

Thesis Title:

**Factors Influencing AI-Based Project Management
and Its Outcomes in Industrial Engineering Projects**

**“Design and Consultancy Engineering Projects – Mixed Method
Study in Saudi Arabia”**

PART-3 of the Thesis

Rev.02

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2025 - 1447

**Submitted to Midocean University in partial fulfillment of the requirements
for the degree of Doctor of Philosophy**

in

Faculty of Management

2026

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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
PMO	Project Management Office
PMI	Project Management Institute
PMIS	Project Management Information System
RL	Reinforcement Learning
SDAIA	Saudi Data and Artificial Intelligence Authority
SEM	Structural Equation Modeling
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 independent factors influencing the utilization of AI-based project management and the measurable outcomes resulting from its integration in design and consultancy engineering projects. The study is grounded in a conceptual model that identifies and categorizes the three sets of variables: independent factors influencing AI utilization, the mediating role of AI-based project management practices, and the resulting project management outcomes. The model serves as the theoretical foundation for both instrument design and data analysis.

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 and balanced organizational perspectives, a structured and balanced sampling approach will be used. The sample will include:

- Firm size: (small, medium, large)
- AI maturity levels: (early adopters, in-progress adopters, advanced users)
- Sector specialization: (architecture, engineering consultancy, project supervision, etc.)

To ensure balanced representation from different types of organizations, the sample will be divided into specific groups based on firm size (small, medium, large) and AI maturity level (early adopters, in-progress adopters, advanced users). Within each group, participants will be selected in a way that reflects the actual proportion of those groups in the overall population of Saudi design and consultancy firms.

For example, if large firms make up 30% of the total population, then approximately 30% of the responses will be collected from large firms. This proportional distribution helps ensure that all firm types and AI maturity levels are fairly represented in the study. It also allows for comparison between groups to understand whether differences exist in AI utilization patterns or project outcomes.

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:

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

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** 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. Purposive sampling will consider the following criteria to enhance relevance and depth:

- Participants must hold relevant leadership or technical positions, such as senior executives, CEOs, middle managers or technical professionals.
- Participants should be directly involved in strategic planning, operational decision-making, or technical implementation related to AI tools or digital project management processes.
- Participants must be affiliated with design or consultancy engineering firms operating within Saudi Arabia to ensure contextual alignment with the study.

To ensure diversity and depth in the qualitative phase, interview participants will be selected to represent a range of roles, seniority levels, and organizational sizes. The sample will include:

- Top management such as, Director, CEO,.. etc to capture strategic perspectives on AI-based project management.
- Middle management such as Senior Project Managers to reflect operational integration and challenges.
- Technical professional such as AI expert and engineers to provide firsthand accounts of tool implementation and technical factors.

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

The study's hypotheses are structured to reflect the conceptual framework variables:

H1a–H1g: Each influencing factor (Data Privacy and Security, Resistance to Change, Cost of AI Implementation, Compatibility with Existing Infrastructure, Workforce Development, Ethical Considerations) has a significant effect on AI-Based Project Management utilization (MV).
H3: AI-Based Project Management utilization (MV) has a significant effect on Project Management Outcomes (DVs).
H2a–H2f: The relationship between each influencing factor (IV1–IV6) and Project Management Outcomes (DVs) is mediated by AI-Based Project Management utilization (MV).

5. **Open-Ended Questions:**

A set of open-ended questions is included at the end of the structured questionnaire. These questions are designed to capture narrative insights that may not be fully expressed through Likert-scale responses. Participants are encouraged to share their views on barriers, enablers, perceived benefits, and strategic recommendations regarding the utilization of AI-based project management practices.

The responses will undergo **thematic coding**, where each response is analyzed and mapped to predefined **dependent variable (DV) themes**, such as decision-making, project quality, data collection accuracy, data analysis, risk identification, time efficiency and collaboration and communication. At the same time, the **underlying factors** mentioned in the responses including technical, organizational, or ethical challenges will be treated as **influencing factors** (linked to the independent variables). This structure allows the researcher to identify **how specific influencing factors affect particular outcomes**, based on participants' own words.

The following logic will be applied during analysis:

- **Open-ended responses** will be grouped under **themes representing the project management outcomes (DVs)**.
- The **content of each response** will be interpreted to identify the **influencing factor (IV)** it addresses, along with the **direction of impact** (e.g., enabling, limiting, improving).
- These results will be used to **triangulate** the quantitative findings derived from SEM, reinforcing the validity and contextual depth of the observed relationships.

To structure this analysis, a coding matrix example is developed to guide the mapping process, as illustrated in the following table:

Open-Ended Responses (Related to Influencing Factors – IVs)	Mapped DV Theme (Project Outcome)
“The high cost of AI implementation makes it difficult to adopt comprehensive project tools.”	Project Quality – Negative impact
“Our AI tools help collect real-time data from multiple sources with improved consistency.”	Data Collection Accuracy – Positive impact
“Due to outdated infrastructure, AI-based systems cannot integrate fully with our current tools.”	Time Efficiency – Negative impact
“Once integrated, the AI platform improved team communication by providing shared dashboards.”	Collaboration & Communication – Positive impact
“Most of our engineers are not trained in AI-based forecasting tools, which slows us down.”	Time Efficiency – Negative impact
“We use AI to flag early-stage risks through data pattern recognition.”	Risk Identification – Positive impact
“It’s hard to make decisions without clear ethical frameworks for AI usage in client-facing projects.”	Decision-Making – Negative impact

Open-Ended Responses (Related to Influencing Factors – IVs)	Mapped DV Theme (Project Outcome)
“AI tools enabled faster scenario analysis, which improved our ability to make strategic project decisions.”	Decision-Making – Positive impact
“Data privacy regulations are too vague, which restricts how much we can automate.”	Data Analysis – Negative impact
“AI adoption helped us improve how we organize and analyze project reports and KPIs.”	Data Analysis – Positive impact
“The AI assistant helped us identify and resolve quality issues in design documentation.”	Project Quality – Positive impact
“Resistance from senior management delayed AI rollout, which affected our ability to track and respond to project risks.”	Risk Identification – Negative impact
“Even with limited AI features, our team was able to automate repetitive data entry tasks.”	Data Collection Accuracy – Positive impact
“Collaboration improved once we used AI-enabled project timelines that synced with team calendars.”	Collaboration & Communication – Positive impact

This coding approach allows the open-ended data to directly reinforce and expand the findings from the quantitative model (via SEM), following a triangulation strategy. It also ensures that the qualitative insights remain tightly integrated with the conceptual framework and research objectives, contributing both explanatory richness and methodological rigor

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 top management, middle management and technical professionals 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. If it yields a Cronbach's Alpha below the 0.70 threshold for any construct, targeted item refinement will be applied. This may include rewording ambiguous items, removing poorly performing items with low item-total correlations, or adding new items to better capture the construct. A follow-up reliability check will be conducted before full-scale deployment to confirm improvements.

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: *This variable measures organizational awareness, adherence, and proactive management of ethical issues in AI utilization for project management. It will be operationalized through questionnaire items addressing:*
 - o Presence and enforcement of formal AI ethics policies (e.g., data usage, transparency, bias mitigation).
 - o Compliance with national and sectoral AI governance guidelines (e.g., SDAIA's AI Ethics Principles).
 - o Availability of training or awareness programs on ethical AI usage for employees.
 - o Perceptions of fairness, accountability, and transparency in AI-driven decision-making.

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 communication and collaboration

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.

The mediating variable, *AI-Based Project Management Utilization*, is conceptualized as the extent to which AI tools are embedded in core project management functions. The specific functions planning and scheduling, documentation and progress reporting, resource forecasting and allocation, task prioritization and coordination, and team communication and collaboration were selected based on a review of PMBOK project management domains, AI in project management literature, and sector specific best practices.

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.

The reliability of the pilot will be evaluated using Cronbach's Alpha. If the pilot study yields a Cronbach's Alpha higher 0.70 will be considered acceptable, indicating a strong degree of internal consistency across each construct. If the pilot study yields a Cronbach's Alpha below 0.70 threshold for any construct, targeted item refinement will be applied. This may include rewording ambiguous items, removing poorly performing items with low item-total correlations, or adding new items to better capture the construct. A follow-up reliability check will be conducted before full-scale deployment to confirm improvements.

Interview recordings will be transcribed using recoding transcription software, with manual verification for accuracy. Transcripts will then be coded thematically coding to ensure consistency between qualitative and quantitative insights and facilitate triangulation.

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 WhatsApp).
- 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)
 - o SEM is selected over simpler regression methods because it enables simultaneous estimation of multiple relationships among independent, mediating, and dependent variables while accounting for measurement error. Unlike regression approaches to mediation, SEM tests both the measurement model and the structural paths in a single integrated framework, improving validity and robustness. This is particularly important in our study, where six independent variables, one mediating variable, and seven dependent variables are analyzed together to capture both direct and indirect effects.
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.

Thematic patterns emerging from qualitative interviews will be compared against the statistical relationships identified in SEM. This triangulation process will validate quantitative findings by confirming convergent patterns, offering contextual explanations for observed statistical associations, and highlighting any discrepancies for further interpretation. For example, if SEM indicates a weak relationship between “Workforce Development” and “AI-Based Project Management,” thematic insights may reveal contextual factors such as limited training budgets or cultural resistance that explain the statistical outcome.

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 **quantitative phase** involves the use of a structured questionnaire to collect statistically analyzable data from professionals across Saudi Arabia’s design and consultancy sector. It allows for the identification and measurement of relationships among the study’s core variables: the influencing factors (independent variables), AI-based project management practices (mediating variable), and the outcomes of AI utilization (dependent variables). Structural Equation Modeling (SEM) will be applied to test both direct and indirect relationships, including mediation effects.

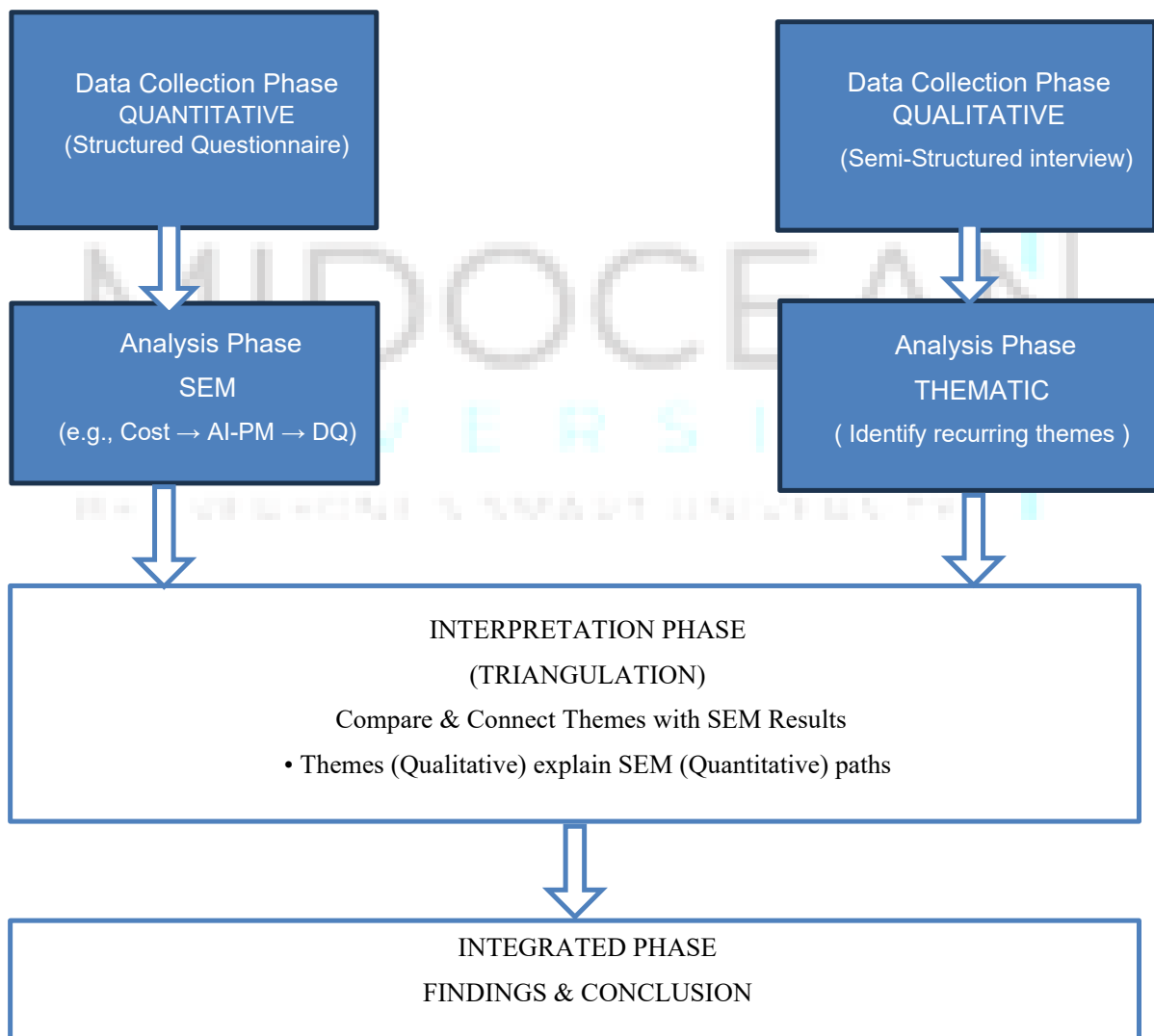
In parallel, the **qualitative phase** incorporates semi-structured interviews with selected experts to explore practical insights, contextual challenges, and real-world experiences related to AI-based project management. Thematic analysis of these interviews will uncover emergent themes aligned with the study variables and help contextualize quantitative trends.

To ensure integration of insights, this study adopts a **triangulation approach**, whereby qualitative findings from expert interviews are used to interpret, validate, and enrich the patterns revealed through quantitative analysis. Thematic analysis of

interview transcripts will uncover real-world examples, contextual explanations, and potential contradictions that help explain statistical relationships or anomalies identified through SEM. This method reinforces the study's methodological rigor by ensuring that quantitative associations are not only empirically validated but also contextually grounded.

Visual Representation of Integration Strategy:

The following flowchart illustrates how the quantitative and qualitative methods work together through SEM, thematic analysis, and triangulation:



The chart illustrates how **quantitative** and **qualitative** methods are **integrated** through a **triangulation approach** to enhance interpretation and ensure robust findings.

It walks through:

1. Data Collection Phase:

- o From the **structured questionnaire** (quantitative)
- o From **semi-structured interviews** (qualitative)

2. Analysis Phase:

- o **SEM** is applied to test relationships (e.g., Cost → AI-based PM → Decision-Making Quality)
- o **Thematic analysis** identifies recurring themes from interview transcripts (e.g., "Cost is a major barrier")

3. Interpretation Phase (Triangulation):

- o Findings from interviews are **connected with SEM results** to **explain, support, or even challenge** quantitative relationships.

4. Integrated Conclusion:

- o A richer understanding is achieved by combining numbers (**how much**) with narratives (**why**), resulting in conclusions that are both **statistically validated** and **contextually meaningful**.

This integration enhances both the methodological rigor and practical relevance of the study by combining statistical evidence with expert-driven interpretation. As a result, the study's findings and recommendations will be not only theoretically robust but also grounded in the lived realities of AI utilization in the Saudi design and consultancy engineering sector.

4 References

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Structure:

The interview will include **3 main sections**, aligned with the study's conceptual framework (Independent Variables → Mediating Variable → Dependent Variables) as below:

Introduction:

Thank you for agreeing to participate in this interview. This is part of my PhD research on the factors influencing the utilization of AI-based project management and its outcomes, particularly within the design and consultancy engineering sector in Saudi Arabia. Your insights will

1. Provide real-world context to support survey findings.
2. Help explain patterns and relationships identified in the quantitative analysis.
3. Contribute to both academic knowledge and practical recommendations for AI utilization in project management.

*This interview is **confidential**. Your identity and organizational details will not appear in the thesis or any related publications. With your permission, the interview will be audio-recorded to ensure accuracy during analysis.*

*Your responses will not only be analyzed independently but will also be **integrated with survey data** (through thematic coding and triangulation) to provide a complete picture of AI-based project management in Saudi Arabia.*

Do you consent to proceed with this interview, and to being recorded?

1. Independent Variables: Factors Influencing AI utilization: These questions explore the key challenges and enabling factors that influence the **utilization** of AI-based project management practices.

Theme (IV)	Question 1	Question 2
Data Privacy and Security	Can you describe any concerns your organization has about data privacy when using AI tools in project management?	How do these concerns influence the decision to adopt or avoid AI technologies in your projects?

Theme (IV)	Question 1	Question 2
	What steps has your organization taken to protect data while integrating AI into project workflows?	How effective do you think your current data protection strategies are in enabling AI use?
Resistance to Change	Have you noticed any hesitation or resistance within your organization when introducing AI for project management?	What do you think are the main reasons behind this resistance?
	What kind of strategies (if any) have been used to help staff adapt to AI tools in project management?	How effective or ineffective were those strategies in addressing resistance to AI?
Cost of AI Implementation	What role do budget constraints play in your organization's decision to adopt AI for managing projects?	How do you assess the balance between the costs and benefits of AI implementation in your projects?
	How does your organization evaluate whether AI implementation is worth the investment?	What kind of financial planning or forecasting is used to justify AI investments in projects?
Compatibility with Existing Infrastructure	How well do your organization's current IT systems integrate with AI tools for project management?	What challenges have you faced in making AI tools compatible with existing infrastructure?
	What preparations or upgrades (if any) were needed to get your organization's systems ready for AI use?	How did these readiness efforts influence the timeline or cost of AI utilization?
Workforce Development	In your experience, are employees sufficiently trained to work with AI tools in project management?	What kinds of skills do you think are missing or need further development?
	What kind of training has your organization provided to support AI adoption?	Has this training made a noticeable difference in how employees use AI tools?

Theme (IV)	Question 1	Question 2
Ethical Considerations	Who is responsible if an AI-driven project decision goes wrong in your organization?	How do you think accountability should be handled when relying on AI for critical project decisions?
	Have you encountered any concerns about bias or fairness in how AI tools make project-related decisions?	What steps should be taken to make AI tools more transparent and trustworthy in project environments?
	How does your organization address regulatory requirements such as SDAIA or national data governance frameworks when implementing AI-based project management tools?	

2. Mediating Variable: AI-Based Project Management: *These questions assess how AI is actually being applied and integrated into project management processes.*

Theme (MV)	Question 1	Question 2
AI-Based Project Management	How is AI currently being integrated into your project management workflows?	Can you share an example where AI changed the way a specific project task or process was handled?
	In your experience, how has AI influenced the way projects are executed or managed?	Has AI improved project execution efficiency, or introduced new challenges?
	How does AI contribute to resource planning or optimization in your projects?	Have you noticed any changes in how resources (time, labor, budget) are allocated due to AI tools?

Theme (MV)	Question 1	Question 2
	Does AI improve communication or collaboration within your project teams? If so, how?	Are there any AI features that help manage stakeholder interactions or meetings?
	How does AI support real-time decision-making during project execution?	Can you give an example of AI-driven insights changing a project decision?
	What role does AI play in tracking project progress and generating reports?	Have AI-based monitoring features helped prevent issues or delays?

3. Dependent Variables: Project Management Outcomes: *These questions examine the actual or perceived results from implementing AI-based practices.*

Theme (DVs)	Question 1	Question 2
Enhancing Decision-Making	In what ways has AI improved the accuracy of your project-related decisions?	Can you share an example where AI helped you avoid a poor decision?
	Do you believe AI tools help in making faster decisions?	How has decision speed affected project outcomes in your experience?
Improving Project Outcomes	Have AI tools contributed to better project deliverables or results?	Which aspect of project outcomes (time, cost, quality) has improved most due to AI utilization?
	How has AI impacted client satisfaction or expectations?	Have stakeholders provided feedback on AI-driven project results?

Theme (DVs)	Question 1	Question 2
Data Collection Accuracy	How has AI changed the way project data is collected and stored?	Are you more confident in your project data now compared to before AI was introduced?
	What measures do AI tools provide to ensure accurate and consistent data?	Has AI helped reduce data-related errors in your project documentation?
Enhancing Data Analysis & Insights	How does AI support you in analyzing complex project data?	Can you describe a case where AI uncovered insights you wouldn't have noticed manually?
	Do you use AI for forecasting project timelines, costs, or risks?	How reliable have these forecasts been in your experience?
Risk Identification Accuracy	Has AI helped identify potential risks earlier in the project lifecycle?	What kind of risks has AI helped you detect that were previously overlooked?
	How does AI support your planning for risk mitigation?	Are there any tools that automatically recommend actions to avoid risks?
Saving Time for Project Managers	What time-consuming tasks have been automated since AI was introduced?	How much time do you think AI saves you on a weekly basis?
	Do you feel AI has freed you to focus more on strategic planning?	How do you reallocate your time now compared to before using AI?
Enhancing Collaboration & Communication	What AI-powered tools do you use for real-time collaboration in your projects?	How have these tools improved teamwork and communication effectiveness?
	How has AI improved communication with clients or upper management?	Can you share an example where AI improved stakeholder satisfaction or understanding?

Factors Influencing AI-Based Project Management and Its Outcomes in Industrial Engineering Projects

"Design and Consultancy Engineering Projects"

العوامل المؤثرة في إدارة المشاريع القائمة على الذكاء الاصطناعي في المشاريع الهندسية الصناعية "
"المشاريع الهندسية التصميمية والاستشارية"

*This questionnaire is designed to collect empirical data to explore the factors influencing the **utilization of AI tools**, their role in **AI-based project management**, and the resulting **project outcomes in design and consultancy engineering projects in Saudi Arabia**.*

تم تصميم هذا الاستبيان لجمع رؤى شاملة حول العوامل المؤثرة على إدارة المشاريع القائمة على الذكاء الاصطناعي في مشاريع التصميم والاستشارات الهندسية في المملكة العربية السعودية

Explanation of the five option for each question

Strongly Disagree – You completely disagree with the statement.

Disagree – You mostly disagree with the statement.

Neutral – You neither agree nor disagree with the statement.

Agree – You mostly agree with the statement.

Strongly Agree – You completely agree with the statement.

Consent Statement:

Before starting, please confirm that you have read and understood the research purpose and consent to participate voluntarily. Your responses will remain anonymous and confidential.

☐ *I agree to participate in this survey.*

Section 1: Demographic Information

1. **Position in Organization:** What is your current job position in design and consultancy projects within your organization?
 - o Top management
 - o Project Manager
 - o Project Engineer
 - o Engineer
 - o Other (please specify)
2. **Years of Experience:** How many years of experience do you have in managing design and consultancy projects?
 - o Less than 1 year
 - o 1–3 years
 - o 4–6 years

- o 7–10 years
 - o Over 10 years
- 3. **Organization Size:** Which of the following best describes your organization's size?
 - o Small (<50 employees)
 - o Medium (50–249 employees)
 - o Large (250+ employees)
- 4. **Level of Familiarity with AI Tools:** What is your level of familiarity with AI tools in design and consultancy project management?
 - o Not familiar at all
 - o Somewhat familiar
 - o Moderately familiar
 - o Highly familiar

Note; If Q4 (“Level of Familiarity”) = “Not familiar” → Skip Q5

- 5. **AI Tools Used:** What types of AI tools or software does your organization currently use in design and consultancy projects (if any)?
 - o Decision-making tools
 - o Quality tools
 - o Data Collection tools
 - o Data Analysis tools
 - o Risk Identification tools
 - o Communication tools
 - o Other (please specify)

Section 2: Independent Variables

Data Privacy and Security

6. Our organization has clear policies and procedures ensuring AI-based project management complies with data privacy and security regulations?

- 1. Strongly Disagree
 - 2. Disagree
 - 3. Neutral
 - 4. Agree
 - 5. Strongly Agree
- 7. AI-based project management in our organization faces challenges in ensuring data security and protecting sensitive information?

1. *Strongly Disagree*
2. *Disagree*
3. *Neutral*
4. *Agree*
5. *Strongly Agree*

Resistance to Change

8. **Employees in my organization are supportive of adopting AI-based project management tools?**

1. *Strongly Disagree*
2. *Disagree*
3. *Neutral*
4. *Agree*
5. *Strongly Agree*

9. **There is resistance among employees toward integrating AI into project management practices?**

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

Cost of Implementation

10. **The cost of AI implementation is a significant barrier in my organization?**

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

11. **The benefits of AI-based project management outweigh its implementation costs?**

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

Compatibility with Existing Infrastructure

12. Our current infrastructure is technically compatible with AI-based project management tools?

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

13. Integrating AI into our current infrastructure presents technical challenges?

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

Workforce Development

14. Our organization provides adequate training and skill development to use AI-based project management tools effectively?

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

15. Lack of adequate training limits the effective utilization of AI-based project management tools?

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

Ethical Considerations

16. My organization follows ethical guidelines and policies for the responsible use of AI-based project management tools?

1. Strongly Disagree

2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

17. Ethical risks (e.g., bias, transparency, accountability) are a concern in our organization's AI-based project management practices.?

1. Strongly Disagree
 2. Disagree
 3. Neutral
 4. Agree
 5. Strongly Agree
-

Section 3: Mediating Variable; Project Management via Artificial Intelligence

Streamline processes e.g., scheduling, documentation

18. AI tools are utilized to support project planning and scheduling.

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

19. AI tools are utilized to prepare and manage project documentation and reports.

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

Resource allocation

20. AI tools are utilized to forecast resource requirements (staff, equipment, materials).?

1. Strongly Disagree
2. Disagree

3. Neutral
4. Agree
5. Strongly Agree

21. AI tools are utilized to allocate resources based on project needs and priorities?

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

Tasks Prioritizing

22. AI tools help prioritize tasks based on urgency, dependencies, or workload.

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

23. AI tools support updating and optimizing schedules during project execution.?

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

Progress reporting

24. AI tools support real-time tracking of project progress and performance.

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

25. AI tools improve the accuracy and timeliness of progress reporting.

1. Strongly Disagree

2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

Communication and coordination

26. AI-enabled platforms facilitate communication among project stakeholders.

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

27. AI-enabled platforms improve coordination of tasks and information across teams.

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

Section 4: Dependent Variables

Decision-Making

28. AI tools improve the accuracy of decision-making in design and consultancy projects.

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

29. AI tools enhance the speed of decision-making for project managers.

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

Project Quality

30. The use of AI contributes to higher quality deliverables in project management.

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

31. AI improves the consistency and reliability of project outputs.

1. Strongly Disagree
 2. Disagree
 3. Neutral
 4. Agree
 5. Strongly Agree
-

Data Collection Accuracy

32. AI-based tools improve the accuracy of collecting project-related data.

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

33. AI reduces errors in recording or documenting project data.

1. Strongly Disagree
 2. Disagree
 3. Neutral
 4. Agree
 5. Strongly Agree
-

Enhancing Data Analysis and Insights

34. AI tools provide valuable insights through advanced analysis of project data.

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree

5. Strongly Agree

35. AI help identify useful pattern and trend that support project improvements.

1. Strongly Disagree
 2. Disagree
 3. Neutral
 4. Agree
 5. Strongly Agree
-

Risk Identification Accuracy

36. AI tools improve the identification of potential risks in projects.

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

37. AI helps assess the likelihood and impact of identified risks more accurately.

1. Strongly Disagree
 2. Disagree
 3. Neutral
 4. Agree
 5. Strongly Agree
-

Saving Time for Project Managers

38. AI helps save time for project managers in routine tasks (e.g., reporting, scheduling).

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

39. AI reduces delays by improving task allocation and monitoring.

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

Effective Communication

40. **AI enhances collaboration among team members in design and consultancy projects.**

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

41. **AI tools improve communication and knowledge-sharing across project stakeholders.**

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

Section 5: Open-Ended Questions

42. What are the most significant challenges your organization faces in the **utilization of AI tools** in project management for design and consultancy engineering projects?

43. In your opinion, what changes whether organizational, technical, or regulatory would support more effective **utilization of AI-based project management**?

44. What tangible or intangible benefits has your organization experienced from utilizing **AI-based project management practices**?

45. What recommendations would you propose to enhance the **utilization and outcomes** of AI-based project management in the Saudi design and consultancy sector?

46. Do you think organization size, sector type, or the demographic profile of project managers affect the utilization or outcomes of AI in project management?

47. If yes, please explain how."