum required sample size ($n = 92$) was determined using Thompson's formula to ensure statistical validity. However, given the requirements of Structural Equation Modeling (SEM), which demands a larger dataset for reliable model estimation, the actual data collection will exceed this threshold to support robust analysis and improve generalizability.

3.2.3 Qualitative Study Sample:

For the qualitative component, a purposive sampling method will be used to select 8–12 expert interviewees from the same population. These will include:

- Organization CEO
- Senior Project Managers
- AI expert and Decision-maker

These interviews will help interpret statistical findings, enrich the discussion, and provide real-world illustrations.

3.3 Construction of Data Collection Instruments

3.3.1 Instrument Overview

To achieve the research objectives and test the proposed hypotheses, this study apply a mixed-method approach, utilizing both a structured questionnaire and a semi-structured interview guide as the primary data collection instruments.

- The structured questionnaire represents the quantitative tool, capturing measurable data across the three core variable groups: factors influencing AI utilization (independent variables), AI-based project management practices (mediating variable), and project management outcomes (dependent variables).
- The semi-structured interviews serve as the qualitative instrument, providing rich contextual insight into the challenges, benefits, and strategic considerations involved in AI-based project management.

This dual-instrument design ensures a comprehensive analysis that includes both empirical validation and in-depth exploration of real-world experiences.

3.3.2 Quantitative Instrument (Questionnaire Structure)

The questionnaire is designed using closed-ended questions on a 5-point Likert scale to assess agreement, frequency, or impact perception. Additionally, a small section of open-ended questions is included to enrich the quantitative data with narrative insights aligned with key research objectives.

The Questionnaire Comprises Five Sections:

1. **Demographic and Organizational Information:**

Captures participants' roles, experience, company size, AI familiarity, and current AI usage in project management.

2. **Independent Variables (Influencing Factors):**

Measures the extent to which the following six factors influence the utilization of AI-based project management in design and consultancy engineering projects:

- o Data Privacy and Security
- o Resistance to Change
- o Cost of AI Implementation
- o Compatibility with Existing Infrastructure
- o Workforce Development
- o Ethical Considerations

3. **Mediating Variable (AI-Based Project Management):**

Evaluates the extent to which AI tools are utilized in core project management tasks such as scheduling, reporting, risk handling, collaboration, and coordination.

4. **Dependent Variables (Project Management Outcomes):**

Evaluates the perceived outcomes of AI utilization: Assesses the perceived outcomes of AI-based project management, including:

- o Decision-making
- o Project quality
- o Data collection accuracy
- o Data analysis and insight generation
- o Risk identification
- o Time efficiency
- o Collaboration and communication

5. Open-Ended Questions:

Support deeper qualitative understanding and explore contextual insights, including barriers, enablers, perceived benefits, and strategic recommendations for enhancing the utilization of AI-based project management practices.

3.3.3 Qualitative Instrument (Expert Interview Guide)

To supplement the quantitative findings and provide contextual depth, a semi-structured interview guide is developed based on the conceptual model and research objectives. This tool will enable a deeper understanding of:

- Perceptions of AI Utilization in project management practices
- Challenges and factors related to data security, workforce capability, and ethical concerns
- Organizational readiness and infrastructure compatibility
- Decision-making dynamics and time efficiency linked to AI
- Real examples from practice in design and consultancy engineering projects
- Industry-specific reflections, especially within the Saudi firms.

Interviews will be conducted in person or virtually, depending on participant availability and logistical feasibility. Participants will include experienced project managers, engineers, and decision-makers from Saudi Arabia's leading design and consultancy firms.

3.3.4 Instrument Validation and Reliability

The questionnaire will be reviewed by academic experts and industry practitioners to ensure content validity. To ensure methodological rigor and the credibility of findings, both the structured questionnaire and the semi-structured interview guide will undergo rigorous validation and reliability procedures.

- **Questionnaire (Quantitative Instrument)**

The questionnaire will be reviewed by an academic scholars and industry professionals to establish content validity, ensuring that the items appropriately reflect the study's independent, mediating, and dependent variables.

A pilot study will be conducted with a small representative sample of participants from the target population. The pilot aims to test:

- Clarity of wording,
- Logical flow,
- Response time,
- consistency,
- Content validity (via expert feedback).

The reliability of the questionnaire will be evaluated using Cronbach's Alpha. A threshold of 0.70 or higher will be considered acceptable, indicating a strong degree of internal consistency across each construct.

This validation process ensures that the questionnaire produces statistically sound and meaningful data for hypothesis testing.

- **Interview Guide (Qualitative Instrument)**

The semi-structured interview guide will be validated through expert review to ensure relevance, neutrality, and clarity of the open-ended questions. It will be pilot-tested with a small number of participants to verify:

- Interview flow and timing
- Comprehension and interpretation of questions
- Thematic alignment with the study's objectives and conceptual framework

Following the pilot, minor revisions may be applied to enhance integrity before full deployment.

To ensure rigor in the qualitative phase, the interview structure will undergo expert validation and pilot testing. Credibility will be reinforced through member checking, while thematic coding - if needed - will follow a systematic and transparent process aligned with the study's conceptual framework.

3.4 Identification of Study Variables

This section defines the key variables that constitute the foundation of the research model. The study framework is structured around three main types of variables:

- **Independent Variables (IVs):** Factors influencing the utilization of AI tools in project management.
- **Mediating Variable (MV):** AI-based project management.
- **Dependent Variables (DVs):** Project management outcomes.

3.4.1.1 *Independent Variables (IVs): Factors Influencing the utilization of AI Tools*

These variables reflect organizational, technical, and ethical dimensions that influence the utilization of AI-based project management practices in design and consultancy engineering projects. The six independent variables identified are:

1. Data Privacy and Security
2. Resistance to Change
3. Cost of AI Implementation
4. Compatibility with Existing Infrastructure
5. Workforce Development (Training and Skills)
6. Ethical Considerations

Each of these variables is operationalized using multiple items on a five-point Likert scale. These independent variables form the foundation for understanding the drivers and barriers that influence the extent to which AI can be effectively utilized in project management processes.

3.4.1.2 Mediating Variable (MV): AI-Based Project Management

This variable captures the transformation of project management practices through the integration of AI tools. It acts as a bridge between the influencing factors (IVs) and the outcomes (DVs), and reflects the degree to which AI has been embedded in core project management functions such as:

- Planning and scheduling
- Documentation and progress reporting
- Resource forecasting and allocation
- Risk analysis and decision support
- Team collaboration and information sharing

These functions were selected based on established literature on AI applications in project management and are reflected across the study's data collection tools to ensure construct alignment.

This variable is critical in understanding how AI reshapes management workflows and mediates the influence of external factors on performance outcomes. The mediating role of this variable will be statistically tested using mediation analysis techniques.

3.4.1.3 Dependent Variables (DVs): Project Management Outcomes

These variables represent the results and benefits associated with the utilization of AI-based project management. They focus on performance, efficiency, quality, and collaboration outcomes achieved through AI integration. The seven dependent variables are:

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

Each variable is measured through structured items designed to evaluate how the utilization of AI-based project management influences key project performance indicators. The data is gathered via the quantitative questionnaire and supported by qualitative insights obtained through expert interviews.

3.5 Implementation Procedures

This section details the practical steps followed to carry out the study from instrument development to data collection and validation. This procedure ensures compliance with ethical research principles and academic integrity.

3.5.1.1 Instrument Development

- **Questionnaire Design (Quantitative Tool)**

The structured questionnaire was developed to measure the three main variable sets defined in the conceptual framework; independent variables, the mediating variable, and dependent variables through dedicated sections and supporting demographic and qualitative items.

1. **Demographic Information** (e.g., position, experience, company size, familiarity with AI).
2. **Independent Variables** – Items measuring data privacy, cost concerns, Resistance to Change, etc.
3. **Mediating Variable** – Items exploring how AI is embedded in project management.
4. **Dependent Variables** – Items measuring project outcomes influenced by AI.
5. **Open-Ended Questions** – Designed to capture deeper qualitative insights that may not emerge from fixed-response questions.

A 5-point Likert scale is used for consistency and statistical reliability. A five-point Likert scale was used for all closed-ended items to ensure clarity, comparability, and statistical validity.

- **Semi-Structured Interview Guide (Qualitative Tool)**

To complement the quantitative data, a semi-structured interview guide was designed. It includes open-ended questions aligned with each of the three variable types:

- Challenges related to each **independent variable**
- Reflections on **AI-based project management practices**
- Perceptions of the resulting **project outcomes**

This qualitative instrument enables deeper exploration of emerging themes and provides context for interpreting quantitative findings.

3.5.1.2 Pilot Testing

Prior to full deployment, the structured questionnaire underwent pilot testing with a small sample ($n = 15$) of professionals working in Saudi design and consultancy firms. The pilot aimed to assess:

- Clarity of wording,

- Logical flow,
- Response time,
- consistency,
- Content validity (via expert feedback).

The interview guide was also reviewed and refined in consultation with academic and industry experts to ensure clarity, neutrality, and relevance.

3.5.1.3 Ethical Considerations

This research strictly adheres to ethical guidelines approved by the university. The following measures were implemented:

- Participants will be fully informed of the study's purpose, scope, and voluntary nature.
- Informed consent will be obtained prior to participation.
- Anonymity and confidentiality were assured; no identifying personal or organizational data was collected.
- Interview participants were granted the option to decline recording.

3.5.1.4 Questionnaire Distribution and Data Collection

Quantitative Data Collection (Questionnaire):

- To be distributed electronically via email and professional platforms (e.g., LinkedIn and Whats'app).
- Target participants will include engineers, project managers, and senior staff from Saudi design and consultancy engineering firms.
- The data collection period will last six weeks, with bi-weekly follow-ups to increase response rates.

Qualitative Data Collection (Interviews):

- Semi-structured interviews will be conducted either in-person or virtually based on participant availability.
- Participants will be selected purposefully to ensure diversity in roles, company size, and AI maturity levels.
- Interviews will be audio-recorded with permission and transcribed for analysis.

3.5.1.5 Data Analysis Procedure

- Quantitative Analysis: Will be Conducted using SPSS for descriptive statistics (e.g., frequencies, means) and inferential testing (e.g., correlation, regression, and SEM for mediation analysis).
- Qualitative Analysis: Thematic analysis using manual coding, organized according to pre-defined codes aligned with the study variables (IVs, MV, and DVs).

3.6 Research Design and Statistical Processing

This section details the overall research design structure and the statistical methods to be employed in analyzing both quantitative and qualitative data. These procedures are selected to ensure methodological rigor and alignment with the study's objectives, research questions, and hypotheses.

3.6.1.1 Research Design

This study adopts a sequential explanatory mixed-method research design, incorporating both statistical analysis and qualitative interpretation.

- **Quantitative Phase:**

A structured questionnaire is distributed to professionals in Saudi design and consultancy engineering firms to collect data on the influencing factors (independent variables), the utilization of AI-based project management (mediating variable), and project outcomes (dependent variables).

- **Qualitative Phase:**

Semi-structured interviews are conducted with a select group of industry experts to capture deeper contextual understanding, clarify survey trends, and provide interpretive insights.

This sequential explanatory design is employed to:

- Identify and evaluate the key factors influencing the utilization of AI tools in project management within design and consultancy engineering projects
- Analyze how AI-based project management mediates the relationship between influencing factors and project outcomes
- Examine the direct influence of these factors on the outcomes of AI-based project management.
- Assess variations in AI utilization and outcomes across different organizational types, sizes, and participant demographics.
- Propose practical recommendations by combining statistical trends with real-world expert insights

The research design follows a correlational approach, with mediation analysis techniques applied through SEM. This enables the analysis of both direct and indirect relationships among variables, while qualitative findings offer deeper interpretive support.

3.6.1.2 Quantitative Data Analysis

To ensure rigorous quantitative analysis, data collected from the questionnaire will be processed using the following statistical techniques:

1. **Descriptive Statistics**

- o Frequency, percentage, mean, and standard deviation to describe demographic characteristics and general response trends.
- 2. **Reliability Testing**
 - o Cronbach's Alpha will assess the internal consistency of each construct. A threshold of ≥ 0.70 will be used to confirm acceptable reliability.
- 3. **Exploratory Factor Analysis (EFA)**
 - o Used to verify dimensionality and identify factor loadings, ensuring items align well with their intended constructs.
- 4. **Confirmatory Factor Analysis (CFA)**
 - o Conducted to validate the measurement model and assess model fit indices.
- 5. **Structural Equation Modeling (SEM)**
 - o SEM will be the primary technique for testing hypotheses related to:
 - Direct relationships (e.g., IVs $\rightarrow$ DVs)
 - Indirect relationships through mediation (IVs $\rightarrow$ MV $\rightarrow$ DVs)
- 6. **Open-Ended Questionnaire Responses**
 - o Thematic analysis will be used to extract meaningful patterns from open-ended survey responses, further enriching interpretation of statistical findings.

3.6.1.3 Qualitative Data Analysis

Data from the semi-structured expert interviews will be analyzed through thematic coding, following this process:

- Transcripts will be coded according to predefined themes aligned with the three variable sets:
 - o **Independent Variables** (e.g., cost, ethics, infrastructure)
 - o **Mediating Variable** (AI-based project management)
 - o **Dependent Variables** (e.g., decision-making, project efficiency)
- Emergent sub-themes will also be noted to enhance interpretation of quantitative results and provide real-world insight into contextual challenges and enablers.

To ensure qualitative rigor, interview protocols will be validated through expert review and pilot testing. Credibility is strengthened through member checking, and thematic coding will follow a structured, traceable approach aligned with the study's conceptual model.

3.6.1.4 Methodology summary

In summary, this study applies a robust mixed-method research design, combining structured quantitative data collection with in-depth qualitative interviews. This methodology aligns with the study's aim of examining the factors influencing the utilization of AI-based project management, the mediating role of AI in transforming project management practices, and the resulting project outcomes in design and consultancy engineering projects. The structured questionnaire enables the collection of statistically measurable insights into the relationships between influencing factors, AI-based practices, and outcomes.

In parallel, the interviews provide rich contextual perspectives and professional judgments from experts in the field. Together, these methods enhance the study's validity, reliability, and contextual relevance, ensuring that both empirical evidence and real-world experience shape the research findings and final recommendations.

The insights gained from qualitative interviews will be integrated with the quantitative findings to validate emerging patterns, clarify unexpected results, and deepen the understanding of observed statistical relationships. This integration enhances both the methodological robustness and the contextual relevance of the study.

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