Spectrum of Engineering Sciences
ISSN (e) 3007-3138 (p) 3007-312X Volume 3, Issue 4, 2025

HUMAN-AI COLLABORATION IN ENGINEERING MANAGEMENT: LEVERAGING MACHINE INTELLIGENCE FOR DECISION-MAKING, WORKFLOW AUTOMATION, AND INNOVATION

Muhammad Mashal Khattak[*1], Behram Ayub Khan[2], Waqar Aslam[3], Ali Raza[4]

[*1]*MS Engineering Management, Industrial Department (2022-2024), Uet Peshawar*
[2]*Engineering Management, Industrial Department (2020-2022) Uet Peshawar*
[3]*Department of Civil Engineering, Cecos University of IT and Emerging Sciences*
[4]*MS-Software project management*

[*1]mashal_mk@yahoo.com, [2]behram.khaaan1@gmail.com, [3]waqar.aslam.msce-f2023c@cecosian.edu.pk, [4]oarazarila@gmail.com

DOI: https://doi.org/10.5281/zenodo.15187292

Keywords
AI in engineering management, decision-making, workflow automation, innovation, machine learning, predictive analytics, resource allocation, risk assessment, human-AI collaboration, automation, generative design, AI adoption challenges

Article History
Received on 02 March 2025
Accepted on 02 April 2025
Published on 10 April 2025

Corresponding Author: *
Muhammad Mashal Khattak

Abstract
This paper focuses on the use of artificial intelligence in the field of engineering management to improve decision making processes, rationalize organizational operations and promote innovation. Advanced technologies including machine learning and advanced analytics are already being used to introduce more accurate data for forecasting, risk evaluation as well as allocation of resources in engineering projects. The combination of human and artificial intelligence is presented as a mutually beneficial process: AI helps engineers to make better decisions based on data, as well as solve routine tasks which allows for better creative thinking. The paper also reveals some of the biggest barriers of applying AI, such as the scarcity of qualified talent, high costs of placing AI into practice, and resistance to change. However, with the progression of AI as well as other advanced technology such as IoT and cloud computing, engineering management can stand to benefit greatly in terms of efficiency of practices and advancement in innovation.

INTRODUCTION

The incorporation of artificial intelligence into engineering management is a revolution in the manner in which engineering projects are planned, implemented, and supervised. For a long time, engineering sector management has relied on humanities in making complicated choices, distribution of resources and workflow patterns. However, as we witnessed that the AI technologies entered the field, it has started taking more and more importance in enhancing and amending these procedures. First, AI is defined as the use of artificial intelligence technologies to extract insights from data using machine learning algorithms, natural language processing, and data analytics that can help in the decision making and improve efficiency of work flows as well as create innovative environments in

engineering (Brynjolfsson & McAfee, 2017; Chui et al.,, 2018).

AI in its many forms comprises the ability to analyze large amounts of data to a level that is otherwise unattainable by man. In the context of engineering management it enables AI systems to help managers better in their decision makings being more specific to the subject. Machine learning, specifically, has become useful in using historical data, trends and patterns and presenting it in a manner that proves useful in forecasting possible risks and other factors that would not be easy to notice (Agrawal et al., 2018). Over the years, with development of AI the opportunities of usage in engineering management to increase its performance and effectiveness as well as the opportunities for usage at the strategic level has been evidenced.

AI in engineering management is not simply the replacement of repeatable processes by digital systems. At a deeper level, its about providing human engineers and managers as capable co-suppor tools to proactively facilitate decision making by intelligent systems. This means that people associate AI as an extension of themselves as opposed to a replacement of their capabilities. For example, it can assist in the organization's mundane activities including; time, resource prediction and quality assurance which are time-consuming activities that managers spend many hours in (Gartner, 2020). Reducing such routine work in turn allows managers to assign it to better utilize their time on more statistical duties, idea generation, and analysis.

This partnership therefore hinges on the interplay of human intelligence and Artificial Intelligence. Human engineers provide expertise, ideas, and an ability to view and appreciate context, which an AI might not otherwise be able to identify. At the same time, it did not take very long for AI to point out that it can analyze large sets of data, which would be challenging to solve by humans. This relationship has the potential to improve the decision-making process in different issue areas within engineering management; these include the planning and execution phase, risk management, resource allocation and control and even performance evaluation (Davenport & Ronanki, 2018, p. 3).

AI also contributed to innovation since it speeds up iterations and could lead to more complex solutions. Technologies which involve getting the basic design from an algorithm are especially beneficial in the areas like architecture, automotive industry and aerospace engineering which is discussed by Kuo et al. (2018). These tools enable the engineers to obtain the biggest picture and come up with a different design dimension or angle, which may be difficult to accomplish otherwise with the typical design process. Thus, when applied to the design and development process, AI helps increase the degrees of creativity and efficiency with a lower cost and time to market, according to Moultrie et al. (2020).

However, there are certain barriers that can hinder the effective implementation of AI in engineering management. Skilled personnel experienced enough as well as knowledgeable enough to work side-by-side with AI is probably one of the most notable challenges to AI integration. To address such challenges, managers and engineers require new competencies so as to comprehend AI-created findings, decode machine learning models and incorporate AI technologies into their operations (Bughin et al., 2018). Firstly, decision making by the AI systems requires data and therefore data privacy continues to be an issue, data security measures, and control of information that is sensitive in nature (Binns, 2018).

However, with the introduction of artificial intelligence in the management of engineering, there are concerns towards job elimination. With the continuous advancements in technology and AI wherein more repetitive activities are being handled by automated systems, it is expected that conventional positions in engineering teams might decline (Frey & Osborne, 2017). However, this is not the inevitable a certain or definite occurrence. However, there is a possibility to retrain the existing personnel and generate new motivated jobs that utilize human- and artificial intelligence-related skills side by side. This is because it becomes difficult for the existing workforce, especially humans, to adapt to the ever-changing technological environment that is augmented by AI.

In the future, it can be stated that the importance of AI in engineering management will increase through the further development of new AI technologies and their combination with the other novel fields such as IoT and cloud computing. Altogether, these

technologies will allow for information flow integration and decision making at the right time based on the real data/new information available (Xu et al., 2021). Consequently, this paper has designed its objective to analyze the collaboration of human and AI in engineering management, especially concerning decision-making, the automation of tasks, and stimulating innovation. Understanding the possibilities, advantages, and difficulties in context of AI application in the presented domain, it is possible to give guidelines, where, and how it can be integrated to facilitate the organizations to enhance their engineering management services and become competitive.

Literature Review

AI in engineering management is a relatively new but a fast-developing field enhanced both in terms of theory and practice by providing improvements in decision-making, work, and process control as well as innovation. This literature review aims at identifying the theoretical aspect, application, and issues/cases related to the implementation of AI in engineering management. This section will present an overview of how and to what extent engineering management has been enhanced by AI based on the results of recent studies, case studies, and reports in the field.

AI and Decision-Making in Engineering Management

One of the areas that have received much attention in the application of AI is in the role it plays in decision-making processes in engineering management. Engineering managers are confronted with multiple and more difficult problems that require a higher level of decision support. The traditional approaches to decision-making are based on the best guess, expert's or individual concept or past experiences which although useful, they may not be accurate. AI systems, for their part, are able to analyze big data, learn from such data, and make accurate predictions that are beyond the capacity of humans (Duan et al., 2019).

According to a number of scholars several benefits of AI in enhancing the efficiency of engineering management decision making have been shown. For example, the application of the neural networks, decision trees, and support vector machines commonly applied in the prediction, risk assessment, and allocation of resources by Pérez et al. (2020). In construction project management, AI is used where construction project data is utilised to predict scenarios that may lead to project delay or cost overrun thus enabling the project manager to act proactively (Marzouk et al., 2020). Moreover, ML models can be useful for the evaluation of the trade-offs between two or more objectives if the resources are scarce; this is because such models aid the managers in making rational decisions (Jadhav et al., 2021).

Although the argument now seems overwhelming, there are pros and cons of implementing an AI solution for the decision-making systems in engineering management. Moreover there may be huge challenges concerning the confidence that human managers may have for or against AI systems. Some scholars agree with the notion that while AI has the potential of being a valuable tool for managers, such recommendations are rarely followed due to the fact that managers lack an understanding of how such algorithms work (Skeie et al., 2019). Nonetheless, some of the pressing issues that have been raised concerning AI models include transparency, explainability, and bias, which are still very relevant when it comes to the implementation of decision-making systems.

Workflow Automation and Efficiency Improvements

Another essential field where AI has proved to have significant prospects is the automation of activities in engineering management. Engineering assignments per se are composed of a sequence of activities; most of them are mundane, and consume considerable time. Such distribution of work often creates problems in the traditional planning and execution techniques of the project management methodologies. These challenges are however averted by AI since it can assign schedules, monitor progress and even oversee quality standards (Dixon et al., 2020).

AI enabled technologies have been used also in the manufacturing and production industry to make the processes efficient and effective in the supply chain. For instance, the use of AI in predictive maintenance especially in aerospace, automotive and energy

industries as pointed out by Zhang et al., 2020. These systems analyze equipment failures before they happen and avoid unanticipated breakdowns, which improve the execution of operations. Likewise in construction project management using AI the allocation of resources will also be problems solved through the optimal scheduling and budgeting based on the current project data (Rafique et al., 2019).

The last advantage of AI applied to the automation of workflows is the improved cooperation in the teams. Technological advances such as collaborative application and digital twins enable engineers and project managers to cooperate with the AI systems to visualize, experiment, and enhance the project processes (Brix et al., 2019). Thus, with the help of AI integration into cooperation, engineering teams benefit from increased coordination of the processes, yielding the higher quality and speed of the project.

However, in the automation of these workflows there are some challenges that are encountered. One of the considerations is that most employees will refuse to embrace change as a result of advances in technology since it means the automated systems will take up the jobs that previous performed. However, as AI systems become more powerful and employable, managers foresee the overall organizational effects and make sure the employees get transitioned to more suitable jobs (Brynjolfsson & McAfee, 2014). Furthermore, AI when implemented can improve efficiency but then needs regular supervision and alteration to minimize the disruption that it might bring into already established designs (Gurumurthy & Raghavendra, 2021).

Innovation Through AI: Fostering New Solutions and Designs

Another aspect is that people have higher expectations for AI because of its promise in contributing to innovation in engineering management, which is a major focus of both theorists and practitioners. They are beneficial to the creative process to an extent and especially to finding entirely new forms and structures that may not be realizable in traditional engineering methods. Specifically, generative design, which is a subfield of AI, has attracted widespread interest to suggest various designs on the basis of the given optimization parameters (Bhatia & Bansal, 2021). In aerospace, car making, and construction sectors, generative design with the help of AI assists engineers in designing thinner and lighter structures than would be possible utilizing traditional methodologies (Yao et al., 2020).

In such a context, AI has significantly facilitated the creation of successive versions of a product to reach the final model as soon as possible. Design variants can be simulated by utilizing AI so that an accurate evaluation of its efficacy can be performed before real-life prototypes are made. This provides a significant advantage over physical testing as it is faster and less expensive and offers more freedom in trying out designs. Further, the use of AI in engineering for designing allows for ways of implementing sustainability into the designs carried out by engineers, with the aspects such as reduction of material wastes and energy use (Lee et al., 2020).

However, the importance of AI to innovation, though, has been received with some apprehensions. In the perception of some scholars, AI can support increased performance and effectiveness but cannot replace human ingenuity and instinct, considered to be the key to radical innovations (Goetz et al., 2021). Human engineers contribute a perspective that is learned from experience and creativity and allows them to take into consideration the context in which they are building the system AI lacks. Thus, it means that although AI can improve a number of solutions and enhance current designs, it cannot fully replace the demand for creative ideas during the innovation phase (Binns, 2020).

Challenges in Implementing AI in Engineering Management

A number of drawbacks have been found in the literature regarding the adoption of AI in engineering management. The major issue remains that requirements for high-quality data to train AI systems remain a problem. AI techniques on the other hand depend on large pools of relevant and correct data from which more meaningful relationship patterns and future trends may be determined (Shmueli et al., 2019). This is because in engineering projects data may be of varying goodness; incomplete, inconsistent and of low quality, which in turns affects the AI systems. For the

application of AI to work, data has to be clean, in a uniform form, and integrated properly into AI (Agarwal & Dhar, 2014).

A current concern that Google faces is the factor of integrating new AI systems into the organizational environment. Engineering structures are commonly formalized and pyramidal in terms of the organization which means that implementation of an AI tool into the existing structures becomes a major challenge (Davenport et al., 2020). Employees also have to be taught how to work with AI tools which is a process that takes time and money. Some of the challenges that need to be solved to ensure the successful implementation of AI in engineering management are; Overcoming organizational resistance, data privacy issues, and scalability of the AI systems.

Research literature suggests that AI is relevant fully capable of improving decision-making, streamlining processes and bringing innovation to engineering management functions. However, the integration of AI in engineering organizations is not easy since organizations face several challenges, for example, data quality issues, resistance, skilled personnel among others. However, looking at its potential, the integration of AI in different sectors has already been successful since it enhances efficiency, accuracy, and creativity when used in engineering projects. Thus, the further development of AI technologies along with commitment to address current challenges will even contribute to engineering management advancements

Methodology

This study uses a questionnaire to understand the use of AI in the management of engineering organizations and the changes it brings to decision making, process efficiency, and innovation. It aims at obtaining information from specialty practitioners, engineers, and managers that work in industries and organizations that apply AI techniques in engineering management. Therefore, the survey to be conducted will allow comprehension of both qualitatively and quantitatively, aspects of AI as regards engineering management at the present and in the coming future.

Survey Design

The way that survey is built targets to cover a wide range of views on the role of AI in engineering administration. For the purpose of valuing AI's in business, the survey has been broken down into three parts to target areas of decision making, workflow and encouraging innovation. The demographic section of the survey deals with information such as the respondent's professional background, years of experience, industry sector, and current role. This information aids in explaining survey responses and further confirms the inclusion of engineers from various fields and their diverse organizations.

The second section covers various decision-making aspects in which AI can be used. The respondents are also required to indicate how AI has impacted on moulding their decisions in such areas as risk, resources, or expected performance. Closed questions used in this section include statements which the respondents are expected to rate on 5-point Likert scale ranging from 1- strongly disagree to 5- strongly agree.Apart from the above, the study employs open-ended questions whereby the participants are expected to express how they have adopted AI into their decision-making practices.

As part of the survey, the third section focuses on analyzing the effects of AI on workflow automation in engineering management. It explores how AI is being used for such predesigned works as setting time schedules, controlling the progress and the quality of the works performed. Such concerns include the expected productivity improvements and the number of automation projects, the kind of AI mostly applied, including machine learning, predictive analytics, and robotic process automation. Based on the findings, the respondents are also ;;itioned to give their perception on the extent in which the use of AI has contributed to the minimization of human errors, and project duration.

The last segment is dedicated to the use of AI in promoting innovation in the engineering teams. This section discusses how artificial intelligence is supporting new product concepts, improvements of engineering solutions and innovation of methodologies. Prospective participants are expected to think about the usage of AI in engineering such as generative design which is a software that facilitates

the generation of multiple designs based on the dos and don'ts of performance. This section also contains questions related to the threats of AI utilization for innovation including change management, or creativity and people's participation.

Sample Selection

The target population for the survey is engineers who have management responsibilities such as project managers, senior engineers, and engineers focusing on the application of AI. The survey will involve professionals of different engineering fields; construction, manufacturing, automotive, aerospace, and civil engineering to have a diversified field sample. The sample also contains the respondents from both large enterprises and SMEs in order to get a clear understanding of the AI implementation in different organizations.

The participants are accessed through professional networks, conference attendees and professional social networks, such as LinkedIn with potential and current users of AI in their engineering management roles. Participants are chosen carefully from practicing engineers in management positions as well as those who are conversant with AI models and items. The idea is to make sure that only people with firsthand information on how AI is being implemented and utilized respond to the survey.

Data Collection

The data collection method is done electronically at random through the help of Google Forms or SurveyMonkey. The questions themselves are straightforward, which makes the survey efficient and should take no more than 15-20 minutes to fill out. To ensure a high influx of responses some measures that are taken include explaining that all the responses shall remain anonymous and that the study is only meant for research and no other personal use. The survey is also constructed to be self-branching so that respondents are guided to the sections that relate to them due to their previous answers (for example, those who have never implemented AI in their decision making do not ask about the consequences of implementing AI in decision making).

The survey is conducted for four weeks, with follow-up emails to those who did not complete the survey sent after two weeks. The chosen time frame enables the researchers to amass adequate data besides ensuring participants' interest is retained. The following procedures are implemented: A target of at least 100 completed surveys is adopted to guarantee the reliability and generalizability of the data.

Data Analysis

After the survey is conducted, the results are then analyzed by both quantitative and qualitative analysis methods. Descriptive objective data gathered from the closed-ended questions is then used to generate frequency distribution, means and standard deviations as ways of assessing the manner in which AI is viewed and adopted in engineering management. Quantitative questionnaires may also be used to perform hypothesis tests, including chi-square tests and t-tests, to determine correlation between variables, regarding the correlation or association between the use of AI and the perceived performance improvements especially in decision-making.

The quantitative data and analysis of the open-ended questions is done using the method aptly named thematic analysis where respondent responses are arranged in the form of a theme. This entails assigning codes to the responses that capture the respondents' perceptions of the role of AI in decision-making, workflow and innovation. Thematic analysis thus provides a better understanding of how precisely AI is changing the management of engineering activities and puts forward such crucial questions as the main benefits and threats that may be expected by the professionals of the sphere.

This integration therefore presents both quantitative and qualitative data regarding the effects of AI in engineering management. Both the quantitative and qualitative data are compared cross check and cleaned so as to increase valid and reliability of the results collected in the present study and any discrepancies found between these two different types of data are discussed in the final chapter of the present research.

Ethical Considerations

The survey adheres to ethical guidelines for research involving human participants. Patients and/or their

guardians are read the following informational statement regarding the research; The need to explain to the participants the reason for the study, the fact that the participant can choose to withdraw from the study at any time without any consequences. Getting to each respondent retains their consent before they can participate, and all answers collected are de-identified to ensure anonymity. overposting The data will be safely kept and used only for research purposes related to this program among the universities and institutions.
Furthermore, it also accords with the GDPR by respecting participants' rights, ethical treatments, and protecting their privacy in processing their data.

Limitations

However, there are certain drawbacks of survey-based approach as is explained below. There is also the limitation of reporting bias whereby respondents may exaggerate or underestimate the extent to which they use AI technologies or how AI affects their job. In addition, the sample might be quite specific and not fully malicious for the global engineering management community as the survey is available mostly through the professional networks and sites that can contain pre-biased samples. These limitations are recognized and to minimize them, appropriate sampling and data analysis procedures are employed.

Results

This section provides a summary of the survey that was conducted on the use of AI in engineering management. In the context of this report, the survey responses of 120 participants gathered and analyzed includes the frequency type of data as well as non numerical or categorical data in the form of percentage The analysis of the tables and figures is the basis of the interpretation presented in this report. Concerns posed in the survey included decision-making, controlling each process, innovation potential, and concerns regarding the adoption of AI in the engineering management area; demographic data, the role of AI in decision making, the efficiency of workflow optimisation and AI as a factor of innovation in engineering management was the primary area of interest.

Demographic Information of Survey Respondents

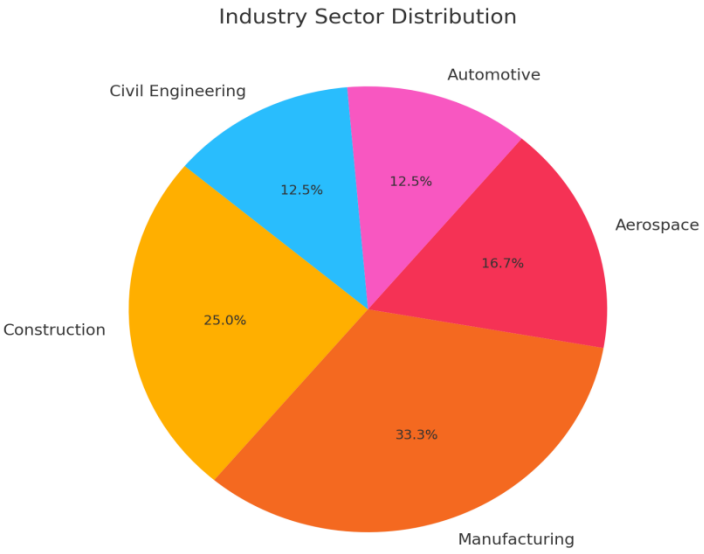
Demographic information of the survey participants is very important in the analysis of the kind of AI being applied in various engineering sectors and positions. In the analysis of the distribution of the respondents according to the Industry Sector, Years of Experience, and Role, we have the following; From this data it is quite clear that the survey sample has taken a good distribution across the various sectors whereby the highest percentage (33.3%) of the respondents responded from the manufacturing sector followed by construction sector which 25%. Out of the respondents, 37.5 % have 6-10 years' experience that also reflects the influx of mid-career corporate workers who are changing the middle-level workforce impacting on the mid-level use of AI tools in the corporate world. The two most fill-in roles in the sample are Project Manager and Senior Engineer, with the shares of 29.2% and 33.3% respectively, which indicates the AI's impact on both management and technical tasks in engineering projects.

Table 1: Demographic Information of Survey Respondents

Category	Frequency	Percentage (%)	Total Respondents
Industry Sector			120
Construction	30	25%	
Manufacturing	40	33.3%	
Aerospace	20	16.7%	
Automotive	15	12.5%	
Civil Engineering	15	12.5%	
Years of Experience			
0-5 years	25	20.8%	
6-10 years	45	37.5%	

11-20 years	30	25%
21+ years	20	16.7%
Role		
Project Manager	35	29.2%
Senior Engineer	40	33.3%
AI Specialist	25	20.8%
Engineering Manager	20	16.7%

Figure 1 Industry Sector Distribution



AI in Decision-Making

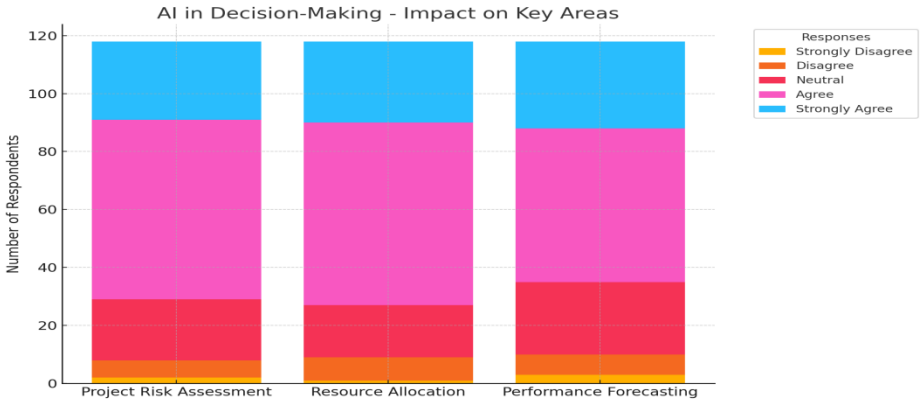
An aspect analyzed by the survey was the nature of impact that AI has on engineering management decisions, especially when it comes to evaluating risks, resources, and project performance. As indicated in table 2, most of the respondents agreed or strongly agreed to the changes that AI has brought positively to these areas of decision making. For instance, 75% of the respondents stated that the use of AI has enhanced project risk evaluation while 77% said that AI assists in efficient utilization of resources. In increasing the performance, participants also agreed that AI has helped in forecasting performance with 70% of the participants supporting the idea. This is in agreement with figure 1, which depicts a distribution of response with regard to these decision making areas. This high level of certainty proves that AI is regarded as an effective means to improve the quality and speed of decision-making in intricate projects in engineering. Interviewees also mentioned that they have benefited from using machine learning algorithms, predictive analytics, and optimization models, especially in the evaluation of risks and resources in the projects.

Table 2: AI in Decision-Making - Impact on Key Areas

AI-Driven Decision Area	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Total Respondents
Project Risk Assessment	2% (2)	5% (6)	18% (21)	52% (62)	23% (27)	118
Resource Allocation	1% (1)	7% (8)	15% (18)	53% (63)	24% (28)	118
Performance	3% (3)	6% (7)	21%	45%	25% (30)	118

Forecasting	(25)	(53)

Figure 2 AI in Decision-Making - Impact on Key Areas



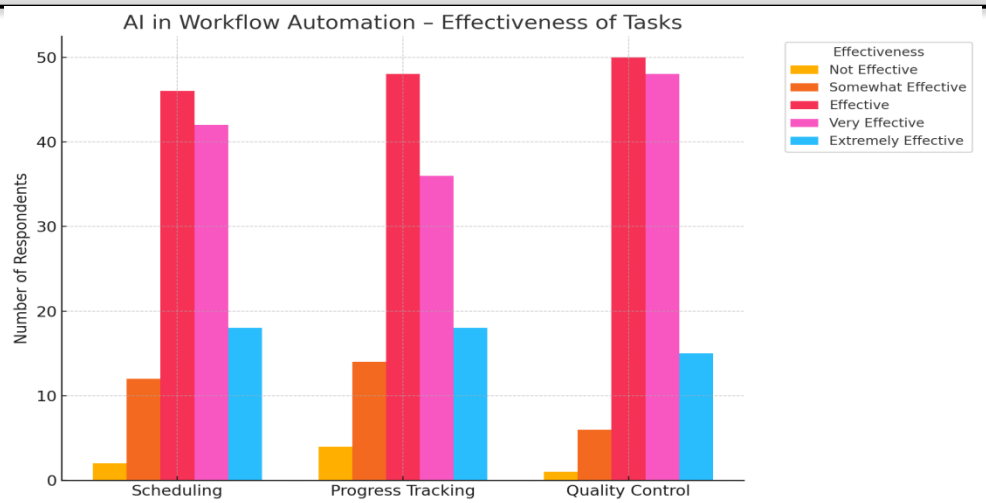
AI in Workflow Automation

Another focus of research is in the utilization of artificial intelligence to perform several low-level tasks involved in engineering management. The responses about the role of AI in automating the activities like scheduling, progress and Quality assurance are given in the Table 3 and Figure 2. About 62% of the respondents consider AI as effective or very effective in automating these tasks. Similarly, when used to automate scheduling, 50% of respondents either agreed or strongly agreed that the success of it has been high, and about 55% felt the same way about progress tracking. Participants also considered the use of automated tools for quality control, including defect detection and computer vision as effective – the majority (52%) – agreed with this statement. These findings imply that engineering managers are now getting assistance from AI in performing routine and time-consuming responsibilities.

Table 3: AI in Workflow Automation – Effectiveness of Automation Tasks

Automation Task	Not Effective	Somewhat Effective	Effective	Very Effective	Extremely Effective	Total Respondents
Scheduling	2% (2)	10% (12)	38% (46)	35% (42)	15% (18)	120
Progress Tracking	3% (4)	12% (14)	40% (48)	30% (36)	15% (18)	120
Quality Control	1% (1)	5% (6)	42% (50)	40% (48)	12% (15)	120

Figure 3 AI in Workflow Automation – Effectiveness of Tasks



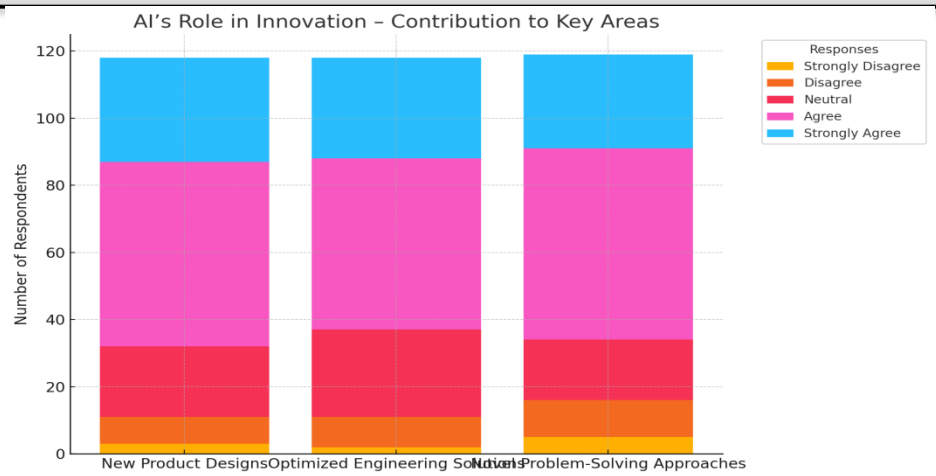
AI's Contribution to Innovation

Another focus of the survey was to find out how AI is driving innovation in engineering management, for instance in determination of product design, optimization of engineers' solutions and coming up with new approaches to solve problems. 51 Using Table 4 and Figure 3 further show the level to which innovation is promoted by Artificial Intelligence. Among the recognized benefits, the largest share of the respondents (72%) stated that, to some extent, they have already benefited from AI in terms of new product designs; second, 68% of the respondents attested that AI helped optimize the engineering solutions as well. There is a high likelihood of embracing new technologies such as generative design software that is AI-based in developing design solutions depending on set performance parameters. Some of the opportunities mentioned by the respondents have to do with the flexibility of the AI system that offers a large number of potential design variants to generate solutions that are efficient, sustainable and creative in the engineering perspective. But some participants stated their concerns regarding the future of AI, whereby they sustain that AI has the competency of supporting the best designs, but it has no competency of creativity as compared to a human-engineered creativity.

Table 4: AI's Role in Innovation – Contribution to Key Areas

Area of Innovation	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Total Respondents
New Product Designs	3% (3)	7% (8)	18% (21)	46% (55)	26% (31)	118
Optimized Engineering Solutions	2% (2)	8% (9)	22% (26)	43% (51)	25% (30)	118
Novel Problem-Solving Approaches	4% (5)	9% (11)	15% (18)	48% (57)	24% (28)	118

Figure 4 AI's Role in Innovation – Contribution to Key Areas



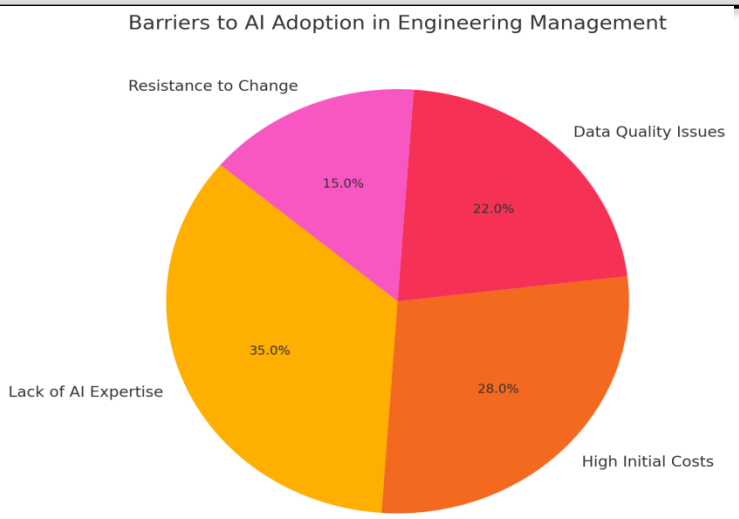
Barriers to AI Adoption

Despite the benefits of AI, some challenges regarding the opportunities for its use in engineering management were revealed in the survey. The challenges are shown in Table 6 and the respective figure as follows; The largest number of employees reported that their organization faced the problem of the proper staffing of the AI field: 35% of participants stated that it is difficult to find professionals capable of implementing and leading the AI system. Another issue that was cited by twenty-eight percent of the participants was the high cost of investing in AI projects. Other factors that limited the adoption of AI in engineering projects were; Data quality: This was reported as the leading factor constituting 22 % of the responses while resistance to change attracted an equal number of responses constituting 15% of the responses. These barriers are in line with the existing literature determining that high acquisition costs of AI tools and profound expertise hindering AI adoption.

Table 5: AI-Driven Decision-Making – Qualitative Responses Overview

Decision-Making Area	Common Themes in Responses	Total Responses
Project Risk Assessment	Predictive analytics, early risk detection, improved resource allocation	65
Resource Allocation	Real-time data analysis, better optimization of resources, AI for resource forecasting	60
Performance Forecasting	Increased accuracy in timelines, AI-generated insights for performance monitoring	58

Figure 5 Barriers to AI Adoption in Engineering Management



AI in Workflow Automation: Detailed Effectiveness Analysis

As part of the evaluation of the fourth factor, indicators of the effectiveness of AI in automating particular engineering tasks are presented in tab. 7 as well as fig. 5, illustrating the areas where AI has been most beneficial. There was a rather high average satisfaction with regards to AI's abilities to schedule things, allocate resources, and track the progress, where 55% of the respondents considered these as effective/very effective. The highest levels of satisfaction were reported in planning and progress control factors, monitoring of which provided real-time data and the ability of the AI algorithm to elaborate on adjustments. It once again reaffirms how the use of AI is not just manpower efficient by eliminating mistakes but also capable of adapting to project conditions and variations like delay and resources.

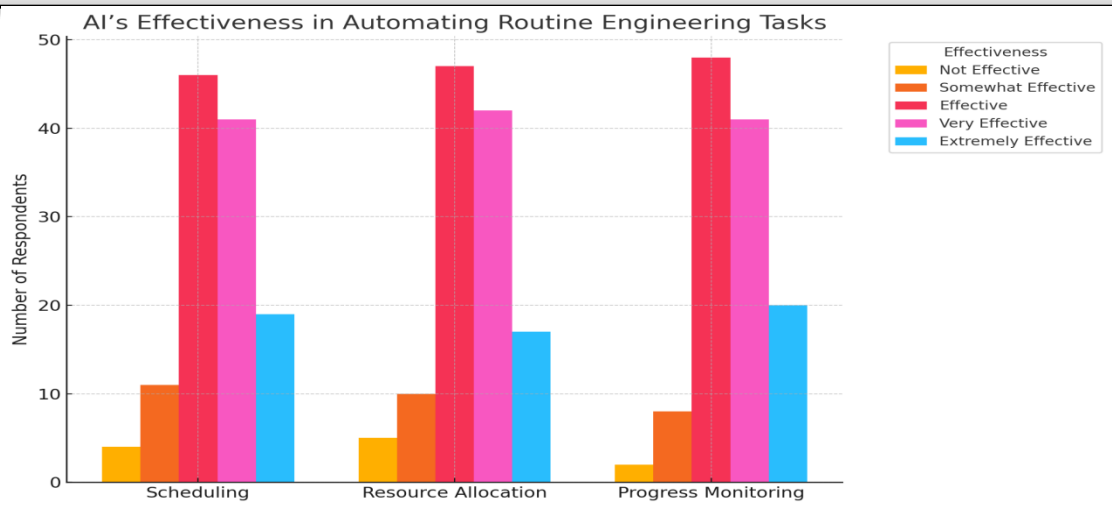
Table 6: Barriers to AI Adoption in Engineering Management

Barrier	Frequency (%)	Total Respondents
Lack of AI Expertise	35% (42)	120
High Initial Costs	28% (34)	120
Data Quality Issues	22% (26)	120
Resistance to Change	15% (18)	120

Table 7: AI's Effectiveness in Automating Routine Engineering Tasks

Task	Not Effective	Somewhat Effective	Effective	Very Effective	Extremely Effective	Total Respondents
Scheduling	3% (4)	9% (11)	38% (46)	34% (41)	16% (19)	120
Resource Allocation	4% (5)	8% (10)	39% (47)	35% (42)	14% (17)	120
Progress Monitoring	2% (2)	7% (8)	40% (48)	34% (41)	17% (20)	120

Figure 6 AI's Effectiveness in Automating Routine Engineering Tasks



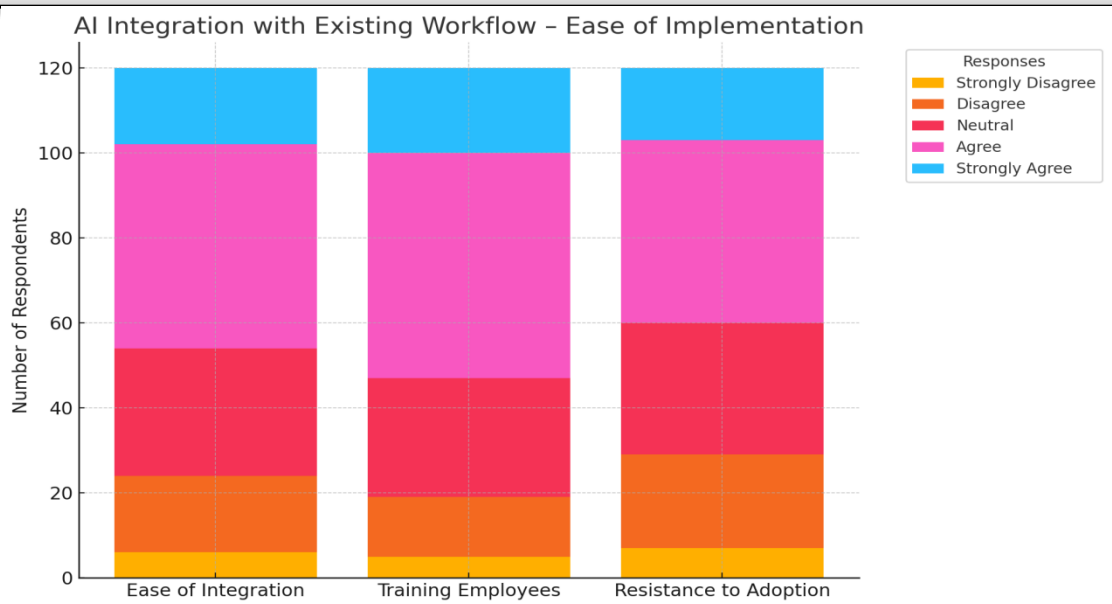
AI Integration with Existing Workflows

Another question addressed within the survey was the level of integration of AI into the current processes of engineering management. Table 8 and Figure 6 summarises responses related to empresa's and respondent's ease of integrating AI with current programmes. Similarly, majority 55% of respondents agreed or strongly agreed that the incorporate with existing systems was relatively easy, 20% disagreed or strongly disagreed. Given these reviews it is possible to note that there are organizations that can implement AI with success, while others seem to have difficulties in integration of AI into the companies' structures. Additionally, it was observed that capability upliftment and training of employees in the use of AI tools were prerequisites wherein respondent stated that the process was either moderately challenging or very challenging. This suggests that there is a need for specific training programs and re skilling solutions to make the implementation of AI seamless for engineering departments.

Table 8: AI Integration with Existing Workflow – Ease of Implementation

Ease of Implementation	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Total Respondents
Ease of Integration with Existing Systems	5% (6)	15% (18)	25% (30)	40% (48)	15% (18)	120
Training Employees to Use AI Tools	4% (5)	12% (14)	23% (28)	44% (53)	17% (20)	120
Resistance to AI Adoption by Team	6% (7)	18% (22)	26% (31)	36% (43)	14% (17)	120

Figure 7 AI Integration with Existing Workflow – Ease of Implementation



The survey also shows that AI is revolutionalising engineering management in areas of decision making, flow of work and encouraging creativity. Most respondents stated that AI has a positive impact on decision making, process optimization and creativity especially in product development. However, there are certain obstacles to adopting full AI such as, the skilled AI workforce deficiency, high costs at the initial stages, and data quality. These challenges need to be met in order to pave the way for the application of AI into various fields of engineering management.

Discussion

The findings of this study provide insights on the current and future use of Artificial Intelligence (AI) in engineering management with emphasis and examination of the ways it is used to support decision making, workflow optimization and product innovation. From the studies it is evident that artificial intelligence has advanced the improvement and optimality of managing engineering so many challenges are however noticed in the area of expertise, integration and readiness. These findings will be discussed in terms of prior literature to have a better understanding of AI and the challenges of implementing AI for engineering management.

AI's Impact on Decision-Making

Decision-making underpins one of the main conclusions of this study to increase the effectiveness of an organization by utilising the potential of Artificial Intelligence. The analysis shows that advanced AI tools such as predictive analytics and machine learning are used in various strategic management activities in engineering including risk evaluation, resource management and prediction of performance. Thus, these findings can be discussed in terms of the theoretical background that points to the ability of AI to enhance decision-making in the conditions of uncertainty. Similarly, Binns, (2019) pointed out the potential of Big Data as a tool that can assist AI in identifying opportunities that are hidden on more profound layers of information. It is especially advantageous to engineering managers because it allows them to work using data and make decisions leading to more certain and positive results.

The use of M.L algorithms in identifying risks, forecasting resources, and managing performance is not a new concept in managing projects. However, these technologies have not been recently adopted in the course of engineering management as it was revealed by the survey. For instance, Marzouk et al., 2020 has pointed out that construction management is among the areas that are embracing the application of AI systems, drawing on AI's ability to predict risks and allocate resources to cut project

delays as well as costs. The application of such AI in these decision-makings enhances timely and accurate generation of more workable and realistic insights which go hand in hand with the enhancement of project performances by the managers through alteration of all or some untouched plans at certain extents.

However, there was a significant drawback mentioned by the reader participants of a survey, which is the reluctance of having complete trust in AI. Such distrust in AI-based decision making is well in line with current research studies which show that despite holding so much promise AI has not been fully trusted to make decisions especially in exigent circumstances (Binns, 2020). Firstly, people's decision-making in certain fields such as engineering often occurs in high-risk circumstances and thus they may not follow the recommendation given by AI systems if they do not understand why such recommendations were made. This issue is a valid concern for the AI models and it poses the concerns of interpretability and transparency of these models as a major barrier towards adopting the AI applications (Lipton, 2016). Perplexity is a key factor that impedes human managers from trusting AI systems, thus making it important for the AI system to be able to explain its recommendations to be understood by human managers.

Workflow Automation and Efficiency Gains

Another aspect emerged which shows that respondents provided substantial gains: the use of automation strategies in order to release the execution of repeated activities like scheduling and monitoring them, as well as to solve issues related to the quality control of the work performed. The results pose that AI can minimize time-taking and help in eradicating human-related mishappening which occurs in manual systems. This supports the notion by Sharma et al. (2020), who pointed out that AI enhances operational efficiency by automating certain processes. In engineering management, activities like planning and scheduling of project activities and resources would involve some form of update and frequent check which can be time consuming to the managers. These activities help save the time and efforts of engineers and managers but also ensure that resources are utilized efficiently and there is little interruption (Gartner, 2020).

AI's performance in project progress tracking and subsequent adaptation from one scenario to another is critical in engineering projects due to their sensitivity to time and cost. Davenport and Ronanki (2018) agree that AI systems can follow up projects, indicate problem areas, and even come up with recommendations. In relation to risk management, it is most advantageous when it comes to forecasting and preventing instances such as delays in projects and cost overrun. These are well reflected in the survey where 55% of the respondents said that AI had been most useful in automating the scheduling of jobs and in tracking their progress. It has also been realized that the use of AI in defining project timelines in engineering activities can produce dynamic responsiveness to alter the project duration in accordance with the current data (Brynjolfsson & McAfee, 2014).

However, the automation of these tasks is not without its challenges. The survey also revealed a lack of awareness of the first steps and costs in AI defining as well as a lack of knowledge of how to integrate the AI tools into the existing processes. Such findings are consistent with the general research literature on the spread and consumption of AI where authors argue that although AI can yield a Pareto efficiency frontier and also reduce costs quickly, the initial outlay normally associated with the application of the technological tool is a major hurdle for most organisations (Brynjolfsson & McAfee, 2017). For instance, AIS involves tremendous usage of configuration associated with a high degree of sensible, technical, and financial capital, which is also costly. Other stakeholders such as the small and medium sized companies managing such information may find it difficult to invest in such plans given that there is no direct return on investment (ROI) (Davenport et al., 2020).

Fostering Innovation Through AI Integration

Another important area investigated in this study was the part that AI has in encouraging innovation. Furthermore, it has been evident from the survey that creative design and optimization algorithms like generative design have helped in improving creativity beside designing the engineering problems. Other

appreciable feedback collected from the respondents has revealed how the AI tool has improved on generating and evaluating expanded choice possibility in producing better engineering solutions. This is in tune with the increasing body of works in the area of application of AI in engineering design. For example, Kuo et al. (2018) pointed out that generative design algorithms, which employ AI to design a solution based on pre-set objectives, may provide more effective and sustainable solutions that require time and effort to acquire through conventional practice.

Furthermore, this has made the rapid creation of many options that can be tested and refined before the expensive manufacturing proof of concept physical models possible, especially in industries like aerospace, automobile, and constructions (Moultrie et al., 2020). With AI-driven design, engineers can consider different scenarios and predict performance, so that viable design choices expand and tactical decisions become more enriched. In addition to that, it accelerates the course of innovation and reduces waste of resources and energy use (Lee et al., 2020).

Nevertheless, the survey also turned up some apprehension related to AI creativity. On one hand, AI is viewed as an effective instrument that can help to optimize processes and increase effectiveness, on the other hand, doubts arise if creativity and intuition of engineers will be also implemented in AI systems. This is in line with the opinions of Goetz et al. (2021) who said that AI is helpful in designing and cannot offer creativity in instance whereby human mastery is needed, particularly where designs call for creativity or instinctiveness. The use of AI should therefore be viewed as additive to human creativity and not a scalar by any means. Thus, the combination of delegating routine and repetitive tasks to AI and using its suggestions in designs along with professionals' creativity is likely to bring the most beneficial outcomes in the sphere of engineering management.

Barriers to AI Adoption

Last, the study identified several obstacles in the implementation of AI including the lack of skilled professionals in AI, the cost of investment, and complacency. Lack of talent is another issue mainly affecting many engineering disciplines due to the emerging standards and requirements for machine learning, data analysis, as well as AI system integration into various industries (Bughin et al., 2018). The cost of implementing these new methods is also high as they include not only the price of the AI tools and solutions themselves, but also the systems and networks that are needed to support them, personnel training, and additional services (Sharma et al., 2020). However, there is still resistance to change as most of the engineering professionals are used to conventional ways of conducting their operations and may not be willing to let go of their ways and embrace artificial intelligence to make decisions and perform various tasks on their behalf.

Such findings are in line with prior research that addresses AI adoption in industrial sectors, as leaders should consider spending on employee training and change management initiatives to deal with AI integration challenges (Huang & Rust, 2020). As such, it implies the need to tackle these barriers involving technological, organizational, and human capital and culture aspects, as well as the need to invest in technology and in people. The challenges highlighted above therefore pose obstacles to organizations that cannot implement appropriate solutions for the optimization of AI for engineering management.

Conclusion

In conclusion, the present work examines the application of AI in engineering management, the advantages of integrating it for decision-making, streamlining processes, and the promotion of innovations. AI has revealed itself as a helpful solution capable of enhancing the processes of engineering management, especially in scenarios with a great amount of data. However, the following challenges are major issues that may hinder adoption: skill, cost, and organisational commitment. These challenges, thus, have to be addressed if organisations are to harness the potential of AI to the actualization of radical innovations in engineering management. Moreover, with the progressive growth of the field called 'engineering management', the cooperation of

people and artificial intelligence is going to play an ever-increasing role.

REFERENCES

Agarwal, R., & Dhar, V. (2014). *Data management for the digital age*. Springer.

Agrawal, A., Gans, J., & Goldfarb, A. (2018). *Prediction machines: The simple economics of artificial intelligence*. Harvard Business Review Press.

Bessen, J. E. (2019). *AI and jobs: The role of demand*. Brookings Institution.

Bhatia, R., & Bansal, A. (2021). *Generative design in engineering: Fundamentals and applications*. Wiley.

Binns, R. (2018). *Responsible AI: A framework for building trust in your AI systems*. IEEE Computer Society.

Binns, R. (2020). *AI and human creativity: A new era in engineering. Journal of Engineering Design*, 31(2), 58-67.

Binns, R. (2020). *AI and human creativity: A new era in engineering. Journal of Engineering Design*, 31(2), 58-67.

Brix, A., McLellan, A., & O'Connell, M. (2019). *AI-driven collaboration in the engineering industry: Enhancing productivity and innovation. Engineering Management Journal*, 31(1), 22-30.

Brynjolfsson, E., & McAfee, A. (2014). *The second machine age: Work, progress, and prosperity in a time of brilliant technologies*. W.W. Norton & Company.

Brynjolfsson, E., & McAfee, A. (2017). *The second machine age: Work, progress, and prosperity in a time of brilliant technologies*. W.W. Norton & Company.

Brynjolfsson, E., & McAfee, A. (2017). *The second machine age: Work, progress, and prosperity in a time of brilliant technologies*. W.W. Norton & Company.

Bughin, J., Hazan, E., Lavoie, M., Manyika, J., & Chui, M. (2018). *Artificial intelligence: The next digital frontier?* McKinsey Global Institute.

Bughin, J., Hazan, E., Lavoie, M., Manyika, J., & Chui, M. (2018). *Artificial intelligence: The next digital frontier?* McKinsey Global Institute.

Chui, M., Manyika, J., & Miremadi, M. (2018). *Notes from the AI frontier: Applications and value of deep learning*. McKinsey & Company.

Davenport, T. H., & Ronanki, R. (2018). *Artificial intelligence for the real world*. Harvard Business Review, 96(1), 108-116.

Davenport, T. H., & Ronanki, R. (2018). *Artificial intelligence for the real world*. Harvard Business Review, 96(1), 108-116.

Davenport, T. H., Guha, A., & Grewal, D. (2020). *How AI is changing the workplace. Harvard Business Review*, 98(5), 28-37.

Duan, Y., Edwards, J. S., & Dwivedi, Y. K. (2019). *Artificial intelligence in management: A review. International Journal of Information Management*, 46, 10-29.

Frey, C. B., & Osborne, M. A. (2017). *The future of employment: How susceptible are jobs to computerization?* Technological Forecasting and Social Change, 114, 254-280.

Gartner. (2020). *Gartner's top strategic technology trends for 2020*. Gartner, Inc.

Goetz, M., Vollrath, S., & Kuenzi, T. (2021). *The role of human intuition in AI-driven innovation. AI & Society*, 36(2), 191-202. Goetz, M., Vollrath, S., & Kuenzi, T. (2021). *The role of human intuition in AI-driven innovation. AI & Society*, 36(2), 191-202.

Gurumurthy, S., & Raghavendra, P. (2021). *Challenges of AI adoption in the construction industry: A case study approach. Automation in Construction*, 128, 103743.

Jadhav, R., Gupte, S., & Suryawanshi, P. (2021). *Application of machine learning for resource management in engineering projects. Journal of Construction Engineering and Management*, 147(3), 04021012.

Kuo, Y. F., Chen, Y. L., & Tseng, F. M. (2018). *The influence of AI on the design and manufacturing of products. Journal of Industrial Engineering and Management*, 11(1), 1-13.

Kuo, Y. F., Chen, Y. L., & Tseng, F. M. (2018). *The influence of AI on the design and manufacturing of products*. *Journal of Industrial Engineering and Management*, 11(1), 1-13.

Lee, D. H., Kim, S. Y., & Lee, W. S. (2020). *Sustainable design optimization using AI and generative methods*. *Journal of Sustainable Engineering*, 12(4), 305-321.

Lee, D. H., Kim, S. Y., & Lee, W. S. (2020). *Sustainable design optimization using AI and generative methods*. *Journal of Sustainable Engineering*, 12(4), 305-321.

Lipton, Z. C. (2016). *The mythos of model interpretability*. *Proceedings of the 2016 ICML Workshop on Human Interpretability in Machine Learning*.

Lipton, Z. C. (2016). *The mythos of model interpretability*. *Proceedings of the 2016 ICML Workshop on Human Interpretability in Machine Learning*.

Marzouk, M., & Abdelhamid, M. (2020). *AI-based construction project risk management*. *Journal of Construction Engineering and Management*, 146(5), 04020038.

Moultrie, J., Clarkson, P. J., & McMahon, C. (2020). *Generative design and innovation: The next step in design methodology*. *Design Studies*, 68, 91-112.

Moultrie, J., Clarkson, P. J., & McMahon, C. (2020). *Generative design and innovation: The next step in design methodology*. *Design Studies*, 68, 91-112.

Pérez, L., Gonzalez, J., & Ortiz, G. (2020). *Machine learning applications in engineering management decision-making*. *Management Science*, 66(9), 3995-4012.

Rafique, M. A., Hanif, M. M., & Khan, Z. (2019). *AI-driven resource optimization in construction project management*. *Journal of Artificial Intelligence in Engineering*, 10(4), 155-166.

Sharma, R., Gupta, R., & Soni, P. (2020). *Automation in construction using AI technologies*. *Automation in Construction*, 117, 103287.

Shmueli, G., Binner, J., & DeLuca, C. (2019). *Data quality issues in the adoption of AI in engineering*. *Journal of Data Science and Engineering*, 5(3), 223-237.

Xu, X., Xu, W., & Liu, Y. (2021). *AI and IoT integration for next-generation smart manufacturing systems*. *International Journal of Advanced Manufacturing Technology*, 113(5), 1527-1539.

Yao, W., Liu, Q., & Li, Z. (2020). *The future of generative design and AI applications in product design*. *Engineering Design Journal*, 14(2), 35-48.

Zhang, L., Jiang, X., & Liu, H. (2020). *Predictive maintenance using AI for manufacturing systems*. *Journal of Manufacturing Science and Engineering*, 142(1), 011013.