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NECESSITY OF INTEGRATING PRINCIPLES OF SUSTAINABLE OF KNOWLEDGE OF CPM FOR SUCCESSFUL OF DESIGN, EXECUTION AND DELIVERY OF CONSTRUCTION PROJECTS

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Abstract

This research investigates the effectiveness of integrated principles of sustainable knowledge of CPM that is “construction project management” which is a comprehensive development initiative designed to enhance leadership skills, competencies, and career prospects for managers and engineers who works in mega projects of construction industry. The primary aim of the sustainable knowledge is to equip project managers with the necessary knowledge and tools to excel in the competitive project environment, ensuring long-term professional success. The research explores how the sustainable information fosters skills in project development, management, evaluation, and delivery across diverse contract types, with a focus on empowering the team to manage projects proficiently in technical, financial, contractual, and legal aspects. The study assesses the alignment of sustainable knowledge with the evolving needs of the modern engineering and project management industries. It identifies key learning outcomes, including improved leadership capabilities, enhanced decision-making, and refined project oversight skills. Through qualitative and quantitative analysis, the research examines participant feedback, career progression data, and industry trends to evaluate the impact of sustainable information on professional growth and leadership development.

Results indicate that participants exhibit significant improvements in their ability to oversee complex projects, lead diverse teams, and navigate the challenges of global engineering projects. Furthermore, the sustainable information shown to increase job satisfaction and career advancement opportunities for engineers and managers, positioning them for success in the international arena. The major conclusion of the research highlights the effectiveness of necessary information and knowledge in addressing the critical skills gap in the engineering and project management sectors. It emphasizes on the role of producing highly capable leaders equipped to manage and deliver successful global projects. The findings suggest that continued investment in such comprehensive training programs related to the integration of sustainable knowledge is essential for the future growth and competitiveness of project managers in the world of engineering industry.

Keywords: empowerment, professional success, project delivery, roles and responsibilities, sustainable knowledge

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Introduction

In the construction industry projects, particularly when managing mega projects, the complexity and scale of the undertaking and commitment require a combination of technical expertise, strong leadership, enough experience and a comprehensive understanding of sustainable practices by project manager and his team. In many organizations project managers and engineers increasingly rely on artificial intelligence (AI) and emerging technologies to address challenges at various project stages, from feasibility analysis to operation and maintenance which is good at a certain level. While technology offers valuable tools, overdependence on AI often leads to a decline in fundamental project management knowledge and skills. Essential principles such as project feasibility analysis, contract types and conditions, principles of design management, bill of quantities preparation and verification, risk management and control, principles of

construction management, and the integration of project management methodologies including the establishment of a Project Management Office (PMO) are frequently overlooked and unnoticed by project manager due to the workload and reliance on technology. This growing reliance on technology, rather than on integrated

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knowledge and structured information, can negatively impact decision-making and project performance. To ensure timely project completion and mitigate delays, it is crucial to reinforce these foundational concepts, equipping managers and engineers with the expertise needed to effectively oversee construction projects while leveraging AI as a complementary tool rather than a sole solution.

In addition, sustainable knowledge that comprising many factors such as strategies, practices, and competencies focused on achieving long-term environmental, economic, and social goals which became an essential framework for project managers. As the industry continues to evolve, the need for sustainable essential information in construction is important and guiding decision-making at all levels. This research investigates the role of sustainable knowledge in enhancing the leadership skills and competencies of project managers, especially when managing mega projects, that present unique challenges across the entire project lifecycle. The study assesses the alignment of sustainable knowledge with the evolving needs of the modern engineering and construction project management industries. From feasibility studies to project completion, project managers must possess a broad range of competencies along with necessary sustainable knowledge and information. These include the ability to assess project feasibility analysis, oversee tendering processes and contracts management, ensure process of design integrity, verification of bill of quantities, and being familiarised in construction process including risk management practices. Sustainability in term of knowledge and implications impacts all these stages and influencing the decision-making processes. From the outset, projects involve a wide range of stakeholders, local communities, contractors, suppliers, and regulatory bodies requires knowledge and set of skills for ensuring the efficient allocation of resources and meeting tight schedules needs foster advanced skills and norms particularly those related to sustainable knowledge. Over-reliance on AI and technology, without a solid foundation and good background in the integrated information of principles of sustainable knowledge can negatively impact decision-making and overall project performance in several ways.

1. Literature review

Integrating sustainable information and knowledge into project management fosters essential skills for project managers, enabling them to navigate the complexities of project development, management, evaluation, and delivery. The implementation of project management within the projects requires strong executive support and an implementation team that is dedicated to make project management work [1]. By incorporating sustainable knowledge principles, managers gain a broader perspective on the environmental, social, and economic impacts of their projects. This knowledge enhances their ability to make informed decisions across various phases, from feasibility, planning to execution, ensuring that sustainability is not an afterthought but a core consideration. Sustainable practices empower project managers to evaluate and manage resources more effectively, reducing waste and inefficiency, while also mitigating environmental risks, mainly through tendering process. Furthermore, these practices contribute to long-term value creation, helping managers prioritize solutions that are not only cost-effective but also ethically responsible and aligned with global sustainable knowledge. Now a day's project managers are using time, cost and quality and scope as a parameter to measure and control the progress of projects as confirmed by [2]. Sustainabile knowledge focused knowledge also improves project managers' ability to proficiently handle the financial, contractual, technical and legal dimensions of projects, especially across diverse contract types. The construction industry continues supporting several sustainable practices such as environmental working conditions where project manager must be able to maintain [3]. Financially, it encourages the adoption of cost-benefit analyses that incorporate long-term sustainability metrics, which often go beyond immediate costs to include lifecycle savings, especially when reviewing bill of quantities and applying value engineering principles. Technically, the integration of sustainable methods pushes project teams to adopt innovative solutions, optimizing processes to enhance performance and resource management. It is important to have skilled limited resources and information that can be managed to maintain and control the project. The aim should be to explore the experience of project teams to enable better understanding of what happens in project to develop performance metrics [4]. Empowering project managers with this comprehensive knowledge allows them to guide teams through the complexities of varied contracts whether conditional contracts, design build or fixed-price contract ensuring that project phases can be finished on time based on the shared information and knowledge through team

collaboration mainly while managing the design process of the project. The project team should be provided and shared with the best facilities and latest information so that they can work in a way the project can be executed without a delay as stated by [5]. The integration of sustainable information and knowledge into project management not only enhances the skills of project managers but also significantly improves the overall performance of project teams. By equipping managers with an understanding of sustainable development goals, they are better prepared to identify potential risks and opportunities related to project performance factors and milestones factors early in the project lifecycle. This foresight allows project managers to take a proactive approach to problem solving and risk mitigation. It is important to know that risk scheduling requires a pro-active approach to ensure all relevant inputs are captured such as potential risks and there is a good understanding of the execution assumption and schedule risk [6]. This leads to fostering a culture of continuous improvement. Additionally, it enables them to lead cross-functional teams more effectively, ensuring that all team members of engineers are aligned with the project's sustainabile information. This results in a more holistic approach to project delivery, where sustainabile knowledge becomes a common factor through technical decisions, and contractual requirements.The project members should be provided with the best facilities according to contractual requirement, so that they can work in a manner in which the project can be executed without a delay [7]. As sustainability continues to shape the future of the built environment, empowering project managers with this knowledge ensures that teams are not only capable of meeting current demands but are also prepared to lead the way in sustainable construction project management practices. The project management approach is relatively modern. It is characterised by methods of restructuring management and adapting special management techniques, with the purpose of obtaining better control and use of existing resources [8]. Sustainable knowledge for projects managers in this research is focused on the theoretical and practical information of engineering project management and construction management, includes a wide range of implications and techniques. These range from skills of general administrative project management, construction management, risk management, resources scheduling & planning, communications, time management, quality management, contracts management and administration, projects monitoring and control, HSE practices, value engineering, and cost control process to avoid delay and cost overrun. Delays are insidious often resulting in time overrun, cost overrun, disputes, litigation, and complete abandonment of projects [9]. Sustainable knowledge and information help projects managers to apply talent, innovation, and other tools to help project owners know and control their potential risks that must be identified and analyzed to achieve their projects goals. Recommended finding of studies stated that developing a strategic mitigating risk management system in construction projects to mitigate delays that they said were impossible to avoid completely is essential [10]. Sustainable knowledge and information aim to deliver learning solutions that serve construction projects where solutions can be found if integrated area of knowledge are understood, properly interpreted and implemented by project team who becomes familiar in the process of managing multiple projects in the same organization.

2. Principles of sustainable information

Principles of sustainable knowledge and information plays a crucial role in shaping the skills and competencies of project managers, particularly in the implications of project development, management, evaluation, and delivery. By integrating sustainabile principles into these areas, project managers gain valuable insights that enhance their ability to make informed decisions, manage resources efficiently, and navigate the complexities of the project regarding to its contract types. This knowledge empowers teams to approach projects with a holistic view, balancing technical, financial, contractual, and legal considerations. As a result, project managers are better equipped to lead teams in delivering projects that meet both immediate objectives and long-term sustainability goals, ultimately fostering more effective, responsible, and resilient project outcomes. This integration not only strengthens project delivery but also ensures that sustainabile knowledge becomes a central factor in every aspect of the project lifecycle. Integrating sustainable knowledge throughout all project phases from initiation and feasibility to completion and handing over ensures that project managers are not only prepared to navigate the technical and logistical challenges, but also equipped to achieve outcomes that align with project and organizational objectives. The following are important information that project managers and stakeholders must be familiar with, as they help ensure smooth project execution across all aspects, without delays or disputes at any stage. This knowledge can be acquired through hands-on experience, continuous learning, ongoing skill development, effective use of available tools, and collaboration with others. Every project manager should consistently focus on the practices of this knowledge to maintain project success.

2.1 Feasibility and Tendering: The project lifecycle starts with a feasibility study, analysing cost, resources, time, and environmental impact. Feasibility analysis allow manager to make formal decision about the project after estimated cost analysis. By generating information, such as estimated cost, it is possible to provide the client with a statement of intent [11]. Sustainable knowledge helps assess long-term viability by considering energy use, resources, and environmental footprint. This ensures informed decisions in tendering, aligning contractors with sustainability goals for a competitive edge. To assess the information used during the tendering phase of any engineering project it is important to categorise the tendering information [12]

2.2 Contract Management and Design: In the contractual phase, managers handle legal agreements, risk, and compliance. Sustainability knowledge ensures contracts include eco-friendly clauses. Sustainability clauses along with clear contractual conditions must be clear. The form of and conditions of contract could also contribute to the management of project risk, including exposure to design liability [13]. During design, managers integrate functionality with green standards, using certifications, innovative materials, and energy-efficient systems to meet sustainability goals. The design should be sustainable specially for design build contracts. Success of design build procurement system does not build on compromising quality, if all parties adopt best practices of design management innovative design practicalities do exist in D/B system [14].

2.3 Bill of Quantities and Construction Management: Managing the bill of quantities (BOQ) is key to tracking costs, materials, and labour. It is a form that describes the work which will be executed in term of quantity and cost. Once the contractor starts the work in the project, the project manager, construction manager and the planning engineer verify all contract documents and they must report about any discrepancies between drawings, bill of quantities and specifications [15]. A sustainability focus helps reduce waste, optimize materials, and choose eco-friendly options within budget. In construction, managers ensure timely, cost-effective progress while meeting safety and environmental standards through lean methods and waste reduction. Using lean construction methods and waste reduction strategies where construction projects managers and others involved parties can optimize efficiency while lowering the environmental impact of the project. Parties involved with construction projects must be properly controlled. [16].

2.4 Value Engineering and Cost Reduction: Value engineering is a methodology that employs an innovative feature problem-solving approach, providing the necessary project output and at the same time minimizing costs. Construction projects aim for timely, budget-friendly delivery without compromising quality. Sustainable knowledge supports value engineering by optimizing materials, methods, and design for cost efficiency. This approach reduces costs, improves resource use, and integrates sustainability for long-term savings and increased project value. VE usually benefits from project costs savings by eliminating additional costs, demonstrating project efficiency, saving time, greater comprehension of project objectives, and increasing project value [17].

2.5 Risk Management and Project Completion: Risk management is one of the most important areas of focus for any project manager, particularly when managing large mega projects, requiring foresight on regulations, resources, and supply chains. Sustainabile knowledge offers a proactive approach to risk mitigation, allowing managers to anticipate and address issues related to resource depletion and regulatory changes. “Risk Identification is discovering, defining, describing, documenting and communicating Risks before they become problems and adversely affect a project.” [18]. Risk plans aids in mitigating risks like all potential problems that may occurs such as unforeseen issues that may cause unexpected problems during any of project phases.

2.6 Principles of construction management: Understanding the principles of construction management is essential for project managers, as it provides the foundation for successfully overseeing complex projects. These principles, which include planning, scheduling, budgeting, risk management, and quality control, ensure that projects are delivered on time, within budget, and to the required standards. The importance of pre project planning that is a part of construction management, and its effect on the success of the project must be recognized “pre project planning process varies significantly throughout the construction industry from one organization to another, and from one business sector to another.”[19]. However, in today’s construction landscape, it’s equally important for project managers to integrate sustainable knowledge into the core principles of construction management principles.

2.7 Causes of project delays: Construction delays stem from planning issues, design changes, site conditions, poor communications, and material or labor shortages. Regulatory and scope changes also contribute. While some are unavoidable, proactive risk management and sustainability help anticipate and mitigate delays, ensuring timely, budget-conscious delivery. The delays of construction projects are common, the “most frequent causes of delays as "unforeseen ground condition", "weather condition", "change by owner", "shortage of technical personnel", "slow purchase of materials and equipment", and "insufficient numbers of equipment"[20]. Sustainable knowledge helps project managers anticipate potential delays of projects related to environmental regulations or resource shortages, enabling them to develop contingency plans to avoid these delays.

2.8 Project Monitoring and Control: One of the critical aspects of project success is the continuous monitoring and control of project performance. Project managers must track the project’s progress, compare it against the planned timeline, budget, and quality standards, and take corrective actions when necessary.Sustainable knowledge enhances this process by enabling managers to establish key performance indicators (KPIs) that focus not just on traditional metrics like time and cost but also milestones and actions that empower managers to implement necessary actions to help minimize delays, reduce costs, and improve overall project sustainability. The purpose of monitoring system is to check the continuity of work progress against the plan to help in taking any corrective action as confirmed by [21]

2.9 Managing Multiple Projects: For project managers handling multiple projects simultaneously, sustainability knowledge is essential in balancing resources and prioritizing projects based on environmental impact, potential risks, and overall feasibility. The ability to manage multiple projects, sustainably can lead to long-term organizational success by optimizing resources, reducing costs, and building a positive reputation in the industry. The contractor may be having multiple projects and may not be in a position to deploy additional workers as per the requirement [22]. It depends upon number of projects that contractor is having per year and available qualified project managers.

From the above, it is essential to integrat sustainable knowledge into all aspects of construction project management from project initiation and feasibility to the completion and handing over, ensures that project managers are not only equipped to handle the technical and logistical complexities of mega projects but also capable of delivering outcomes that align with project goals and objectives. As the construction industry continues to face increasing pressure to operate responsibly, equipping project managers with the tools and knowledge to navigate these challenges is also required for their professional success and the future sustainability of the industry.

3. Key challenges of work environment

Key challenges associated with over-reliance on AI and technology in project management is common problem, particularly when not supported by a strong foundation of sustainable principles of knowledge. Over-reliance on AI and technology, without a solid foundation of sustainable knowledge in construction project management principles and information, can negatively impact decision-making and overall project performance in several ways. In construction industry, the degree of reliance on AI varies across organizations is based on multiple factors, such as team experience, project duration, and available budget. While AI and technology provide valuable tools for project managers, they should enhance rather than replace human expertise. A balanced approach where managers and engineers strengthen their understanding of information and knowledge is required in construction project management while using AI as a supportive tool leads to more informed decision-making and proactive risk management.

3.1 Effects of Over-Reliance on AI and Technology by Project Managers

The use of AI in mega projects without referencing solid information of construction project management standards can lead to inaccurate decision-making, resulting in costly delays and inefficiencies. Safety risks may also increase if AI-driven recommendations overlook critical regulations, clauses and data. Additionally, relying on incomplete or incorrect AI data can lead to legal and compliance issues, such as violations of building codes and contractual disputes. Poor AI-driven forecasting may cause resource misallocation, leading to inefficiencies in labor, materials, and budgeting. Furthermore, excessive dependence on AI can reduce accountability, as project managers may neglect due diligence and fail to take full ownership of crucial decisions. Description of negative affect of over-reliance on AI in table1.

Table 1: Negative Effects of Over-Reliance on AI in Construction Project Management

	Negative effect	Description
1	Inaccurate Decision-Making	AI without solid data from the construction management plan can lead to flawed project decisions, causing delays and cost overruns
2	Lack of critical thinking and problem-solving skills	AI provides solutions based on data and algorithms, but it lacks human intuition, experience, and contextual understanding
3	Legal and Compliance Issues	Decisions based on incomplete or incorrect AI data can result in violations of building codes and legal disputes.
4	Resource Misallocation	Poor AI-driven forecasting can lead to inefficiencies in labor, materials, and budgeting, affecting project sustainability.
5	Misinterpretation of AI recommendations	If the input data is incomplete, outdated, or biased, AI may provide misleading recommendations
6	Weak risk management and control	AI can assist with risk predictions, but it cannot replace human judgment in assessing risks based on real-time project dynamics.
7	Poor contract and legal awareness	AI can aid contract management by identifying clauses and potential disputes, but managers must grasp contract terms and legal aspects for effective negotiation and conflict resolution
8	Erosion of leadership and collaboration	Project success relies on communication, negotiation, and leadership skills AI cannot replicate. Over-reliance on AI may weaken interpersonal decision-making, causing team disengagement and poor coordination.
9	Over-Reliance on automated decision-making reduce adaptability	AI systems operate based on predefined algorithms, which may not account for unique project conditions. Managers who overly depend on AI may struggle to pivot when unexpected challenges arise

Over-reliance on AI in construction mega projects without solid data can lead to poor decision-making, safety risks, legal issues, resource misallocation, and reduced accountability, ultimately causing delays and inefficiencies

4. Research methodology

A comprehensive research approach is developed for this study, integrating insights from a literature review with the development of targeted questionnaires. Project Managers overseeing large construction projects were invited to complete the questionnaires to provide accurate data on the necessity of required information, benefits, knowledge sharing, and tools process of updating these information. Primary data was collected through literature reviews and multiple sources, including meetings, interviews, and questionnaires. The research methodology combined both qualitative and quantitative analyses to ensure a thorough investigation. Quantitative analysis applied statistical methods to survey data to enhance reliability, while data collection incorporated both primary and secondary sources. Each data type was carefully examined and justified to establish its relevance to the study's objectives. For the qualitative, analysis qualitative approach to research as the study of things in their natural setting, attempting to make sense of, or to interpret, phenomena in terms of the meanings people bring to them [23]

5. Design of questionnaire

Questionnaire surveys serve as a primary data collection method, designed to evaluate the extent to which project managers possess and apply integrated principles of sustainable information and knowledge throughout the project lifecycle. The surveys also assess how this knowledge enhances their competencies in ensuring timely project delivery while empowering their teams to manage projects effectively across technical, financial, contractual, and legal aspects. These surveys also evaluated the role of projects managers in problem-solving and ensuring timely project delivery. In this study, one hundred project managers working at ten leading construction firms in the UAE were invited to participate by answering the questions related to principles of sustainable knowledge presented in table 2 based on the identified four themes (Feasibility, Tender & Contract Management), (Design Management & Cost Review), (Risk Management & Delay avoidance), and (Managing and Delivering Mega Projects). Table 2 highlights four theme of sustainable knowledge that has been identified in the literature review. The questionnaire is structured around topics of each theme identified in the study background, each addressing critical issues that can significantly affect project progress if project team

are not referring to solve problems and issues during the work progress. Participant feedback has been analyzed to evaluate the significance of each factor in influencing project outcomes.

Table 2: Principles of sustainable information and knowledge

SN	Main Theme- Core		Principles of sustainable knowledge	Validity	Means	Rendering	St. Dvn.
1	**Feasibility, Tender & Contract Management**	1	Feasibility and Tendering	100	3.21	61%	1.620
		2	Contract Management and Design	100	3.61	63%	2.013
2	**Design Management & Cost Review**	1	Bill of Quantities and Construction Management	100	3.52	62%	1.981
		2	Value Engineering and Cost Reduction	100	3.99	67%	2.621
3	**Risk Management & Delay avoidance**	1	Risk Management and Project Completion	100	3.21	61%	1.538
		2	Principles of construction management	100	3.11	58%	1.553
		3	Causes of project delays		2.98	53%	1.510
4	**Managing Mega projects**	1	Project Monitoring and Control	100	3.52	62%	1.981
		2	Managing Multiple Projects	100	2.98	53%	1.510

6. Results and discussion

According to the data analysis and findings, it is founded that 60% of experienced project managers in construction often rely on established principles of information and knowledge management rather than turning to AI for solutions. Their preference for traditional methods comes from the belief that human expertise, professional judgment, and contextual understanding are irreplaceable in managing complex projects. Construction projects involve technical, contractual, legal, and financial challenges that require a deep understanding of industry standards, regulatory frameworks, and best practices. While AI can process vast amounts of data quickly, it lacks the critical thinking, and adaptability that experienced managers develop over years of practice. Project managers recognize that each construction project is unique, and applying standardized AI-generated solutions may not always be appropriate.

They prefer to draw upon their own expertise, past experiences, and industry knowledge to make informed decisions tailored to the specific circumstances of a project. Construction management involves a high degree of negotiation, collaboration, and problem-solving, where human interaction plays a crucial role. Legal disputes, contractual interpretations, and financial strategies often require careful consideration, judgment, and strategic decision-making that AI cannot fully replicate. It was stated by many of them that relying on AI without understanding its limitations can lead to errors, misinterpretations, or reliance on inaccurate data, potentially causing significant project risks. Project managers who prioritize traditional principles of construction management over AI-driven solutions do so because they trust their knowledge, experience, and professional judgment to navigate the complexities of a project more effectively than automated systems.

40% of experienced project managers refrain from directly referring to traditional principles of knowledge in construction project management throughout the project lifecycle due to the past experience they have, where problems are common. Instead, they increasingly rely on artificial intelligence (AI) tools to resolve issues and obtain critical information related to technical, contractual, legal, or financial matters since the tools are available at any time. Some of them developed an intuitive grasp of fundamental construction management principles, often see AI as a superior tool that enhances their decision-making rather than a replacement for traditional knowledge. Most of them confirmed that AI-driven solutions can quickly analyze patterns, predict potential risks, and suggest optimal strategies without the cognitive limitations associated with human decision-making. This is based on the updated data and information, they do believe that AI can enhance decision-making processes, and improve risk assessment. They also think that AI-driven platforms can integrate legal frameworks, contractual obligations, and financial data, offering precise recommendations based on updated industry regulations, contract clauses, and

financial projections. This allows them to focus more on strategic leadership rather than spending excessive time deciphering dense project documentation.

Unlike conventional knowledge-based approaches, which require new project managers can manually analyze and apply best practices from previous projects, academic principles, or regulatory guidelines. In contrast, AI systems provide instant access to vast repositories of structured and unstructured data, allowing them to reference knowledge principles until they gain sufficient experience. The critical factor driving this preference is the high-pressure nature of construction projects, where swift decision-making is essential. AI tools offer predictive analytics, instant solutions, and real-time updates that minimize delays and disruptions, while traditional principles of construction project management remain relevant to each of them. Experienced project managers still play a crucial role in validating AI-generated recommendations, applying human judgment where necessary, and ensuring that AI outputs align with project objectives. The preference for AI over traditional knowledge-based approaches is not due to a disregard for fundamental construction management principles but rather a recognition that AI-driven solutions provide faster, more precise, and more efficient ways to manage the technical, legal, contractual, and financial complexities of construction projects which are subjected to fundamental of information and principles of knowledge that every project manager must be familiar with.

7. Data Analysis and findings

Experienced project managers value the ability to analyze information critically, assess risks holistically, and apply proven methodologies to address challenges effectively. They also recognize that AI tools, while useful, should complement human expertise rather than replace it. As stated in section 6 of this report that 60% of experienced project managers in construction often rely on established principles of information and knowledge management rather than turning to AI for solutions, and 40% of experienced project managers refrain from directly referring to traditional principles of knowledge where main reasons make them to confirm their statements are explained in table 3

Table 3: Summary of reasons of each responded group

	60% of respondents prefer to use principles of knowledge		**40% of respondents who don't prefer to use principles of knowledge but to use AI**
1	Contextual Understanding & Critical Thinking	1	Efficiency & Speed
2	Reliability & Accuracy in Decision-Making	2	Data-Driven Insights
3	Interpretation of Legal & Contractual clauses	3	Automation of Repetitive Tasks
4	Effective Communication & Negotiation	4	Improved Accuracy
5	Long-Term Knowledge & Continuous Learning	5	Enhanced Collaboration

By integrating these strategies, project directors, managers, and engineers can maintain a strong foundation in construction project management principles while effectively leveraging AI as a supporting tool. The goal is to ensure that professionals remain knowledgeable, adaptable, and capable of making informed decisions, ultimately leading to better project outcomes and timely delivery . Experienced project managers should use AI as a supporting tool to process large data sets, identify risks, and optimize efficiency while still applying their expert knowledge, critical thinking, and practical experience to interpret results and make the final decisions. In conclusion, using AI is correct as long as it complements, rather than replaces, fundamental construction management knowledge. AI can significantly improve efficiency, but human oversight remains essential to ensure that decisions contextually appropriate for each unique project. Human expertise remains crucial for navigating the complexities of the industry. By balancing AI-driven insights with human judgment, project managers can achieve more sustainable and successful project outcomes

8. Conclusion

Integrating sustainable knowledge into construction project management offers a comprehensive approach to addressing the multifaceted challenges of mega projects. It not only enables managers to handle the technical and logistical complexities of these projects but also ensures long-term professional success through responsible leadership. As sustainable knowledge becomes an increasingly important factor in the success of construction projects, equipping project managers with the information, tools and knowledge to navigate these challenges is essential for the future of the career growth of projects managers. The research revealed the required level that incorporates the stages of project

management, from initiation, feasibility to managing and handing over multiple projects is referring to fundamental of sustainable knowledge of each phase. It also provides a clear link between the knowledge of project managers that must possess and the challenges they face, underscoring the importance of sustainability in each area.

The sustainable knowledge provides a solid foundation for project managers to deliver their projects on time through recommended actions and implications of principles of knowledge. Sustainable information and knowledge, combined with AI, can enhance project managers' competencies and improve timely project delivery. While AI streamlines data analysis, risk assessment, and decision-making, it must be supported by solid industry knowledge and sustainable practices to ensure accuracy. Project managers who effectively integrate principles of sustainable knowledge with AI can optimize resource allocation, enhance communication, and maintain compliance with regulations.

9. Recommendation

To avoid over-reliance on AI and ensure that project directors, managers, and engineers continue to develop, refer and apply fundamental principles of construction project management, a structured valuable approach can be developed and adopted by strengthening education and development programs. Organizations should provide continuous professional development programs focusing on core construction project management principles. That can be implemented by offering workshops, and refresher information on essential implications of construction concepts, and developing mentorship programs where experienced professionals guide younger project managers and engineers. The program will offer opportunity for managers and engineers seeking to enhance their leadership skills, competencies, and career prospects. It can equip them with the necessary knowledge and tools to thrive in today's highly competitive projects environment. Project managers position themselves for long-term success and professional growth of their careers. Aim of the program is guideline for managing and controlling all types of mega projects in construction industry through competent and innovative qualified agile resources because it will emphasize on understanding the processes of preparing, managing, evaluating, monitoring, and delivering projects, regardless their value or contract type. The plat form/ program prepare projects leaders, managers, and engineering team of any project to enhance skills of engineering profession integrated with management and knowledge of scientific applications of sustainable knowledge along with practices of monitoring and control projects and performance of engineering profession and competencies. Expected outcomes of the program leading to fostering comprehensive knowledge and skills in the development, preparation, management, evaluation, monitoring, and delivery of projects and building capabilities and competencies of expert engineers, managers and focusing on practices of engineering profession that can be accomplished. Recommended subjects that can be used in the guideline/program are listed in table 4

Table 4: Recommended topics of principles of sustainable knowledge

	Theme	Subjects and topics
1	**Effective delivery of projects through feasibility, tendering & contract management**	- Feasibility analysis for projects Tendering process and analysis Contract management &FIDIC for traditional and D/B contract
2	**Effective design management, and cost control review**	Principles of project design and design team Preparing and verifications of bill of quantities Essentials and principles of Value engineering
3	**Practices of project risk analysis and delays, and causes of project**	Principles of risk analysis, scoring system and risk prioritization Common practices of construction management Causes of project delays
4	**Strategic leadership for managing multiple mega projects**	Principles of projects monitoring and control Essentials of managing multiple projects Set-up of PMO in construction, and agility in construction

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