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Integration of Artificial Intelligence Applications and Knowledge Management Processes for Construction Projects Management

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Abstract

Artificial intelligence systems have gained access to various scientific and research fields, especially in the construction industry. The study seeks to confirm the vital role of introducing Knowledge Management (KM) integrated with Artificial intelligence (AI) applications in the projects. It requires qualifying engineers and imposing their current qualifications to achieve the benefits of Integration of AI Applications based on KM processes to perform their professional roles and recognize the need to develop their capabilities through training and development. The field survey was intended only for 85 engineers working on construction projects (public and private sectors). Three axes were clarified to allocate the extent of the sample response and determine the benefits of using the KM process and AI applications for the success of construction projects. The results showed a positive relationship between the demographic variables of the response and the benefit of using the KM process and AI applications and explaining the variance in the regression relationships. Therefore, the study suggests integrating AI applications based on the KM process to achieve business goals and effectively benefit and exchange management, as its use leads to faster and more effective decision-making, especially if the project strategy approves it.

Keywords: Knowledge Management; Artificial Intelligence; construction; Correlation; Regression.

1. Introduction

Knowledge is vital in our daily lives, whether at the personal level or within institutions; knowledge enables us to understand the world around us and make the right decisions effectively. It is luxurious, as the information, experiences, skills, and capabilities of the individual or organization enable them to make the correct decisions and behaviors promptly. It includes scientific, experimental, cultural, social, technical, administrative, and other knowledge. Knowledge is constantly changing and evolving due to updates, innovations, and changes in society, culture, technology, economics, science, and modern technologies. So, knowledge management is the process of identifying, collecting, organizing, analyzing, distributing, and using knowledge in an organization and includes the creation and improvement of systems, methods, and operations to collect, share, and use knowledge within the organization [1].

The use of information, data, knowledge, skills, and abilities inherent within organizations is one of the most important reasons for their success, in addition to the organization's ideas, commitment, and motives in making good decisions, which is evidence of this organization's distinctive environment. Therefore, organizations are interested in implementing KM processes and techniques as an integral part of comprehensive development strategies for their increasingly important role in global economic development [2].

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In our current era, AI applications are assuming increasing importance due to their possession of the keys to the fundamental processes of explicit knowledge in attracting, storing, sharing, and spreading, doubling the value of data and information, and employing them in supporting knowledge management, which has exceptionally increased in importance and area in recent years thanks to unlimited capabilities in construction projects [3].

Applying AI techniques to construction projects gives the project manager more control and better management of all project phases. Human error by project managers is one of the inherent problems facing project management, which leads to project failure. The application of AI techniques in any project phase can lead to improving accuracy, forecasting, and addressing administrative and technical errors in projects whose benefits have become apparent, especially in dealing with uncertainty, improving efficiency, scheduling, stakeholder management, and improving cost management in engineering, procurement, and construction (EPC) projects [4].

However, the problem of integrating the use of AI applications with the concept of KM faces many challenges, and this is clear from the different percentages of variation between workers in the construction industry sector, especially engineers, in how to apply it in the project work.

The engineers need to be able to use AI applications to complement their experience in KM. It requires studying a set of demographic characteristics for engineers and knowing the extent to which these characteristics affect the ability of engineers to use artificial intelligence applications with knowledge management to achieve the goals required for the success of projects. It is what the current study is seeking to find out.

2. Literature Review

Many scientific studies have reviewed the discovery of AI and its role in enhancing KM systems and practices through various methods that support appropriate decision-making. Some studies have focused on the overall benefits and available opportunities that can significantly facilitate the work of construction sector organizations.

The study referred to many scientific publications in the past century that studied the topic of AI-PM, indicating that the construction sector is the sector most affected by AI due to the nature of massive projects in this sector, which are characterized by their complexity. Multiple studies have dealt with artificial intelligence significantly in planning and measurement processes, predicting project time, studying uncertainty, studying safety issues, project delivery, predicting project status, and many other applications and fields in various project phases and within multiple scenarios supported by artificial intelligence.

Anumba & Khallaf's study reported the benefits of using AI-based knowledge management through different vital technologies that facilitate knowledge management in the construction field by classifying some artificial intelligence techniques for organizational knowledge management processes and systems. The most important benefits are the ease of matching knowledge with problems, retrieving data quickly, increasing the ability to create new knowledge, improving knowledge evaluation, increasing capital, greater flexibility in representing knowledge, ease of participation, and improving the decision-making process [5]. Igbinovia & Ikenwe's study recommended the need to encourage organizations to create knowledge through scientific methods supported by artificial intelligence, with the need to support research activities and encourage cooperation and teamwork between individuals and institutions [6].

Ramaj & Pjero's study also recommended deepening knowledge about information technology through training or special courses. Especially in light of the increasing use of information systems in all sectors and different industries in which there is business through mutual interaction between professional bodies and universities [7]. Karki & Hadikusumo's study was conducted to find the competency factors of project managers in Nepal by developing a predictive model of project manager performance using a machine learning approach in medium-sized construction projects. The study determined that project managers must have high competence in leadership skills, personal characteristics, team development and delegation, communication, technical, problem-solving, and relationship management skills [8].

The workers must connect with knowledge management while developing their abilities to use artificial intelligence, which requires new skills, competencies, and capabilities. It calls for enhancing perceptions, skills, and work practices so that workers can benefit from their knowledge management partners while avoiding risks. These early preparations by organizations help apply the capabilities of artificial intelligence based on knowledge management processes, which is only achieved through an effective symbiotic partnership between workers in knowledge management and intelligent systems [9].

Therefore, our study seeks to clarify the impact of applying knowledge management based on artificial intelligence and to reveal the various goals that must be met for the success of investment projects by shedding light on scientific methods for managing investment construction projects and arriving at methods that help control projects. Successful application can only be achieved after providing a qualified cadre of engineers who can develop their skills using artificial intelligence in the stages of knowledge management. It requires knowing the biographical characteristics of engineers and their relationship with the success of the integration method to achieve the project goals.

3. Methodological Framework

The flow chart in Figure 1 explains the methodology of the study, which consists mainly of the Conceptual Framework for the theoretical application and the practical study to finalize the test of the two hypotheses for the study. As mentioned below:

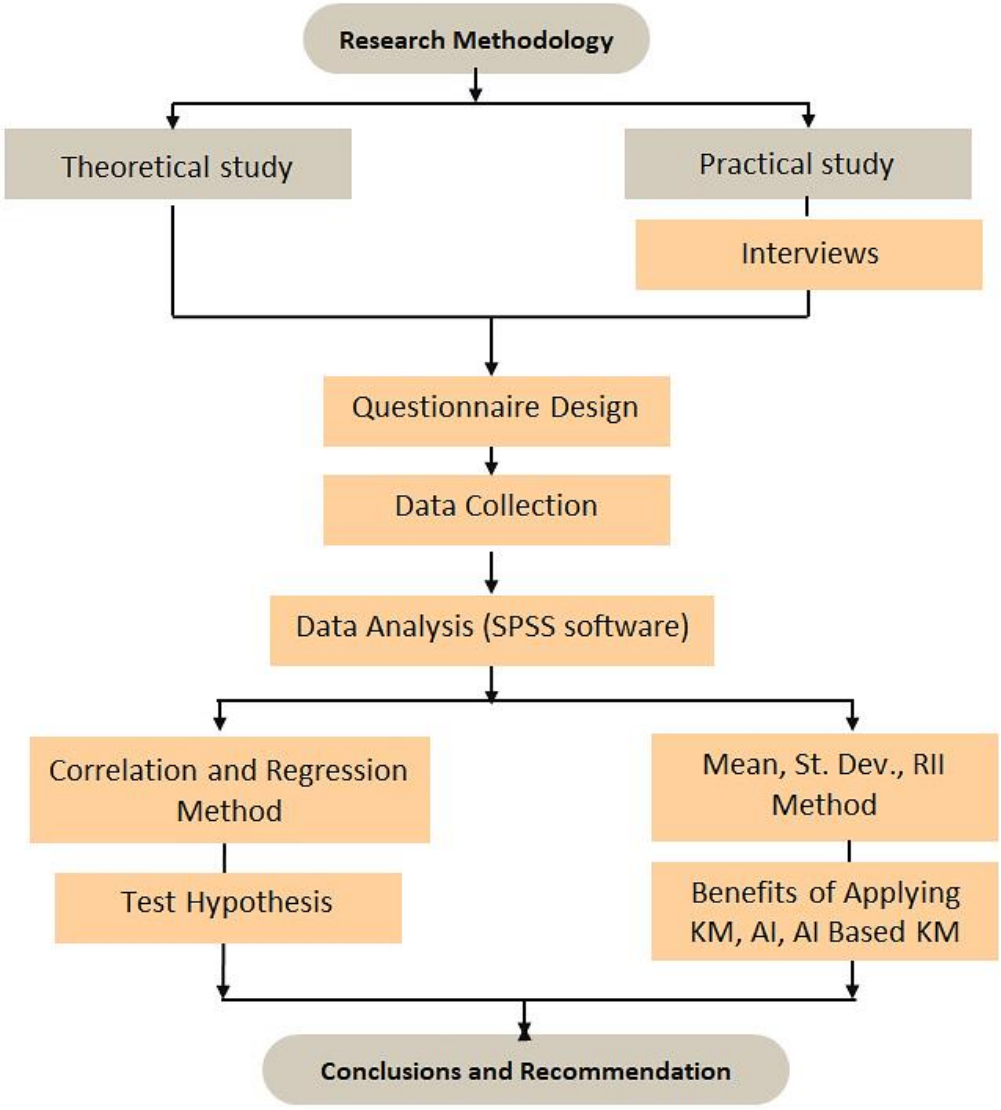

Figure 1. Flow chart of the study

3.1. Problem, Justification and Objectives of the Study

Investment projects must improve using AI applications based on KM processes at all project stages. The different demographic characteristics of engineers may contribute to significant skills and abilities to use AI integrated with the KM process, in addition to determining the level of training necessary to improve engineers' skills and professional capabilities.

After recent technological development, the construction industry has flourished in Iraq to carry out and develop the construction industry in a way that serves the country's interests, especially after the disclosure of the strategic Iraqi plan for the year 2030 and the beginning of the work to reconstruct the liberated cities. Various construction projects have worked on the inclusion and application of all modern technologies in the rehabilitation and implementation of construction projects, which will inevitably lead to an upgrade in the performance of construction projects and identify the main obstacles facing the management of construction projects and address their causes.

Determine the relationship type between the applying AI applications based on KM with the performance and qualifications of engineers. This can help to address the project problems, especially delays in cost and time overruns, treat the challenges, and help in completing the project activities in a shorter time with a lower cost within the required quality. The correlation type will also determine the qualifications required for engineers to work for construction companies seeking unique distinctions within the current competition in the construction industry.

The following are the main objectives can be clarified:

a) Detecting the benefits of applying the KM process in construction project management in Iraq.

b) Detecting the benefits of applying AI applications in construction project management in Iraq.

c) Detecting the benefits of integrating AI Applications and KM processes for construction project management in Iraq.

d) Recognizing the correlation between demographic variables and the integration of AI Applications and KM processes for construction project management in Iraq from the engineers' point of view.

e) Interpreting the variation in the regression relationships between demographic variables and the integration of AI Applications and KM processes for construction project management in Iraq from the engineers' point of view.

3.2. Hypotheses of the Study

The study states two hypotheses:

1st Hypothesis: There is a positive correlation between the demographic variables for engineers (Age, Qualification, Current Position, and Years of Experience) and:

a) The Benefits of applying the KM process in the construction projects management.

b) The Benefits of applyingAI applications in the construction projects management.

2nd Hypothesis: There is a statistically significant effect for the demographic characteristics of the engineers (Age, Qualification, Current Position, and Years of Experience) and:

a) The Benefits of applying the KM process in the construction projects management.

b) The Benefits of applyingAI applications in the construction projects management.

3.3. Methodology of the Study

The analytical descriptive approach and the deductive approach were adopted to address the impact of the application for integrating AI applications and KM processes for construction project management in Iraq from the engineers' point of view in Iraq.

The practical study was applied to a random sample of public and private sectors in Iraq from a selected sample of engineers; the study clarifies various benefits from statistical results to link various factors and influences that led to the integrated relationship results. Statistical Package for the Social Sciences (SPSS-version 25) was used to analyze and process the data contained and test the hypotheses' validity.

4. Conceptual Framework

The study's conceptual framework will focus on two crucial axes, knowledge management (KM) and Artificial Intelligence (AI), by focusing on various theoretical foundations and concepts.

4.1. Knowledge Management (KM) Concepts

KM is a multidisciplinary business model that deals with all aspects of knowledge in all companies, including knowledge creation, codification, sharing, and imparting to enhance learning and innovation. All technological tools and organizational procedures that can contribute to the success of organizations must be included [10].

4.1.1. Definition of KM

KM is defined as "planning, organizing, controlling, coordinating, and synthesizing knowledge and assets related to intellectual capital, operations, personal and organizational capabilities, and capabilities, so that the greatest possible positive impact on the results of competitive advantage is achieved, and KM includes achieving the process of sustainability of knowledge and capital intellectual money and its exploitation [11]. It is also defined as the ability of knowledge to create new knowledge, disseminate it throughout the organization, and embody it in products and services [12].

4.1.2.KM Processes

KM has several processes that differ according to their inputs. The researchers unanimously agreed that there are six essential processes for KM, namely: diagnosing knowledge, defining knowledge goals, generating knowledge, storing knowledge, distributing it, and finally applying it, which can be explained in detail as follows [13].

A) Knowledge Acquisition and Generation

The process of acquiring knowledge can be defined as obtaining knowledge from various sources (experts, specialists, competitors, customers, databases, or through the archives of the organization) using performance measurement methods, attending conferences and workshops, using experts, periodicals, publications, email, and individual learning [14]. It is possible to obtain knowledge sometimes by chance, provided that the importance of this knowledge is realized through various methods such as storage and retrieval in a better way to achieve the desired benefit, and this method differs from one organization to another, provided that it is understood in its way because it has a substantial impact on the culture of the organization and its style in managing the approach to knowledge acquisition that is required to achieve the success of the organization [15].

B) Knowledge Storage

After the Knowledge Acquisition process, it is stored in many ways; the most essential storing ways are:

1) Organizations can record everything that happens for all information in a specific place as individual records, like regular files or on a computer network. It is available for all organization members to view the information if they want it in the needed time [16].
2) A responsible person stores information accurately by collecting it in a manner that is easy to use by everyone if they want to view it, without caring about analyzing knowledge and being able to disseminate and circulate it effectively. All individuals can provide their knowledge to any person or department if they want to view it in time. Nevertheless, this entity should analyze and purify the knowledge, then store it in the best and most accurate manner so the organization or a specific responsible person can easily circulate it.
3) Collect knowledge in an organized manner, analyzed and purified. It is arranged, coordinated, and fragmented to be stored in the best way, but taking this into account, it must be quickly circulated, published, and extracted accurately and efficiently by any individual working in the organization [17].

C) Knowledge Sharing

The third loop in KM circles is knowledge transfer; it depends on the presence of formal and informal methods and applicable mechanisms. "Informal methods may include job changes inside or outside the organization, personal relationships that bind workers to each other, and work teams [18]. Many factors affect the transfer of knowledge in the organization, like cost "when purchasing devices, using technology, holding conferences and seminars, and the transfer of knowledge can be affected by the potential of content change in light of the structure of the hierarchical organizational structure [6].

D) Knowledge Application

The application of knowledge is the primary goal of the KM process. This application requires organizing knowledge (through classification, indexing, or appropriate tabulation of knowledge), knowledge retrieval (by enabling employees in the organization to access it quickly and in the shortest time) and making knowledge ready for use (deleting some inconsistent parts, re-correcting and constantly examining knowledge, introducing new and appropriate ones, and excluding obsolete ones [18]. That is, the knowledge must be used functionally and effectively to fill a void or need. KM has proven through its practical applications and, in many situations, that it is the fastest and easiest way to add value to the organization and individuals [19, 20].

4.2. Artificial Inelegant (AI) and Its Conditions

AI is the product of 2,000 years of traditions of philosophy, perception, and learning theories and 400 years of mathematics that led to the possession of theories in logic, probabilities, and computing, in addition to a long history of the development of psychology and what revealed the capabilities and workings of the human brain [21].

4.2.1. Definition of AI

AI is defined as computing systems that can participate in human-like processes such as learning, adaptation, synthesis, self-correction, and the use of data to process complex tasks. It has become clear how AI has changed the performance of jobs and tasks in various fields, and many experts predict that by 2030, more than 80% of repetitive tasks will be eliminated by intelligent machines. The application of AI in the construction industry, based on previous knowledge, is nothing new and has proven successful in various fields [22].

Artificial intelligence aims to solve problems in various disciplines in a manner similar to human methods by creating images and texts and making decisions based on stored data. This means that any organization can integrate artificial intelligence capabilities into various applications to improve business, accelerate decision-making, and stimulate innovation [23].

4.2.2. AI Terms

There must be three main elements of AI are implemented correctly, and they are mainly represented in the following:

a) The ability to learn this information from statement to information to knowledge, after the growth of his intelligence abilities in analysis and deduction, then the ability to maneuver and choose from among the available alternatives [24].

b) The possibility of collecting and analyzing data and information is the ability to visualize relationships between this information and data, especially in light of the increasing spread of giant data available on databases [25].

c) Making decisions based on analyzing information is the stage of making intelligent decisions among several options and not relying on just one algorithm to achieve a specific goal [26].

5. Field of the Study

Field study consists from the following procedures:

5.1. Design the Study Questionnaire

To facilitate field study procedures and collect and analyze data to complete the field side of the study, a questionnaire was prepared in a way that helps collect data and obtain accuracy in its design with what was covered in the theoretical side as well as previous studies and the clarity of the questions and phrases of the questionnaire to enable the sample members to answer them objectively.

The current study relied on a structure similar in design to a previous study conducted to reveal the impact of knowledge management processes based on artificial intelligence software when applied to construction projects in the Kingdom of Saudi Arabia and on a group of study factors that were added to the axes of the questionnaire. It is worth noting that the Alghamdi & Al-Dirman study recommended enhancing the application of knowledge management based on artificial intelligence software to solve the problems of delayed completion of construction projects, as well as the need for financial attention, and striving to improve project efficiency while sharing and applying knowledge that supports knowledge management processes [27]. That is what our current study is trying to prove, but from the point of view of engineers working on Iraqi construction projects. It concluded by constructing a questionnaire that includes two parts, as follows:

- The first part includes personal data related to the general characteristics of the study sample members, including age, qualification, current position, and years of experience.
- The second part is divided into three dimensions, as follows:

  a) The Benefits of applying the KM process (15 elements).

  b) The Benefits of applyingAI applications (17 elements).

  c) The Benefits of applying an integrated combination of KM and AI applications (18 elements).

5.2. Select Sample of the Study

The study depended on a deliberate sample, including a group of engineers working in various construction companies in the public and private sectors in various construction sectors in Iraq. The study sample was distributed to 100 questionnaires for engineers characterized by high professionalism and efficiency. After retrieving and sorting them, it was found that 85 questionnaires were suitable for statistical processing.

5.3. Internal Consistency

Internal consistency, or the study's validity, is that the questionnaire questions perform and measure what they were designed to measure [28]. It means the clarity of the questionnaire, its vocabulary, the questionnaire paragraphs, and its comprehensibility to the members of the study sample who will be included in the questionnaire, as well as the questionnaire paragraphs being for statistical analysis. Internal consistency can also be defined as the degree of interconnection of each scale factor with the total result of the total scale to which the phrase belongs [29, 30].

The questionnaire was distributed to ten (10) experts from academics and engineers in the public and private sectors to perform and measure what the questionnaire was designed to measure, the clarity of the questionnaire, vocabulary, elements of a questionnaire, and its concept for the study.

Tables 1 to 3 show a summary of the results, which showed a statistically significant relationship between the elements of each axis. The questionnaire designed for the study has a high degree of internal consistency.

Table 1. Validity of the internal consistency for KM Process Benefits

No.	Dimensions and axes of the study	Correlation with the total	
		Pearson Correlation	Sig
1	Improve the decision-making process	0.923**	0.000
2	Follow up on the implementation of the project plan	0.931**	0.000
3	Continuous improvement of operations	0.911**	0.000
4	Improve the efficiency of tasks or activities	0.949**	0.000
5	Contribute to improving teamwork	0.960**	0.000
6	Reduce the company's costs and prepare the project budget	0 .962**	0.000
7	Control project time planning	0 .948**	0.000
8	Improve the quality of products and services	0.949**	0.000
9	Exchange experiences between employees and communication	0.903**	0.000
10	Share information among stakeholders	0.951**	0.000
11	Reduce the risks of tasks/activities	0.940**	0.000
12	Describe procedures within the organisation	0.949**	0.000
13	Prove methods to feature KM in construction projects	0.923**	0.000
14	Recourse allocation and analysis	0.947**	0.000
15	Develop quality control on the spot	0.965**	0.000

**: A significant relationship between the statement and the total score of its axis.

Table 2. Validity of the internal consistency for AI Applications Benefits

No.	Dimensions and axes of the study	Correlation with the total	
		Pearson Correlation	Sig
1	Learn the best practices	0.913**	0.000
2	Prepare and issue the predictive reports	0.961**	0.000
3	Provide recommendations to address the causes of the delay	0.912**	0.000
4	Prepare purchasing management automatically	0.936**	0.000
5	Link resources with project activities	0.901**	0.000
6	provide a project uncertainty assessment	0 .953**	0.000
7	provide a project risk management and analysis	0 .948**	0.000
8	Plan performance and analysis for projects	0.946**	0.000
9	provide a project time management and analysis	0.913**	0.000
10	Issue alerts when the project deviation	0.937**	0.000
11	Introduce safety oversight for construction tasks	0.942**	0.000
12	Introduce cost estimation and management	0.944**	0.000
13	learn to develop local practices	0.925**	0.000
14	Prepare the budget for bidding properly	0.938**	0.000
15	Familiarise the relevant legislation for the project	0.928**	0.000
16	Selecting the materials or equipment	0.897**	0.000
17	Develop quality control on the spot	0.902**	0.000

**: A significant relationship between the statement and the total score of its axis.

Table 3. Validity of the internal consistency for Integrated AI & KM Benefits

No.	Dimensions and axes of the study	Correlation with the total	
		Pearson Correlation	Sig
1	Compliance with the project implementation plan	0.913**	0.000
2	Match the contractor's capabilities to the requirements of the project	0.814**	0.000
3	Improve the implementation of the KM system	0.771**	0.000
4	Enhance the significant amount of project time	0.681**	0.000
5	Resolve expected risks in projects for all parties	0.823**	0.000
6	Match the achieved costs with the estimated cost	0.842**	0.000
7	Facilitate the difficulties in the contractor's financial	0.815**	0.000
8	Enhance site supervision	0.789**	0.000
9	Improve the competence of the project manager	0.698**	0.000
10	Improve communication between project parties	0.814**	0.000
11	Set up the Violations with subcontracting parties	0.791**	0.000
12	Prove methods to feature KM in construction projects	0.781**	0.000
13	Focus on the individual level rather than the team level	0.845**	0.000
14	Enhance sharing knowledge	0.872**	0.000
15	Apply the necessary technological infrastructure to implement it	0.865**	0.000
16	Gather scattered information systems and various technological means	0.799**	0.000
17	Improve time and extra workload	0.812**	0.000
18	Clarify unknown concepts to the contractor and the engineers	0.0903**	0.000

**: A significant relationship between the statement and the total score of its axis.

The correlation coefficients shown in the tables above on the three axes are characterized by internal consistency, as the correlation relationship is statistically significant. The Sig. value (the significance level) of the statistical values of the Pearson correlation coefficients calculated in each dimension is less than the 0.05 significance level, indicating a relationship between the study axes for each axis.

5.4. Reliability of the Study

The concept of reliability refers to the ability of an instrument to measure what it is designed to measure over different periods. Cronbach's alpha coefficient was used to determine the stability of the study tool [31, 32].

Table 4 indicates the results of Cronbach's alpha coefficient values for all study axes, which were more significant than 0.7; this indicates that the study tool has high stability and reliability [33]. The questionnaire for the study has reliability.

Table 4. coefficients of Cronbach's alpha

Dimensions and axes of the study	No. of elements	Cronbach's alpha coefficient
Benefits of applying the KM process	15	0.923
Benefits of applying AI applications	17	0.907
Benefits of applying an integrated combination of KM and AI	18	0.929

5.5. Statistical Methods

SPSS was used to collect and analyze the data from the study. Many statistical methods commensurate with the nature of the data were used [34]. These methods are Arithmetic Mean, Standard Deviation, Relative Important Index, Correlations between the Variables, and Multiple Regressions Analysis.

6. Statistical Results

The following are the final results that will be adopted to verify the research hypotheses.

6.1. Demographic Characteristics

Table 5 reviews the different characteristics of the sample distribution stated in the questionnaire under study. It includes (Age, Qualification, Current Position, and Years of Experience) and they represent in Figure 2.

Table 5. Demographic characteristics

Variable	Category	frequency	%	Accumulative per cent
Age	21-30	16	18.82	18.82
	31-40	17	20	38.82
	41-50	20	23.53	62.35
	More than 51	32	37.65	100
Qualification	Diploma	14	16.47	16.47
	Bachelor's	33	38.82	55.29
	Master's	24	28.24	83.53
	PhD	14	16.47	100
Current position	Director general	6	7.06	7.06
	Project manager	17	20	27.06
	Advisor	20	23.53	50.59
	Site engineer	42	49.41	100
Years of Experience	Less than 5 yr.	21	24.71	24.71
	6-10	19	22.35	47.06
	11-15	18	21.18	68.24
	16-20	15	17.65	85.89
	More than 20	12	14.12	100

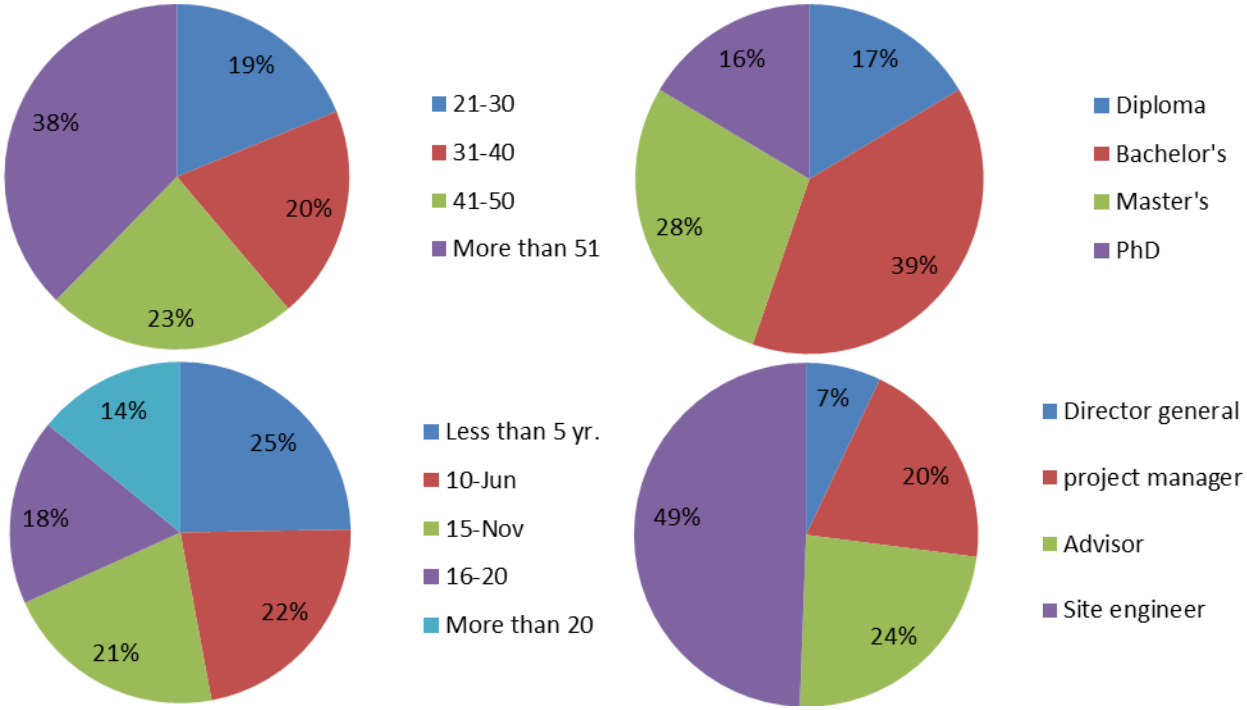

Figure 2. Demographic characteristics

6.2. Results and Descriptions

6.2.1. Mean, Standard Deviation, and Relative Important Index Results

A. Benefits of applying the KM process in construction project management:

This axis dealt with 15 objectives to determine how the sample used the KM process in the construction work. Table 6 refers to the Arithmetic Mean, Standard Deviation, Variance, and Relative Important Index (RII) results. There was high agreement among the respondents to all objectives of this axis, as the percentage reached the axis (77.64%). The five most essential percentages of the sample's responses to the objectives of this axis are: contribute to improving teamwork (85%), improve the efficiency of tasks or activities (82.8%), exchange experiences between employees and communication (82.6%), continuous improvement of operations (82.4%), and follow up on the implementation of the project plan (82.4%).

Table 6. Statistical Results for the Benefits of Applying KM Process

No.	Objective	Std. Deviation	Mean	RII%	Ranking
1	Improve the decision-making process	1.28	4.07	81.4	7
2	Follow up on the implementation of the project plan	1.349	4.12	82.4	5
3	Continuous improvement of operations	1.051	4.12	82.4	4
4	Improve the efficiency of tasks or activities	1.002	4.14	82.8	2
5	Contribute to improving teamwork	0.937	4.25	85	1
6	Reduce the company's costs and prepare the project budget	0.988	4	80	9
7	Control project time planning	0.919	4.01	80.2	8
8	Improve the quality of products and services	1.156	3.79	75.8	11
9	Exchange experiences between employees and communication	0.997	4.13	82.6	3
10	Share information among stakeholders	1.128	3.88	77.6	10
11	Reduce the risks of tasks/activities	1.128	4.12	82.4	6
12	Describe procedures within the organisation	1.106	3.78	75.6	12
13	Prove methods to feature KM in construction projects	1.020	3.11	62.2	15
14	Recourse allocation and analysis	0.989	3.50	70.0	13
15	Develop quality control on the spot	1.012	3.21	64.2	14
	Total		**3.882**	**77.64**	**High**

B. Benefits of Applying AI applications in construction projects management:

This axis dealt with 17 different objectives to determine the percentages of AI applications used in the management and follow-up of projects. Table 7 refers to the Arithmetic Mean, Standard Deviation, Variance, and Relative Important Index (RII) results. There was high agreement among the respondents to all objectives of this axis, as the percentage reached the axis (80.44%). The five most essential percentages of the sample's responses to the objectives of this axis are: prepare and issue the predictive reports (92.4%); learn the best practices (87.6%); link resources with project activities (85.6%); introduce safety oversight for construction tasks (84%); and prepare purchasing management automatically (83.8%).

Table 7. Statistical Results for the Benefits of Applying AI Applications

No.	Objective	Std. Deviation	Mean	RII%	Ranking
1	Learn the best practices	0.899	4.38	87.6	2
2	Prepare and issue the predictive reports	0.723	4.62	92.4	1
3	Provide recommendations to address the causes of the delay	1.028	4.12	82.4	8
4	Prepare purchasing management automatically	0.945	4.19	83.8	5
5	Link resources with project activities	0.881	4.28	85.6	3
6	provide a project uncertainty assessment	0.957	4.01	80.2	10
7	provide a project risk management and analysis	0.926	4.02	80.4	9
8	Plan performance and analysis for projects	0.957	4.01	80.2	11
9	provide a project time management and analysis	0.937	4.16	83.2	7
10	Issue alerts when the project deviation	1.067	3.93	78.6	12
11	Introduce safety oversight for construction tasks	1.021	4.2	84.0	4
12	Introduce cost estimation and management	1.091	3.8	76.0	15
13	learn to develop local practices	1.082	3.92	78.4	13
14	Prepare the budget for bidding properly	1.045	4.16	83.2	6
15	Familiarise the relevant legislation for the project	1.067	3.80	76.0	14
16	Selecting the materials or equipment	1.102	3.50	70.9	16
17	Develop quality control on the spot	1.072	3.23	64.6	17
	Total		**4.02**	**80.44**	**High**

C. Benefits of applying an integrated combination of KM and AI in construction projects management:

This axis dealt with 18 different objectives to determine the benefits and impacts of using the integrated combination of KM and AI in construction projects related to the engineers' view. Table 8 refers to the Arithmetic Mean, Standard Deviation, Variance, and Relative Important Index (RII) results. The respondents agreed highly to all reasons for this axis, as the percentage reached the axis (77.37%). The results were arranged in ascending order, depending on the five most essential percentages of the sample's responses to the objectives of this axis are: "Compliance with the project implementation plan (92.5%), Resolve expected risks in projects for all parties (89.9%), Gather scattered information systems and various technological means (85.3%), Enhance the significant amount of project time (85.1%), and Apply the necessary technological infrastructure to implement it (83.5%)".

Table 8. Statistical Results for the Benefits of the Integration of AI Applications based on KM

No.	Objective	Std. Deviation	Mean	RII%	Ranking
1	Compliance with the project implementation plan	0.676	4.627	92.5	1
2	Match the contractor's capabilities to the requirements of the project	0.885	3.675	73.5	12
3	Improve the implementation of the KM system	0.866	3.928	78.6	9
4	Enhance the significant amount of project time	0.895	4.253	85.1	4
5	Resolve expected risks in projects for all parties	0.846	4.494	89.9	2
6	Match the achieved costs with the estimated cost	0.970	3.6386	72.8	13
7	Facilitate the difficulties in the contractor's financial	0.997	3.699	74.0	11
8	Enhance site supervision	0.934	4.072	81.4	7
9	Improve the competence of the project manager	1.025	3.59	71.8	14
10	Improve communication between project parties	0.989	3.29	65.8	17
11	Set up the Violations with subcontracting parties	1.045	3.41	68.2	15
12	Prove methods to feature KM in construction projects	0.926	3.26	65.2	18
13	Focus on the individual level rather than the team level	0.981	3.988	79.8	8
14	Enhance sharing knowledge	0.872	4.084	81.7	6
15	Apply the necessary technological infrastructure to implement it	0.885	4.181	83.6	5
16	Gather scattered information systems and various technological means	0.938	4.265	85.3	3
17	Improve time and extra workload	0.857	3.855	77.1	10
18	Clarify unknown concepts to the contractor and the engineers	1.012	3.32	66.4	16
	Total		**3.868**	**77.37**	**High**

The results also indicate how the demographic characteristics of the sample affect achieving the benefits of applying knowledge management and artificial intelligence applications. There are clear variations and differences depending on the category of the sample. Figure 3 indicates that the current generation of engineers (age from 21 to 30) excels in using artificial intelligence in their work in parallel with the use of knowledge management. This will lead to a huge stimulation of integration between the two axes. Therefore, age has an inverse relationship with the axes of the study.

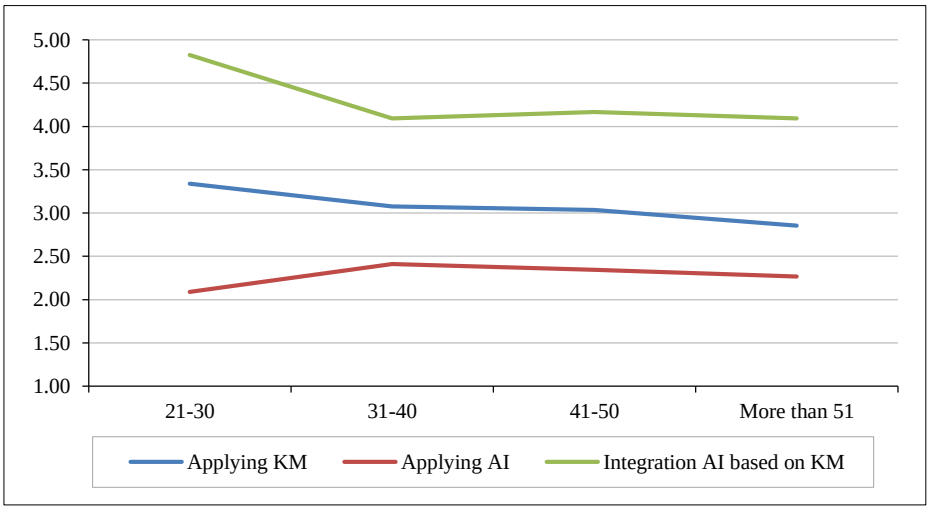

Figure 3. Effect of age category

As for Figure 4, academic achievement has an important role in achieving the goal; the relationship is linear with the study axes.

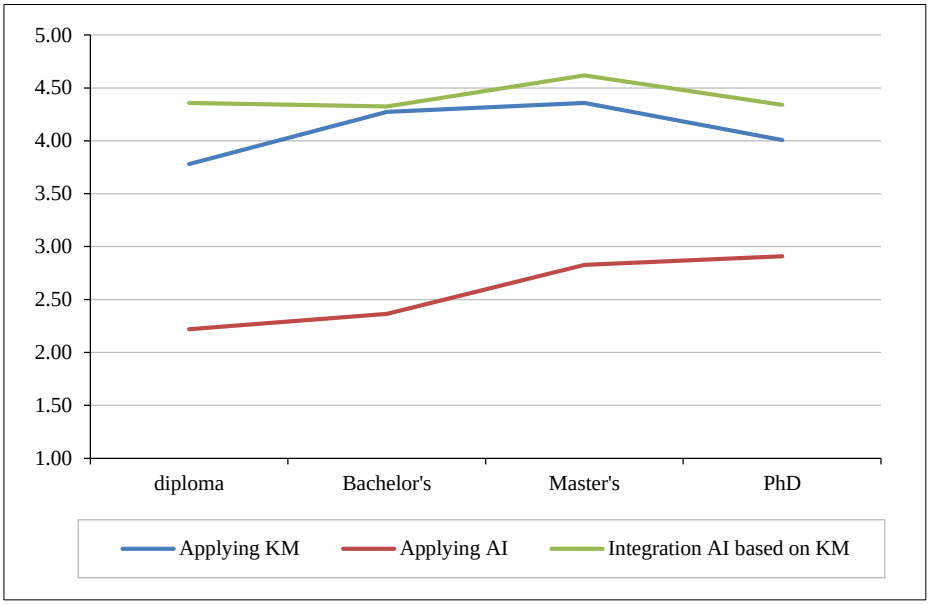

Figure 4. Effect of Qualification category

However, Figure 5 notices a diverse relationship with the current job position of the engineer, and this is good and fits with their responsibilities for managing construction tasks. But the project manager has an important role in achieving high points for the three axes under study.

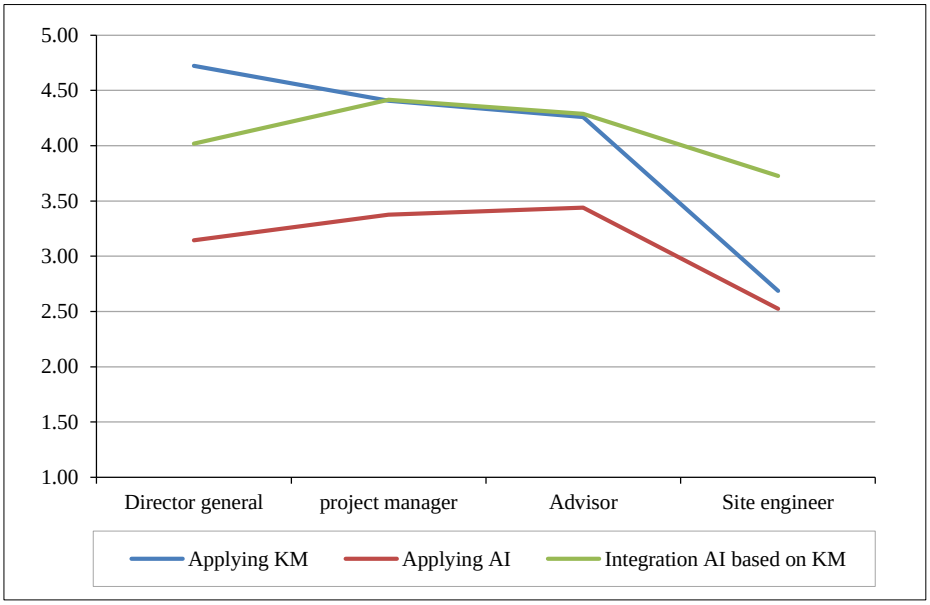

Figure 5. Effect of Current position category

Figure 6 shows the effect of experience with the use of KM processes and AI applications. Although it is not possible for those with great experience to be compatible with the uses of AI in their work, they received a high rating in knowledge management despite their reliance on the manual method in implementing activities. The results show that the respondents who have experience (10–20) have experienced most of the different applications in AI and have become experienced in their field of work by using AI applications. As for those who have little experience, they need higher training to compete with those with greater experience due to their ability to understand the basics and applications of artificial intelligence.

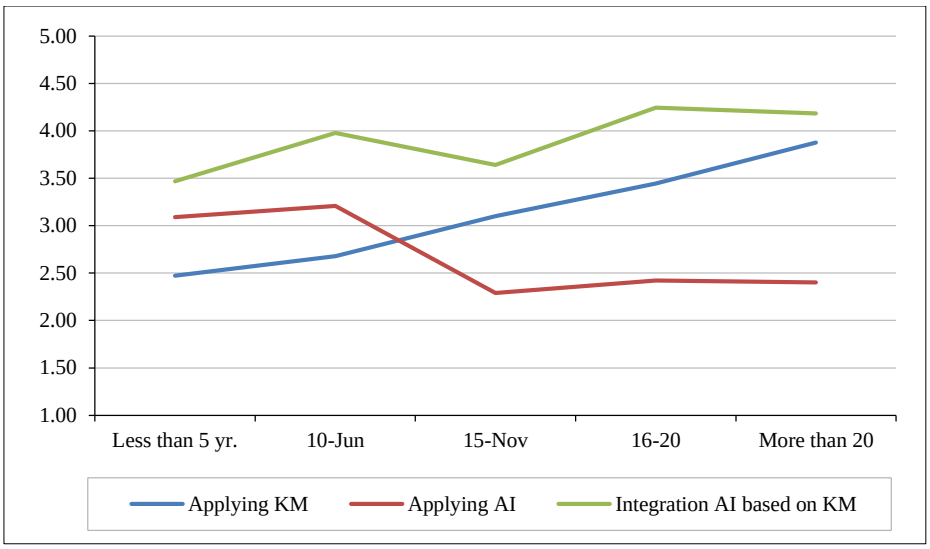

Figure 6. Effect of Years of Experience category

6.2.2.Test of Hypothesis

1st Hypothesis: The statistical hypothesis adopted a positive correlation between the demographic variables of the selected sample, including (Age, Qualification, Current Position, and Years of Experience) and the two axes (The Benefits of applying the KM process and AI applications in construction project management). Table 9 indicates the results of hypothesis testing according to the simple correlation coefficient between the variables.

Table 9. Simple correlation coefficient between variables

Category		Applying AI applications	Applying KM process
Age	Pearson Correlation	**-0.196**	**-0.152**
	Sig. (2-tailed)	0.072	0.164
Qualification	Pearson Correlation	**-0.238***	**-0.259***
	Sig. (2-tailed)	0.028	0.017
Current position	Pearson Correlation	**0.395****	**0.372****
	Sig. (2-tailed)	<0.001	<0.001
Years of experience	Pearson Correlation	**0.328****	**0.302****
	Sig. (2-tailed)	0.02	0.03

**. Correlation is significant at the 0.05 level (2-tailed).

*. Correlation is significant at the 0.01 level (2-tailed).

1) There is a negative statistically significant correlation between Age and the two axes (Applying KM processes and AI applications), and the values of the simple correlation coefficient between them are -0.196 and -0.152, respectively, which are out of a statistically significant value at the probabilistic level of 0.05.

2) Statistically significant correlation between qualification and the two axes (Applying KM processes and AI applications), the values of the simple correlation coefficient between the variables are (-0.238 and -0.259), respectively, which are two statistically significant values at the level of probability 0.05.

3) A positive statistically significant correlation between the current position and the two axes (using KM processes and AI applications in the management of investment projects), as the value of the correlation coefficient between the two variables, reached (0.395 and 0.372), respectively, which is a statistically significant value at the probabilistic level of 0.05.

4) There is a positive statistically significant correlation between years of experience and (Applying KM processes and AI applications in construction project management; the values of the simple correlation coefficient between them reached 0.328 and 0.302, respectively, which is a statistically significant value at the probabilistic level of 0.05.

2nd Hypothesis: Regression analysis was used to determine the relationships between the variables. Linear regression approximates the causal relationship between two or more variables. Regression models are considered highly valuable because they are one of the most common ways to make predictions and inferences [35].

Simple linear regression occurs when there is only one response variable or when studying and analyzing the effect of one variable on another variable. It is concerned with studying the dependence of one variable, known as the dependent variable or dependent variable on one or more variables defined as explanatory variables or independent variables to estimate or predict the average values of the dependent variable with the information of the explanatory variables. Regression analysis is used for three primary purposes [36]. The study explains the variation in the application of the KM process in construction project management and then for AI applications in construction project management with the demographic variables of the samples.

A. Interpretation of variance for applying the KM process in construction project management:

The research hypothesis developed was that there is an impact of all demographic variables on the use of the KM process. This hypothesis was tested according to the linear regression coefficient, as its results are shown in Table 10.

Table 10. Correlation coefficient of determination

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.579 [a]	0.378	0.290	0.76460

a. Predictors: (Constant), Age, Qualification, Current Position, Years of Experience.

The results indicate that the value of the multiple correlation coefficient between all demographic variables and the use of the KM process in construction projects amounted to the values of the three correlation coefficients, the simple correlation coefficient R (0.579). The coefficient of determination, square R, was (0.378), while the adjusted coefficient of determination was (0.290), which means that the independent explanatory variables (Age, Qualification, current position, Years of experience) were able to explain the changes that occurred in the interpretation of variance in the application of the KM process in construction project management. The rest is attributed to other factors. State the following hypothesis to test the significance of the regression:

$$H_0: B_1=B_2= B_3= B_4 \quad (1)$$

where H_1 is At least one parameter is not equal to zero.

From Tables 11 and 12, the value of (Sig<0.001) is less than the value ($\alpha = 0.05$), so reject the null hypothesis and accept the alternative hypothesis; the regression is significant. That means there is an effect of the independent variables on the dependent variables, and predict the dependent variable by independent variables.

Table 11. Analysis of variance in a multiple linear regression model

Model		Sum of Squares	Mean Square	F	Sig.
1	Regression	22.443	5.611	9.597	<0.001[a]
	Residual	46.769	0.585		
	Total	69.212			

a. Predictors: (Constant), Age, Qualification, Current Position, Years of Experience.

Table 12. Model summary

Model	Unstandardised Coefficients		Standardised Coefficients	t	Sig.	Correlations		
	B	Std. Error	Beta			Zero-order	Partial	Part
(Constant)	5.775	0.329		17.579	<.001			
Age	0.696	0.229	0.875	3.031	0.003	-0.196	0.321	0.279
Qualification	-0.306	0.246	-0.323	-1.244	0.217	-0.238	-0.138	-0.114
Current position	-1.150	0.207	-1.244	-5.563	<0.001	-0.395	-0.528	-0.511
Years of Experience	0.246	0.197	0.376	1.249	0.215	-0.193	0.138	0.115

To determine which of the coefficients is significant and causes significant analysis of variance for the multiple linear regression test for the significance of each parameter separately, it was found that two factors (Qualification and Years of Experience) are not significant, which means they have no significant effect on the significance of the analysis of variance regression. However, in the case of the variables (Age and current position), these coefficients are significant and impact the use of knowledge applications. The significance of the analysis of variance is due to the multiple linear regressions. To find out the percentage for each variable that contributes to explaining the variation in the applying KM process in construction project management, correlational analysis and stepwise multiple regression were performed, as

shown in Tables 13 to 15, where the results indicate a multiple linear regression equation that includes two variables: Age and current position. The results of the coefficient of determination indicate that the two variables explain 29.1% of the variance in the applying KM process.

Table 13. Adjusted model summary (KM process)

Model	R	R Square	Adjusted R Square	Std. The error of the Estimate	Change statistics		
					R Square Change	F Change	Sig. F Change
1	0.555[a]	0.308	0.291	0.76420	0.308	18.257	<0.001

a. Predictors: (Constant), Age, Current Position.

Table 14. Adjusted Analysis of Variance in a multiple linear regression model

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	21.324	2	10.662	18.257	<0.001[a]
	Residual	47.888	82	0.584		
	Total	69.212	84			

a. Predictors: (Constant), Age, Current Position.

Table 15. An adjusted model summary

Model	Unstandardised Coefficients		Standardised Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	5.579	0.295		18.899	<0.001
Age	0.741	0.175	.932	4.242	<0.001
Current Position	-1.148	0.203	-1.242	-5.652	<0.001

B. An explanation of the variation in AI applications in construction project management:

The research hypothesis developed was that there is an impact of all demographic variables on the use of AI applications in investment projects. This hypothesis was tested using the linear regression coefficient, as shown in Table 16.

Table 16. Correlation coefficient of determination

Model	R	R Square	Adjusted R Square	Std. An error in the Estimate
1	0.611[a]	0.373	0.342	0.64814

a. Predictors: (Constant), Age, Qualification, Current Position, Years of Experience.

The results indicate that the multiple correlation coefficient between all demographic variables and the use of AI applications in construction projects amounted to the values of the three correlation coefficients, including the simple correlation coefficient R, which was 0.611. The coefficient of determination, square R, was (0.373), while the adjusted coefficient of determination was (0.342), which means that the independent explanatory variables (Age, Qualification, current position, Years of experience) were able to explain the changes that occurred in the interpretation of variance in the use of AI applications in investment construction projects. The rest is attributed to other factors. State the following hypothesis to test the significance of the regression:

$$H_0: B_1=B_2= B_3= B_4 \quad (2)$$

where H_1 is At least one parameter is not equal to zero

From Tables 17 and 18, the value of (Sig<0.001) is less than the value ($\alpha = 0.05$), so reject the null hypothesis and accept the alternative hypothesis; the regression is significant. That means there is an effect of the independent variables on the dependent variables, and predict the dependent variable by independent variables.

Table 17. Analysis of variance in a multiple linear regression model

Model		Sum of Squares	Mean Square	F	Sig.
1	Regression	20.028	5.007	11.919	<0.001[a]
	Residual	33.607	0.420		
	Total	53.635			

a. Predictors: (Constant), Age, Qualification, Current Position, Years of Experience.

Table 18. Model summary

Model	Unstandardised Coefficients		Standardised Coefficients	t	Sig.	Correlations		
	B	Std. Error	Beta			Zero-order	Partial	Part
(Constant)	5.608	0.278		20.139	<0.001			
Age	0.891	0.194	1.274	4.583	<0.001	-0.152	0.456	0.406
Qualification	-0.428	0.209	-0.513	-2.052	0.043	-0.259	-0.224	-0.182
Current position	-1.042	0.175	-1.280	-5.948	<0.001	-0.372	-0.554	-0.526
Years of Experience	0.120	0.167	0.209	0.722	0.472	-0.202	0.080	0.064

To determine which of the coefficients is significant and causes significant ANOVA for multiple linear regression, test the significance of each parameter separately. It was found that factors (Years of Experience) are not significant, and this means they have no significant effect on the significance of the analysis of variance regression. However, in the case of the variables (Age, Qualification, current position), these coefficients are significant and impact the use of AI applications. The reason for the significance of the analysis of variance is the multiple linear regression. To find out the percentage for each variable that contributes to explaining the variation in the use of AI applications in investment projects, correlational analysis and stepwise multiple regression were performed, as shown in Tables 19 to 21, where the results indicate a multiple linear regression equation that includes three variables: Age, Qualification and Current position. The results of the coefficient of the determination indicate that the three variables explain 34.6 % of the variance in the use of AI applications.

Table 19. Adjusted model summary (Applying AI Application)

Model	R	R Square	Adjusted R Square	Std. An error in the Estimate	Change statistics		
					R Square Change	F Change	Sig. F Change
1	0.608	0.369	0.346	0.64622	0.369	15.812	<0.001

a. Predictors: (Constant), Age, Qualification, Current Position.

Table 20. Analysis of variance in a multiple linear regression model

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	19.809	3	6.603	15.903	<0.001[a]
	Residual	33.216	81	0.4152		
	Total	53.025	84			

a. Predictors: (Constant), Age, Qualification, Current Position.

Table 20. An adjusted model summary (AI Application)

Model	Unstandardised Coefficients		Standardised Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	5.523	0.252		21.950	<0.001
Age	0.948	0.178	1.354	5.331	<0.001
Qualification	-0.334	0.162	-0.400	-2.056	0.043
Years of experience	-1.031	0.174	-1.268	-5.926	<0.001

7. Conclusions

The study seeks to find new advantages to enhance the success of the implementation of construction projects in different regions of the governorates of Iraq depending on the type of applied characteristics, like the work of management and facilities used. The study dealt with enhancing the KM process based on AI applications. The study reached several results, the most important of which are:

- The percentage of engineers' responses on the axis of the benefits of applying the KM process to construction projects (77.64%) is relatively high.
- The percentage of engineers' responses for the benefits of using AI applications in project management and follow-up is very high, amounting to 82.13%.
- The percentage of engineers' responses for the benefits of integrating AI applications based on the KM process in project management is very high, amounting to 77.37%.

- The percentage of engineers' benefits about using the integration of KM and AI in construction projects related to the view of engineers in descending order to include (Compliance with the project implementation plan, Resolving expected risks in projects for all parties, gathering scattered information systems and various technological means, enhancing the significant amount of project time, and applying the necessary technological infrastructure to implement it).
- The impact of two variables (Qualification and Years of Experience) on the application of the KM process in construction projects is not significant; they have no significant effect on the significance of the analysis of variance regression.
- The impact of two variables (Age and current position) is significant and impacts the application of the KM process for the significance of the analysis of variance.
- There is a negative statistically significant correlation between the age and the two axes (KM processes and AI applications in construction projects); the values of the simple correlation coefficient between them reached 0.196 and 0.152, respectively, which are two statistically significant values at the probability level of 0.05.
- There is a negative statistically significant correlation between the age and the two axes (using the KM process and AI applications in the management of investment projects); the values of the simple correlation coefficient between the variables reached 0.283 and 0.259, respectively, which are two statistically significant values at the level of probability 0.05, which is a statistically significant value at the probabilistic level of 0.05.
- There was a positive statistically significant correlation between the current position and the two axes (using the KM process and AI applications in the management of investment projects), as the value of the correlation coefficient between the two variables reached 0.395 and 0.372, respectively, which is a statistically significant value at the probabilistic level of 0.05.
- There was a positive statistically significant correlation between years of experience and the two axes (using the KM process and AI applications in the management of investment projects); the values of the simple correlation coefficient between them reached 0.328 and 0.302, respectively, which is a statistically significant value at the probabilistic level of 0.05.

7.1. Recommendations

KM is a fundamental philosophical principle in the new information era. Because it has a considerable impact on the value-added benefits if it is implemented correctly and integrated with AI software to enhance a practical path for the parties involved in the implementation process, access to knowledge and information in a faster time, and passing many of the required modifications and changes. However, AI software can assist in various KM processes by different construction companies, regardless of the type of construction project.

The study showed that the success of many investment companies in adopting AI applications is due to solid reasons, such as the huge investments at the beginning, their awareness of its full benefits, or how it can enhance KM within the company and during the various stages of the project. So, there is ample space for research and development in the future, mainly if the user focuses directly on his ability to use these systems and develop them to serve the construction process. The role of the expanded value of knowledge gives importance to KM in building a structure for the technological approach within the company, and this work takes the form of qualitative research to assess the level of the categories of AI software currently used or required to be used in the KM process. For this, future research must be done extensively to introduce new concepts to most investment companies that desire to apply and expand AI applications based on KM. Provide that the user's demographic characteristics are essential for the correct application and appropriate development of KM integration in all construction project phases.

The study recommends the need to strengthen the adoption of the application of KM based on AI applications to resolve all problems of delayed completion of investment construction projects in Iraq, in addition to the need to pay attention to the financial aspect and improve the efficiency of these projects by sharing and applying KM in integration with the application of intelligent applications, which is the basis of KM operations.

Adopting the demographic characteristics of engineers (years of experience, current position) can help organizations choose the appropriate engineers to perform their professional work to help complete projects with high quality. It can also be adopted for the purpose of training and development to raise the skills of engineers in light of the great development witnessed by the construction industry after the tremendous developments in most applications of artificial intelligence.

8. Declarations

8.1. Author Contributions

Conceptualization, M.R.A. and M.M.D.; methodology M.R.A.; validation, M.R.A. and M.M.D.; formal analysis, M.R.A.; investigation, M.M.D.; resources, M.R.A.; data curation, M.R.A.; writing—original draft preparation, M.R.A.; writing—review and editing, M.R.A.; visualization, M.R.A.; supervision, M.R.A.; project administration, M.R.A.; funding acquisition, M.R.A. All authors have read and agreed to the published version of the manuscript.

8.2. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

8.3. Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

8.4. Conflicts of Interest

The authors declare no conflict of interest.

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