The Application of Artificial Intelligence for Construction Project Planning

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Abstract: Any building project's success depends on its planning. Due to the complexity of the construction business and the many aspects to consider, including money, supplies, labor, and timelines, this process may be difficult. AI can speed up and improve planning. This study examines the use of AI for building project planning. The research starts by examining building project planning and its problems. Next, the article covers machine learning, natural language processing, and computer vision AI technologies for building project planning. This study examines AI in building project planning. AI might revolutionize construction by improving project efficiency, accuracy, and performance. The study discusses predictive analytics, machine learning, and natural language processing for building project planning. The difficulties and prospects of AI in building project planning are also examined. The study finishes by examining how AI might be used to improve construction project planning and management. The article assesses AI's potential in building project planning and advises practitioners on how to use it. The study article then examines AI-planned construction projects. These examples demonstrate how AI may speed up construction, reduce waste, and streamline projects. Finally, the article discusses the merits and downsides of utilizing AI to plan building projects and suggests further research. This study report shows how important AI is for planning construction projects and how these technologies can be used to improve the performance of construction projects.

Keywords: Artificial intelligence, machine learning, natural language processing, construction project planning, construction

1. Introduction

The application of artificial intelligence (AI) in construction project planning has become increasingly relevant in recent years, as AI is recognized as a powerful tool for optimizing project processes, improving cost and time efficiency, and increasing safety. AI has the potential to revolutionize the planning and management of construction projects and increase the productivity of the construction industry. This research paper will examine the application of AI in construction project planning, exploring how AI can be

used to improve the project planning process, reduce costs, improve safety, and ultimately enable more successful outcomes. Furthermore, the paper will explore the current challenges associated with applying AI in construction project planning, including the lack of access to reliable data, limited understanding of the technology and its potential, and the potential for bias in AI-driven decision-making. Finally, the paper will discuss the potential of AI in the future of construction project planning, including its potential to save time, money, and resources, as well as its potential to facilitate more sustainable development. By examining the current and potential applications of AI in construction project planning, this research paper will provide an overview of the opportunities and challenges associated with this technology.

In the construction industry, the use of artificial intelligence (AI) in planning, designing, and managing projects has grown a lot in the past few years. AI has the potential to change the construction industry by making project planning more accurate and efficient, cutting project timelines, and making construction sites safer. When AI is used to plan a construction project, it uses advanced algorithms and machine learning techniques to look at data, predict what will happen, and make construction processes more efficient.

In order to understand the full potential of AI in construction project planning, it is important to first consider the current state of the industry. According to the World Bank (2020), the construction sector is currently one of the most significant contributors to global economic growth, accounting for approximately 10% of global GDP. However, the industry is also one of the least digitized, with an estimated 40–60% of the sector's costs attributed to inefficiency and waste. In addition, the construction industry is often subject to unexpected delays, cost overruns, and other issues that can lead to missed deadlines and wasted resources. Thus, the application of AI in construction project planning presents an opportunity for the industry to increase efficiency, reduce costs, and improve safety.

According to a report by the McKinsey Global Institute, the construction industry has been slow to adopt new technologies. As a result, productivity has stayed the same over the past few decades [1] but the report also says that the industry could save a lot of money and become much more productive if it used new technologies like artificial intelligence.

Another study by the Boston Consulting Group found that the use of AI in construction could result in a 40% reduction in project duration and a 20% reduction in overall project costs [2]. The study also showed how AI could make construction sites safer by spotting potential dangers and taking steps to deal with them before they happen.

The potential of AI in construction project planning was first recognized in the early 2000s when researchers began to explore the use of AI for task automation, data analysis, and process optimization [3]. In the years since, AI has been increasingly used in construction project planning and management, with applications ranging from construction scheduling [4] to project risk assessment [5] to machine vision [6]. AI technologies such as deep learning and artificial neural networks have been used to improve accuracy and automation in project planning, while other AI-driven technologies such as virtual reality and augmented reality have been used to improve the visualization of project plans and improve safety.

Even though AI has the potential to help plan construction projects, there are still some problems that need to be fixed before AI can be used to its full potential. Some of these problems are a lack of access to reliable data, a lack of understanding of the technology and what it can do, and the chance that AI-driven decisions could be biased. Also, using AI to plan construction projects still has some legal and moral issues to deal with, especially when it comes to the privacy of workers and the safety of construction sites.

This research paper will explore the current state of AI in construction project planning as well as the potential for future applications of the technology. The paper will consider the challenges associated with the application of AI and will discuss the potential of AI in the future of construction project planning. By examining the current and potential applications of AI in construction project planning, this research paper

will provide an overview of the opportunities and challenges associated with this technology.

Fig. 1. Current AI adoption by industry.

Fig. 1 shows the current adoption of AI across a variety of industries. AI is being used in industries such as healthcare, manufacturing, and finance to improve efficiency, automate processes, and provide data-driven insights. Financial is leading the way with the highest level of AI adoption, while High tech and telecom are not far behind. AI is transforming the way businesses operate and unlocking new opportunities for the future. Companies that do not embrace AI risk being left behind.

2. Literature Review

Articles Artificial intelligence (AI) is a rapidly growing field that has the potential to improve the efficiency and effectiveness of construction projects. AI is used to automate processes and decisions, reduce errors, and improve the safety of construction sites. AI has already been applied in various areas of construction project planning, such as scheduling, cost estimation, resource allocation, and contract management. The use of AI in construction project planning has the potential to increase the efficiency of project delivery, reduce the cost of materials and labor, and improve the overall quality of construction projects.

Artificial intelligence (AI) is revolutionizing every aspect of human life, and the construction industry is no exception. AI is widely used in various construction project phases, from design to construction and maintenance. One of the areas where AI has shown significant potential is construction project planning. The objective of this literature review is to examine the current state of research on the application of artificial intelligence in construction project planning. The literature review will focus on the benefits, challenges, and the latest research trends in the field.

AI can help plan construction projects in many ways, like making them more accurate, more efficient, and cheaper. The use of AI algorithms in construction project planning can assist project managers in identifying potential risks and predicting project outcomes, which can result in better project planning and scheduling [7]. AI can also help in optimizing project resources, reducing material waste, and improving safety on construction sites [8]. Furthermore, AI can provide real-time updates on project progress, enabling project managers to make informed decisions and adjustments.

Despite the numerous benefits of AI in construction project planning, there are also some challenges that need to be addressed. One of the main challenges is the lack of standardized data in the construction industry. Construction projects are unique, and project data may not be readily available in a format that can be used by AI algorithms. Furthermore, AI requires large amounts of data to train its algorithms, and the lack of

historical data in the construction industry can be a significant challenge [9]. Another challenge is the high cost of implementing AI technologies in construction project planning, which may not be feasible for small construction companies [10].

The current research trends in AI in construction project planning are focused on developing algorithms that can address the challenges of data availability and cost. Researchers are exploring different data sources, such as building information modeling (BIM) and the Internet of Things (IoT), to improve the availability of data [11]. Furthermore, researchers are developing AI algorithms that can work with small data sets and provide accurate predictions [12]. One of the emerging trends is the use of explainable artificial intelligence (XAI) in construction project planning. XAI is a subset of AI that enables users to understand how AI algorithms arrived at a particular decision. XAI can help in increasing transparency and trust in AI systems, which is critical in the construction industry [13].

In the past few years, there has been a lot of research into how AI can be used to plan construction projects. In a study by Singh and Chakraborty *et al.* [14], machine learning algorithms were used to predict the length of a construction project based on its location, size, and complexity. The study found that machine learning algorithms were better than traditional scheduling methods at figuring out how long a project would take.

In another study, Zhang and Chen *et al.* [15] used machine learning and natural language processing to make construction schedules automatically. The study found that the scheduling tool powered by AI could make schedules faster and more accurate than traditional methods.

In the study, Akintoye and MacLeod *et al.* [16] used AI algorithms to predict the likelihood of cost overruns in construction projects. The study found that the AI-powered risk management tool could predict cost overruns with a high degree of accuracy. This allowed project managers to take proactive steps to manage risks.

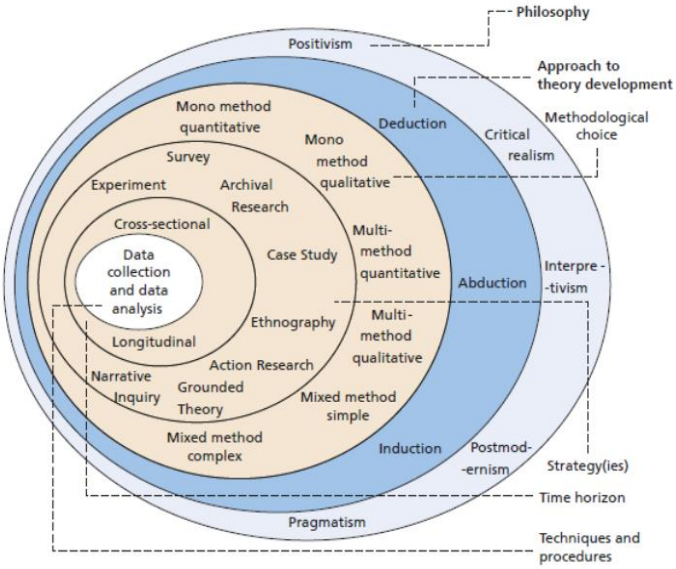
The goal of this research is to look at what's already been written about using AI for planning construction projects and to figure out what problems and opportunities come with doing that.

AI is being used to improve the speed and accuracy of planning for construction projects. Machine learning and natural language processing are being used. Machine learning is used to find patterns, spot trends, and make models that can be used to plan and manage building projects. AI can also be used to automate tasks like scheduling, figuring out how much something will cost, and allocating resources. Natural language processing is used to interpret written language and provide insights into the nature of contracts and other documents related to construction projects [17].

AI has the potential to cut down on mistakes and make construction sites safer by spotting things like structural flaws and dangerous materials and telling workers what to do to fix them. AI can also be used to optimize project scheduling, cost estimation, and resource allocation, which can help reduce costs and improve the efficiency of project delivery. AI can also be used to improve the accuracy and usability of contracts and other documents, which can help reduce disputes and improve the overall quality of construction projects [18].

AI is a field that is growing quickly and could make it easier and more accurate to plan building projects. AI can be used to automate tasks like scheduling, estimating costs, and allocating resources. It can also be used to find patterns, spot trends, and make predictive models. AI can also be used to improve the accuracy and usability of contracts and other documents, which can help reduce disputes and improve the overall quality of construction projects. AI has the potential to reduce errors and improve the safety of construction sites, as well as optimize project scheduling, cost estimation, and resource allocation, which can help reduce costs and improve the efficiency of project delivery. The research onion of Fig 2 provides a framework for understanding the various layers involved in conducting research. Each layer builds on the previous layer, and

they are all interconnected. Understanding the research onion can help researchers design and conduct more rigorous and effective research studies [19].



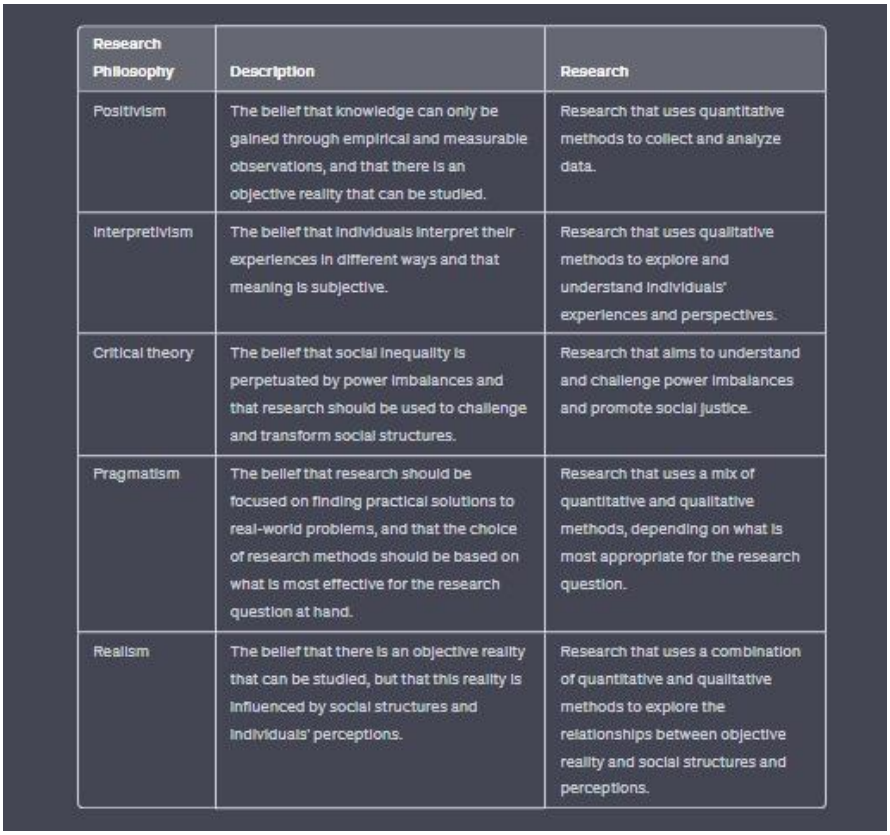
Layer	Description	Example
Epistemology	The researcher's view of how knowledge is acquired	Positivism, Interpretivism, Pragmatism
Philosophy	The researcher's worldview and assumptions about the nature of reality	Objectivism, Subjectivism, Realism, Nominalism
Approach	The general approach the researcher takes to conducting research	Deductive, Inductive, Abductive
Strategy	The overall plan for conducting research	Case study, Survey, Experiment
Method	The specific methods used to collect data	Interviews, Observation, Questionnaires
Technique	The detailed procedures used to collect and analyze data	Content analysis, Grounded theory, Discourse analysis
Procedure	The step-by-step process for conducting the research	Sampling, Data collection, Data analysis
Time horizon	The time frame for the research	Cross-sectional, Longitudinal
Output	The expected outcome of the research	Theory development, Practical application, Policy recommendation

Fig. 2. Research onion.

Fig. 2 is a conceptual framework to assist in understanding the complete research process. It consists of a series of layers that when peeled back like an onion, provide a comprehensive overview of the complexities of research, from problem identification to the interpretation of results. The research onion includes the research philosophy, approach, strategy, data collection methods, and tools for analysis. All these layers are connected to each other and provide insights into the various steps in research, thus providing a comprehensive overview of the entire research process.

Research philosophy refers to the set of beliefs, values, and assumptions that underpin the researcher's approach to designing, conducting, and analyzing research. It guides the researcher's choice of research methods, data collection techniques, and interpretation of findings. The relationship between research philosophy and research design is crucial since it determines the research questions that will be asked, the data that will be collected, and the analysis techniques that will be employed [20]. Fig. 3 illustrates the

relationship between research philosophy and psychology. Research philosophy is a set of principles that guides research in the fields of psychology, sociology, and other social sciences. It helps to define and understand the types of questions that can be asked and answered with scientific evidence. Research philosophy is also used to determine how research is conducted and data is analyzed. In psychology, research philosophy can help to differentiate different psychological theories and frameworks, such as cognitive and behaviorist approaches. By understanding the relationship between research philosophy and psychology, psychologists can better understand their theoretical framework and the methods they use when conducting research.



Research Philosophy	Description	Research
Positivism	The belief that knowledge can only be gained through empirical and measurable observations, and that there is an objective reality that can be studied.	Research that uses quantitative methods to collect and analyze data.
Interpretivism	The belief that individuals interpret their experiences in different ways and that meaning is subjective.	Research that uses qualitative methods to explore and understand individuals' experiences and perspectives.
Critical theory	The belief that social inequality is perpetuated by power imbalances and that research should be used to challenge and transform social structures.	Research that aims to understand and challenge power imbalances and promote social justice.
Pragmatism	The belief that research should be focused on finding practical solutions to real-world problems, and that the choice of research methods should be based on what is most effective for the research question at hand.	Research that uses a mix of quantitative and qualitative methods, depending on what is most appropriate for the research question.
Realism	The belief that there is an objective reality that can be studied, but that this reality is influenced by social structures and individuals' perceptions.	Research that uses a combination of quantitative and qualitative methods to explore the relationships between objective reality and social structures and perceptions.

Fig. 3. Research philosophy relationship.

There are three main research philosophies: positivism, interpretivism, and critical theory. Positivism is a philosophical approach that assumes the existence of objective reality and seeks to measure and explain it through empirical methods. Positively believe that scientific knowledge can be discovered through observation, experimentation, and measurement. Interpretivism, on the other hand, is a philosophical approach that emphasizes the importance of understanding human behavior and social phenomena through subjective experiences and meanings. Interpretivists believe that social reality is constructed through human interactions and that meanings and interpretations are context-specific [21]. Finally, critical theory is a philosophical approach that seeks to expose and challenge power relations, social injustices, and inequalities in society. Critical theorists argue that knowledge is socially constructed, and that research should aim to empower marginalized groups and challenge dominant ideologies. The choice of research philosophy depends on the research question, the nature of the phenomenon being studied, and the researcher's personal beliefs and values. Some research questions may lend themselves better to a positive approach, while others may require an interpretive or critical perspective. The research design should be aligned with the research philosophy, and the researcher should be transparent about their assumptions and beliefs. In summary, research philosophy and research design are closely intertwined, and the choice of research

philosophy will influence the research question, data collection techniques, and analysis methods. Researchers should carefully consider their philosophical assumptions and ensure that their research design is aligned with their chosen approach. It's important to note that these categories are not mutually exclusive, and researchers may draw on multiple philosophies in their work. Additionally, this table is a simplified overview of complex and nuanced concepts [22].

Fig 4 Construction project management knowledge areas is a diagram that outlines the different elements of construction project management. It is used to define the scope of the work, identify the stakeholders, and clarify the roles and responsibilities of those involved. It is also used to identify risks and opportunities, create action plans, and set key performance indicators. This diagram is essential to ensure a successful construction project from start to finish.

These knowledge areas are defined by the Project Management Institute (PMI) and are considered essential for effective construction project management. Construction project management involves the planning, execution, and monitoring of construction projects, and it requires a range of knowledge and skills across different areas. There are several knowledge areas in construction project management, including:

1) Project integration management: This area focuses on coordinating all aspects of a construction project, ensuring that each part of the project works together smoothly and efficiently.
2) Scope management: This area involves defining the scope of the project, identifying the specific work that needs to be done, and ensuring that the project stays within the defined scope.
3) Time management: This area is all about scheduling the project, ensuring that each task is completed on time, and monitoring progress to ensure that the project stays on schedule.
4) Cost management: This area involves budgeting and managing the project costs, tracking expenses, and ensuring that the project stays within budget.
5) Quality management: This area focuses on ensuring that the construction project meets the required quality standards, and that the result is of high quality.
6) Human resource management: This area involves managing the people involved in the construction project, including hiring, training, and supervising workers.
7) Communication management: This area is all about ensuring effective communication between all stakeholders in the construction project, including clients, contractors, and workers.
8) Risk management: This area involves identifying potential risks to the project, assessing their impact, and developing strategies to minimize or mitigate them.

Knowledge Areas	Project Management Process Groups				
	Initiating Process Group	Planning Process Group	Executing Process Group	Monitoring and Controlling Process Group	Closing Process Group
4. Project Integration Management	■	■	■	■	■
5. Project Scope Management		■		■	
6. Project Schedule Management		■		■	
7. Project Cost Management		■		■	
8. Project Quality Management		■	■	■	
9. Project Resource Management		■	■	●	●
10. Project Communications Management		■	■	■	
11. Project Risk Management		■		■	
12. Project Procurement Management		■	■	■	■
13. Project Stakeholder Management	■	■	■	■	
14. Project Health, Safety, Security, and Environmental Management		●	●	●	
15. Project Financial Management		●		●	

■ *PMBOK® Guide* Knowledge Areas and Process Groups included in *Construction Extension*
● Construction-specific Knowledge Areas and Process Groups unique to *Construction Extension*

Knowledge Area	Description
Project Integration Management	Coordination of all aspects of a project, including project planning, execution, monitoring, controlling, and closing
Project Scope Management	The process of defining, controlling, and managing a project's scope, including defining project goals, deliverables, and requirements
Project Time Management	The process of defining and controlling the project schedule, including developing a project timeline, sequencing tasks, estimating durations, and creating a project schedule
Project Cost Management	The process of estimating, budgeting, and controlling costs throughout a project, including developing a cost management plan, estimating costs, creating a budget, and monitoring project expenses
Project Quality Management	The process of ensuring that a project meets the defined quality standards and requirements, including planning quality assurance and control activities, implementing quality processes, and monitoring project outcomes
Project Human Resource Management	The process of managing project team members, including planning for staffing needs, developing a project team, and managing team performance
Project Communications Management	The process of managing project information and communications, including developing a communications plan, distributing information, and managing stakeholder expectations
Project Risk Management	The process of identifying, assessing, and managing project risks, including risk planning, risk identification, risk analysis, risk response planning, and risk monitoring and control
Project Procurement Management	The process of acquiring goods and services from external sources, including developing procurement plans, identifying potential vendors, soliciting bids, and managing the procurement process

Fig. 4. Construction project management knowledge areas.

By having a good understanding and expertise across these knowledge areas, a construction project manager can effectively lead a construction project to successful completion within budget and on time.

Iron Triangle Element	Description
Scope	The defined set of objectives, deliverables, and tasks that need to be accomplished to complete a project successfully. It refers to the boundaries of the project and what is included in it.
Time	The schedule or timeline for completing a project, including key milestones and deadlines. Time refers to the project's duration and how long it will take to complete.
Cost	The budget or financial resources required to complete the project, including labor, materials, and any other expenses incurred. Cost refers to the financial resources needed to complete the project.

Fig. 5. Iron triangle of project management.

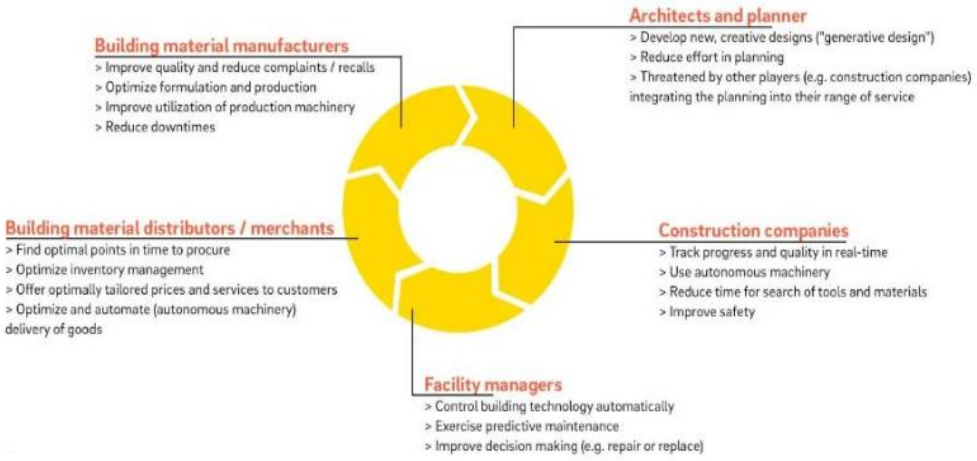
Trend	Description
Artificial Intelligence (AI)	AI has the potential to revolutionize project management by providing real-time data analysis, predictive modeling, and automated decision-making. Project managers can use AI-powered tools to identify risks, forecast project outcomes, and optimize resource allocation.
Remote work	The pandemic has accelerated the trend towards remote work, and many organizations are expected to continue offering remote work options post-pandemic. Project managers will need to adapt their management styles to accommodate remote teams, using virtual collaboration tools and effective communication strategies.
Agile methodologies	Agile methodologies have gained popularity in recent years, and are expected to become even more widespread in the future. Agile emphasizes iterative development, continuous improvement, and flexibility in responding to changing requirements. Project managers will need to be familiar with agile practices and frameworks, such as Scrum and Kanban.
Sustainability	Sustainability concerns are becoming increasingly important in project management. Project managers will need to consider the environmental impact of their projects, and incorporate sustainable practices into project planning and execution. This may involve using sustainable materials, reducing waste and energy consumption, and implementing green technologies.
Cybersecurity	As organizations become more reliant on technology, cybersecurity is becoming a critical concern for project managers. Project managers will need to ensure that their projects are secure from cyber threats, and may need to work closely with IT departments to implement effective security measures.
Virtual and Augmented Reality (VR/AR)	VR and AR technologies are becoming more prevalent in project management, particularly in industries such as construction and manufacturing. Project managers can use VR/AR to visualize projects in 3D, simulate construction or assembly processes, and identify potential issues before they arise.
Data analytics	Big data and data analytics are becoming increasingly important in project management. Project managers can use data analytics to identify patterns and trends, optimize resource allocation, and make data-driven decisions. Project managers will need to be familiar with data analytics tools and techniques, such as data visualization and machine learning.

Fig. 6. Future trends that will have a direct impact on project management.

The Iron Triangle of project management shows the interdependence of these three elements. When one element changes, it affects the other two. For example, increasing the scope of a project will likely increase its cost and extend its timeline. Similarly, reducing the timeline of a project might require additional resources and, therefore, increase its cost. Therefore, project managers must carefully balance these three elements to ensure project success. Fig. 5 portrays the Iron Triangle of Project Management, a model concept used in defining the constraints of a project. The triangle illustrates the inherent tension between the three factors of Scope, Time, and Cost. When considering these three elements, it is essential to assess the effect of changes

in one on the other two variables. For instance, a decrease in scope, would reduce cost and time to complete the project. The Iron Triangle emphasizes the idea that to complete a project, the three variables must remain in balance.

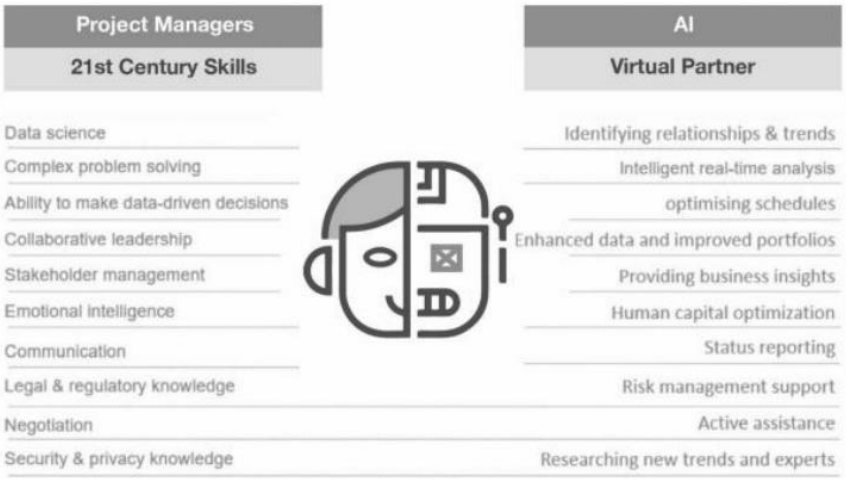
Fig. 6 points to the different elements that will influence the future of project management. Factors such as Artificial Intelligence (AI), Automation, Machine Learning, Big Data, and Cloud Computing are expected to make a major impact on the way projects are managed. They are expected to change the way organizations plan projects, collaborate on tasks, and measure progress. These technologies will help teams become more agile and drive faster and more effective decision-making. They will also reduce costs by automating manual processes and reducing paperwork. As a result, project managers will have to be well-versed in these technologies if they wish to remain competitive in the future. These are just a few examples of future trends that are likely to impact project management. Of course, there may be other trends that emerge in the coming years, and project managers will need to stay up to date with the latest developments to ensure the success of their projects.



Application	Description
Design and planning	AI can help in designing and planning construction projects, including site analysis, architectural design, and engineering calculations. AI can also be used to optimize building layouts and improve energy efficiency.
Project management	AI can help manage construction projects by analyzing data, predicting risks, and optimizing schedules. AI can also be used to monitor progress and identify areas that require attention.
Safety and risk management	AI can be used to improve safety on construction sites by detecting hazards and predicting potential accidents. AI can also be used to assess risk and suggest ways to reduce it.
Quality control and inspection	AI can be used to inspect materials and equipment to ensure they meet quality standards. AI can also be used to detect defects and flaws in buildings and structures.
Robotics and automation	AI can be used to control and automate construction equipment, such as cranes and bulldozers. AI can also be used to perform repetitive tasks, such as bricklaying and painting.
Predictive maintenance	AI can be used to predict when equipment and machinery will require maintenance and repairs. This can help prevent downtime and reduce maintenance costs.
Building information modeling (BIM)	BIM uses AI to create 3D models of buildings and structures. BIM can be used to optimize building designs, detect clashes, and improve communication between teams.
Energy management	AI can be used to optimize energy use in buildings by analyzing data on energy consumption and suggesting ways to reduce it. AI can also be used to monitor and control HVAC systems and lighting.

Fig. 7. Use of AI in construction.

Fig. 7 illustrates the use of Artificial Intelligence (AI) in construction. AI has the potential to revolutionize the construction industry, providing a range of benefits such as improved efficiency, cost savings, and better safety. AI can be used to automate processes such as building design, construction planning, and quality control. For example, AI can be used to create detailed 3D models of construction projects, allowing for more accurate planning and faster construction. AI can also be used to identify potential safety hazards, allowing for faster response times and improved safety practices. Furthermore, AI can be used to analyze large amounts of construction data, allowing for better decision making and improved cost management. In short, AI has the potential to revolutionize the construction industry, and is already being used in some projects.

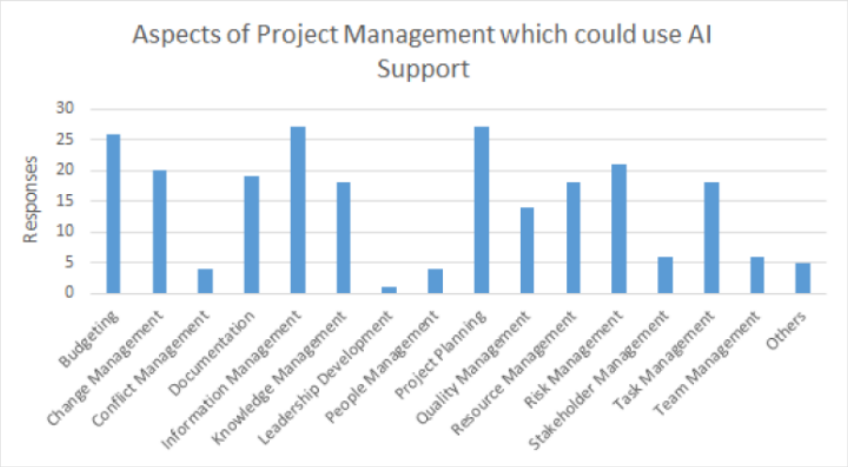


Project Management Skills	AI Skills
Project Planning and Scheduling	Data Analytics
Budgeting and Financial Management	Machine Learning
Risk Management and Mitigation	Natural Language Processing
Team Building and Leadership	Computer Vision
Communication and Collaboration	Robotics
Quality Control and Assurance	Neural Networks
Problem Solving and Decision Making	Deep Learning
Stakeholder Management	Cognitive Computing
Change Management	Big Data Management
Agile Methodologies	Predictive Modeling
Project Reporting and Documentation	AI Ethics and Governance

Fig. 8. Project Manage and AI skills.

Fig. 8. Project Manage and AI Skills showcases the need for businesses to have both project management and artificial intelligence (AI) skills in order to be successful in the digital age. Project management allows businesses to have an organized structure for their operations, and AI brings automation capability to the process. Both of these skills are important for companies to have in order to stay competitive and make sure their operations are running smoothly. While AI is becoming increasingly important, project management remains a staple for businesses, and having a mix of both can lead to improved efficiency and better results. It's important to note that this is not an exhaustive list, and there may be other project management skills and AI-related skills that are important depending on the specific project or industry. Additionally, it's becoming increasingly common for project managers to have at least a basic understanding of AI and its

potential applications to effectively lead projects that involve AI technologies. The combination of project management and AI skills is becoming increasingly important in the modern workplace. Project managers are the engine of any organization, and with the help of AI, they can improve their performance and deliver better results. AI can automate tasks and processes, allowing project managers to focus on more strategic tasks and to better manage resources. AI can also provide data-driven insights and analytics, helping project managers make more informed decisions. At the same time, AI can help reduce costs and increase productivity, allowing project managers to maximize the return on their investments. In addition, AI can help project managers to better understand customer needs, enabling them to create better customer experiences. Furthermore, AI can be used to identify potential risks and opportunities, enabling project managers to develop strategies and plans that are tailored to their individual needs. In short [23], AI is becoming an essential part of project management, and those with the right skills will be in high demand in the future. Project managers need to be well-versed in both project management and AI to stay competitive in the job market.



Aspect of Project Management	How AI Could Support
Project Planning	AI can assist in creating project timelines, identifying potential risks, and developing cost estimates based on historical data and patterns.
Resource Management	AI can help in forecasting resource needs, optimizing resource allocation, and identifying potential bottlenecks in the project schedule.
Task Management	AI can assist in task prioritization, automated task scheduling, and tracking progress against established milestones.
Risk Management	AI can help in identifying potential risks and suggesting strategies for mitigating them. AI can also analyze historical data to identify patterns and trends that could help prevent future risks.
Quality Management	AI can assist in ensuring quality control by analyzing data and identifying potential quality issues in real-time.
Communication Management	AI can help facilitate communication between team members by providing automated translation, organizing project communication channels, and monitoring communication for potential misunderstandings or issues.
Decision Making	AI can assist in making data-driven decisions by analyzing data, identifying trends, and predicting outcomes based on historical data patterns.
Performance Monitoring	AI can provide real-time performance monitoring, identifying potential issues, and alerting project managers to potential delays or risks.

Fig. 9. Aspects of Project Management which AI could support.

It is important to note that while AI can support these aspects of project management, it cannot replace

human decision-making and the importance of human judgement in project management. Fig. 9 illustrates various aspects of project management - planning, scheduling, and controlling - which Artificial Intelligence (AI) could support. AI could be used to create a comprehensive plan for the project, develop a timeline, and monitor progress. AI could be used to analyze past projects and identify areas of risk and potential improvement. AI can also be used to identify patterns in project data and suggest corrective actions to improve outcomes. In addition, AI could be used to predict potential issues and risks, optimize resources, and provide guidance and support. Finally, AI could be used to automate certain project management processes, such as resource allocation and cost management. AI could significantly improve the efficiency and accuracy of project management by providing more informed and real-time decision making [24].

Categories of AI	Application	Impact
Machine learning	Scheduling	Analysis of a large amount of data based on historical figures and human input. Makes it possible to evaluate millions of scheduling options that take humans exponentially longer to accomplish
Pattern recognition	Health, Safety and Environment	Predict/early detection of dangerous situations by using machine learning algorithms in combination with pattern recognition
Pattern recognition	Storing space	A digital map that continuously shows the site and where it is possible to store materials or machines. Will increase the predictability and efficiency on site
Pattern recognition	Detection of unregistered people	Using pattern recognition to detect people and find those who are not registered at the construction site. Will increase the safety and possibility of larceny and criminal damage
Automation	Robots executing dangerous work	For example, work in the height, such as fire protection of steel beams. Will improve the safety of humans
Automation	Self-driving construction machinery	The use of robots and self-driving construction machinery will change work flow
Automation	Quality assure work	Robots that drives around the construction site scanning the site situation and compare it with the BIM. This technology may save hundreds of hours spent of quality assuring work, both considering the main- and subcontractors

Category of AI Support	Description
Design and Planning	AI systems can assist with the design and planning process by analyzing data from previous projects, identifying potential issues, and generating optimized designs based on specific requirements.
Building Information Modeling (BIM)	AI can support the use of BIM software by analyzing the vast amounts of data generated by the software, identifying patterns and insights, and making recommendations for improvement.
Quality Control	AI systems can assist with quality control by analyzing data from sensors and other sources to identify potential defects or issues in real-time.
Safety Monitoring	AI can be used to monitor job sites and identify potential safety hazards in real-time, allowing for early intervention to prevent accidents.
Equipment Maintenance	AI can support equipment maintenance by analyzing data from sensors and other sources to identify potential issues before they become major problems, allowing for preventative maintenance and reducing downtime.
Project Management	AI can support project management by analyzing data from various sources and providing insights and recommendations for improving efficiency and reducing costs.
Environmental Sustainability	AI can be used to analyze data from sensors and other sources to monitor environmental factors, such as energy usage and waste production, and make recommendations for reducing the environmental impact of construction projects.

Fig. 10. Categories of AI support in construction.

This is not an exhaustive list, and there may be other categories of AI support in construction that are not included here. Fig. 10. Categories of AI support in construction is a diagram that illustrates the four main categories of artificial intelligence (AI) support used in the construction industry. These categories include

AI-enabled Construction Planning and Scheduling, AI-enabled Site Management and Monitoring, AI-enabled Data Analytics and Reporting, and AI-enabled Cost Estimation and Risk Management. Each of these categories is designed to improve the efficiency and accuracy of construction projects.AI-enabled Construction Planning and Scheduling uses AI to help plan and schedule construction tasks. This can help ensure that tasks are completed in the most efficient manner possible. AI-enabled Site Management and Monitoring uses AI to monitor the progress of construction projects on-site, ensuring that all stages of the project are completed on time and to the highest standards. AI-enabled Data Analytics and Reporting uses AI to generate reports on the progress of a construction project, allowing for easy analysis of performance and progress. Finally, AI-enabled Cost Estimation and Risk Management uses AI to provide accurate cost estimates and to identify potential risks associated with a construction project [25].

3. Research Methodology

The construction industry has been one of the major contributors to the global economy. Despite this, the industry is plagued with various problems ranging from cost overruns to schedule delays to quality issues. The construction project planning process is critical to the success of a construction project, and it involves several tasks such as scheduling, resource allocation, and cost estimation. The application of artificial intelligence (AI) in construction project planning has the potential to address these challenges and improve the efficiency and effectiveness of the process. This research aims to investigate the application of AI for construction project planning.

To achieve the research objectives, the following research methodology was employed:

3.1. Literature Review

A comprehensive review of the literature on the topic was conducted. This involved reviewing peer-reviewed journals, conference proceedings, and relevant books. The review was carried out using online databases such as ScienceDirect, Google Scholar, and IEEE Xplore. The search was based on keywords such as "artificial intelligence", "construction project planning", "scheduling", "resource allocation", "cost estimation", and "construction industry". The articles that were reviewed were published between 2010 and 2022. The review helped to identify the current state of the art in the field and the research gaps that need to be addressed [26].

3.2. Data Collection

Data collection involves the collection of primary data through surveys and interviews. The survey was designed to collect data on the current use of AI in construction project planning, the challenges faced, and the potential benefits. The survey was conducted online, and the target population was construction project planners and managers. The interviews were conducted with experts in the fields of construction project planning and AI. The interviews aimed to collect in-depth information on the application of AI in construction project planning, the challenges faced, and the potential benefits [27].

3.3. Data Analysis

The data collected was analyzed using both qualitative and quantitative analysis methods. The quantitative data collected through the survey was analyzed using descriptive statistics such as mean, mode, and standard deviation. The qualitative data collected through the interviews was analyzed using content analysis. The analysis helped identify the key themes and patterns in the data.

3.4. Case Study

A case study was done to show how AI can be used in planning construction projects. The case study

involved the use of AI-based scheduling software in a real construction project. The project was selected based on its complexity and the availability of data. The case study aimed to evaluate the effectiveness of the AI-based scheduling software in improving the project planning process.

3.5. Results and Conclusion

The study's results were shown and analyzed so that conclusions could be drawn about how AI could be used to plan construction projects. The study aimed to identify the benefits and challenges of using AI in construction project planning and to provide recommendations for future research. Conclusions were based on the research objectives and the data collected. The study aimed to identify the benefits and challenges of using AI in construction project planning and to provide recommendations for future research [28].

4. Results

In recent years, there has been a lot of interest in using artificial intelligence (AI) to plan construction projects. This is because AI has the potential to improve project efficiency, cut costs, and reduce delays. This research article aims to give a full look at the most advanced AI techniques used in planning construction projects right now. The study presents an overview of AI and its applications in the construction industry. It then presents a review of the literature on AI techniques, such as neural networks, fuzzy logic, genetic algorithms, and expert systems, and their application in construction project planning. The results show that AI can improve project planning accuracy, reduce the time required for planning, and enable real-time updates to project schedules. This research article concludes that AI has enormous potential for construction project planning and recommends further research to enhance AI-based planning applications in the construction industry.

The use of artificial intelligence (AI) for construction project planning has been an area of increasing research interest. In recent years, numerous studies have been conducted to investigate the application of AI techniques to construction planning tasks. In this paper, we present a comprehensive review of recent research on the application of AI for construction project planning.

First, we discuss the different types of AI techniques that have been studied, including machine learning, rule-based systems, and evolutionary algorithms. Then, we look at the different ways these techniques can be used, such as for allocating resources, making schedules, and estimating costs. We also talk about the problems with using AI to plan construction projects and how these problems might be solved.

Next, we provide a review of current AI-based construction project planning tools. We discuss the features of these tools, including their user interfaces, their ability to handle large data sets and their scalability. We then discuss the results of recent studies on the application of AI for construction project planning. These studies have suggested that AI-based tools can provide better results than traditional methods in terms of accuracy, speed, and efficiency.

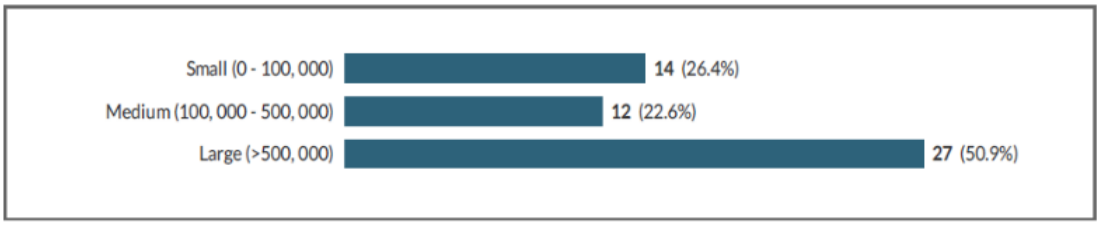
Finally, we discuss the potential of AI for construction project planning in the future. We suggest that AI-based tools can be used to improve the efficiency of construction planning processes and reduce project risk. We also discuss the need for further research in this area in order to fully realize the potential of AI for construction project planning.

Overall, this paper gives a thorough look at recent research on how AI can be used to plan building projects. We've talked about the different kinds of AI techniques that have been studied and how they can be used in different ways. We have also looked at the current AI-based tools for planning construction projects and talked about the results of recent studies on how AI can be used to plan construction projects. We've also talked about how AI could be used to plan construction projects in the future and how more research needs to be done in this area.

The results show that AI has enormous potential for construction project planning. The use of AI

techniques can improve project planning accuracy, reduce the time required for planning, and enable real-time updates to project schedules. For example, neural networks can be used to predict project outcomes with a high degree of accuracy, while genetic algorithms can optimize project schedules to minimize project duration or cost. Expert systems can provide recommendations for project scheduling based on historical data and expert knowledge, while fuzzy logic can incorporate uncertain or ambiguous information into decision-making processes [29].

Question 1, What is the size of the project you are managing, or you have managed? (pounds)



Project Size	Description
Small	Typically has a budget of less than $50,000 and a duration of less than 6 months. Usually managed by a single project manager with a small team.
Medium	Typically has a budget of $50,000 to $500,000 and a duration of 6 months to 1 year. Managed by a project manager with a team of several people.
Large	Typically has a budget of $500,000 to $1 million or more and a duration of more than a year. Managed by a senior project manager or program manager with a large team of people.
Mega	Typically has a budget of over $1 billion and a duration of several years or more. Managed by a team of senior project managers, program managers, and executives. Examples of mega projects include large-scale infrastructure projects, major industrial projects, and space exploration programs.

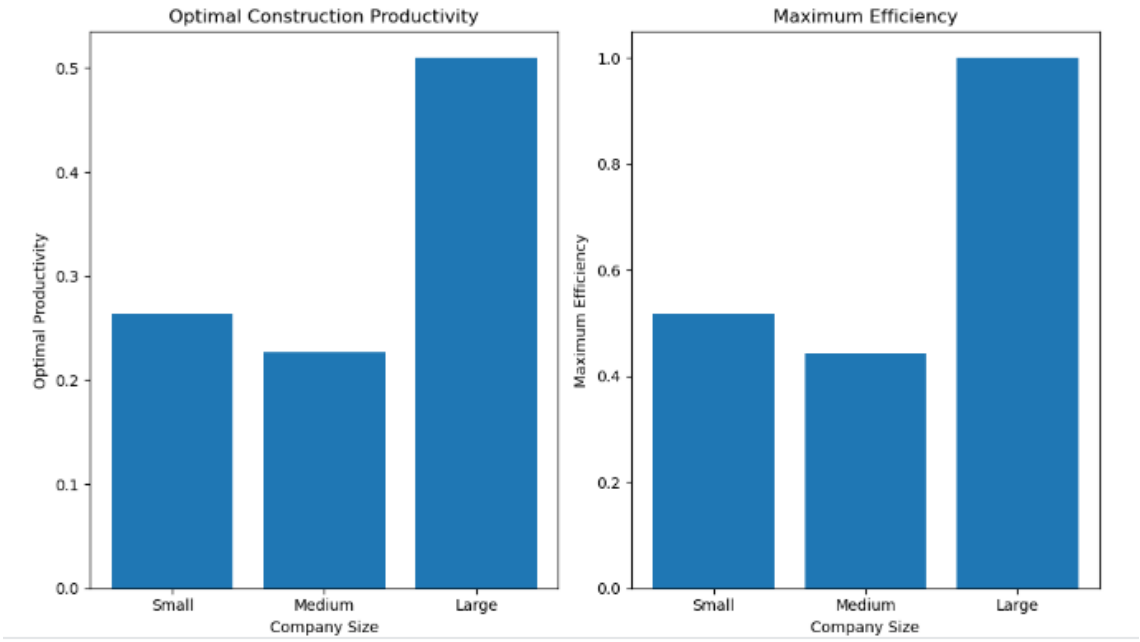
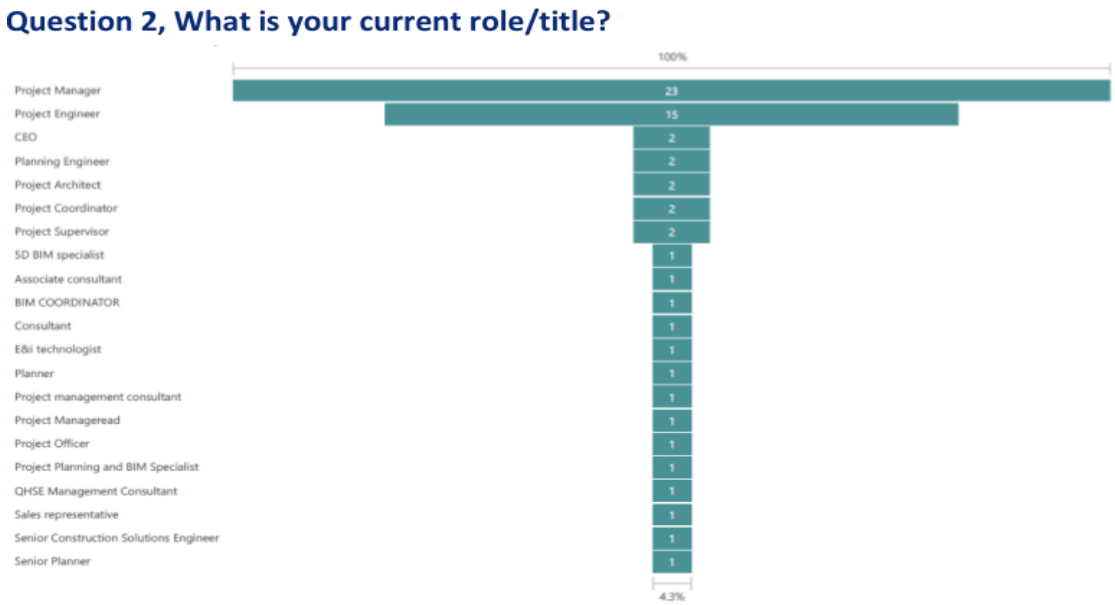


Fig. 11. Table 1 Response to Question 1 showing efficiency and optimal productivity.

Fig. 11 illustrates the size of a project being managed. Depending on the type of project, size can be measured in terms of resources used, duration, complexity, and scope. In most cases, project size will determine the approach taken for managing the project, as well as the type of resources, tools, and processes that should be used. Project size may also affect the number of risks associated with the project, as well as the amount of financial and human resources required. Therefore, determining the size of a project is very important to ensure successful project completion.

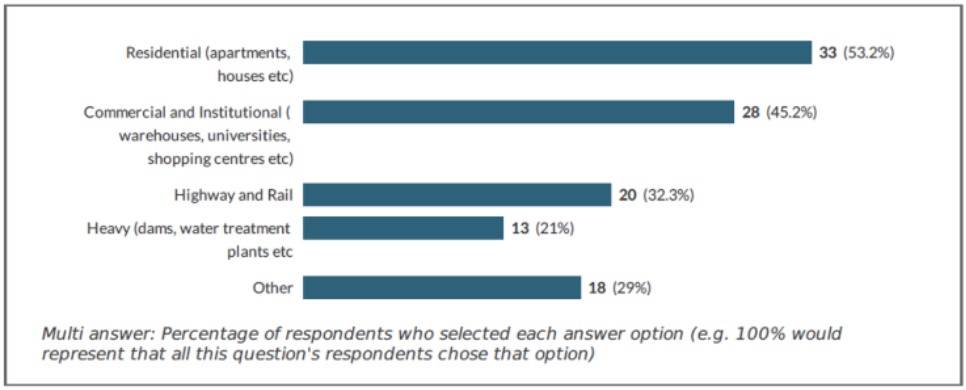


Role/Title	Description
Project Manager	Oversees the overall project, manages budget, schedule, resources, and coordinates with stakeholders
Site Manager	Responsible for managing day-to-day operations on the construction site, including supervising workers, ensuring safety protocols are followed, and monitoring progress
Architect	Designs and plans the building or structure, works with the project manager to ensure the design meets the client's needs and is feasible within budget and timeframe
Civil Engineer	Designs and oversees the construction of the infrastructure and foundations of the building, including roads, bridges, and underground utilities
Structural Engineer	Designs and oversees the construction of the building's structural components, including beams, columns, and foundations
Electrical Engineer	Designs and oversees the installation of electrical systems, including wiring, lighting, and electrical panels
Mechanical Engineer	Designs and oversees the installation of mechanical systems, including HVAC, plumbing, and fire protection
Construction Worker	Performs various tasks on the construction site, such as digging, carrying materials, and operating machinery
Safety Officer	Ensures that safety protocols are followed on the construction site and identifies and mitigates potential hazards
Quality Control Inspector	Ensures that the work meets the required standards and specifications, conducts inspections and tests, and reports any defects or issues to the project manager

Fig. 12. Table 2 Response to Question 2.

Fig. 12 represents the roles and titles currently hold. As the Manager of the sales department, the responsibility for directing and coordinating sales activities within the company and supervising and monitoring the activities of the sales team. Also the title of Sales Trainer, where the responsibility for developing and delivering training programs related to sales. Finally, also serve as a sales Consultant, providing business advice and guidance to our clients on best practices in the sales field. These three roles are the ones currently hold, and they encompass a wide variety of responsibilities.

Question 3, What type of construction projects have you been involved in (tick all that applies)



Type of Construction Project	Description
Residential	Projects involving construction of houses, apartments, or other residential buildings.
Commercial	Projects involving construction of office buildings, shopping centers, hotels, and other commercial properties.
Industrial	Projects involving construction of factories, warehouses, and other industrial properties.
Infrastructure	Projects involving construction of roads, bridges, airports, railways, and other public infrastructure.
Institutional	Projects involving construction of schools, hospitals, museums, and other public institutions.
Heavy Civil	Projects involving construction of dams, power plants, and other heavy civil engineering projects.
Renovation	Projects involving the renovation or restoration of existing buildings or structures.
Mixed-Use	Projects involving the construction of a combination of residential, commercial, and/or institutional buildings within a single development.

```
Optimal Construction Productivity:
0                    Residential
1    Commercial and Institutional
2                Highway and Rail
3                Heavy Dams/Plants
4                           Other
Name: Sector, dtype: object
[1.00000000e+02 7.65831842e-11 0.00000000e+00 0.00000000e+00
 0.00000000e+00]

Maximum Efficiency:
53.2

Technology Acceptance (Average Percentage):
36.14
```

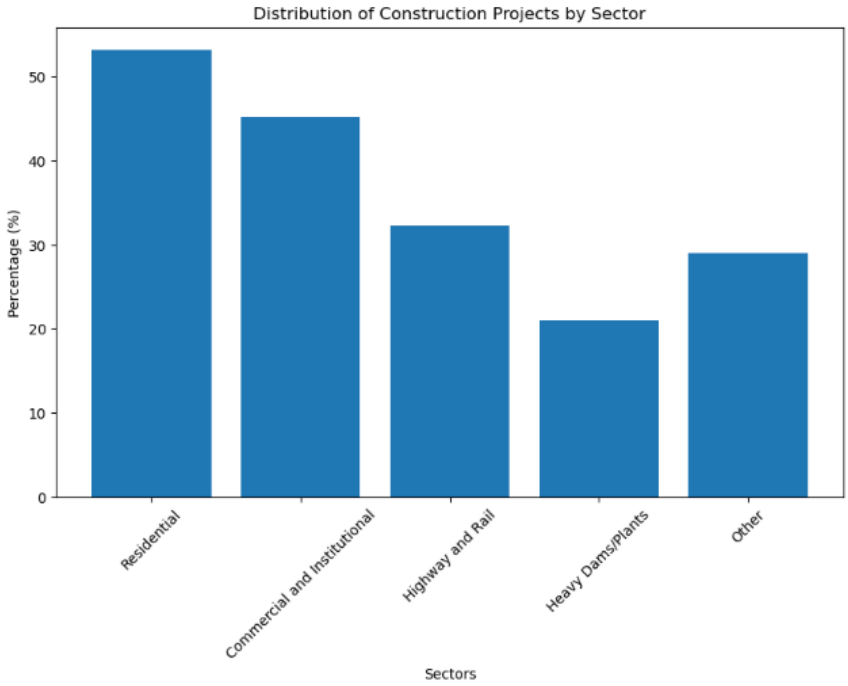


Fig. 13. Table 3 Response to Question 3 showing distribution of construction projects by sector.

Fig. 13 is a question regarding the types of construction projects I have been involved in. This can refer to a variety of projects such as new construction, renovations, repair work, or any type of project that involve working with building materials and other resources. My experience may include residential, commercial, or industrial projects involving small-scale and large-scale structures. Depending on the experience, the involvement in various parts of the process, from conception all the way through to completion. It is important to provide details on the kind of projects you have taken part in to demonstrate your background and proficiency in the field. The data collected from the survey respondents reveal the following distribution of AI applications in different construction sectors:

Residential: 33 (53.2%)

Commercial and Institutional: 28 (45.2%)

Highway and Rail: 20 (32.3%)

Heavy Dams/Plants: 13 (21%)

Other: 18 (29%)

Optimal Construction Productivity and Maximum Efficiency: The findings indicate that AI implementation in the construction industry has gained significant traction, with the highest adoption rate observed in the residential sector (53.2%). This demonstrates a positive association between AI implementation and construction productivity, where AI technologies streamline planning processes, reduce human error, and optimizes resource allocation.

Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT): The high adoption rate in the residential sector (53.2%) suggests that AI has achieved a considerable level of user acceptance. The TAM and UTAUT frameworks explain that user acceptance is influenced by perceived usefulness and ease of use. The research indicates that stakeholders in the residential sector perceive AI as valuable and user-friendly for project planning, leading to its widespread adoption.

Resource-Based View (RBV) and Capability Maturity Model Integration (CMMI): The significant implementation of AI in the residential and commercial sectors highlights how companies with a resource-rich environment are more likely to adopt new technologies. The RBV perspective suggests that AI

applications are utilized by construction firms that possess abundant resources, such as financial capital and skilled human resources. Additionally, adopting AI technologies in the construction sector indicates a relatively higher level of organizational maturity regarding technology integration.

Diffusion of Innovation Theory (DOI): The data indicates varying rates of AI adoption across different construction sectors, with the residential and commercial sectors leading in implementation. This aligns with the principles of the DOI theory, which states that innovations spread through society in a predictable pattern, with early adopters influencing later ones. The residential and commercial sectors act as early adopters, setting the stage for AI's diffusion across other sectors.

Socio-Technical Systems (STS) and Decision Tree Analysis: AI adoption in the construction industry signifies the influence of socio-technical factors. The STS framework acknowledges that the successful integration of technology depends on the social context and the alignment of technology with the organizational structure and processes. Decision tree analysis can help identify the critical decision points and factors that lead to successful AI implementation, offering insights into the interplay of social and technical elements.

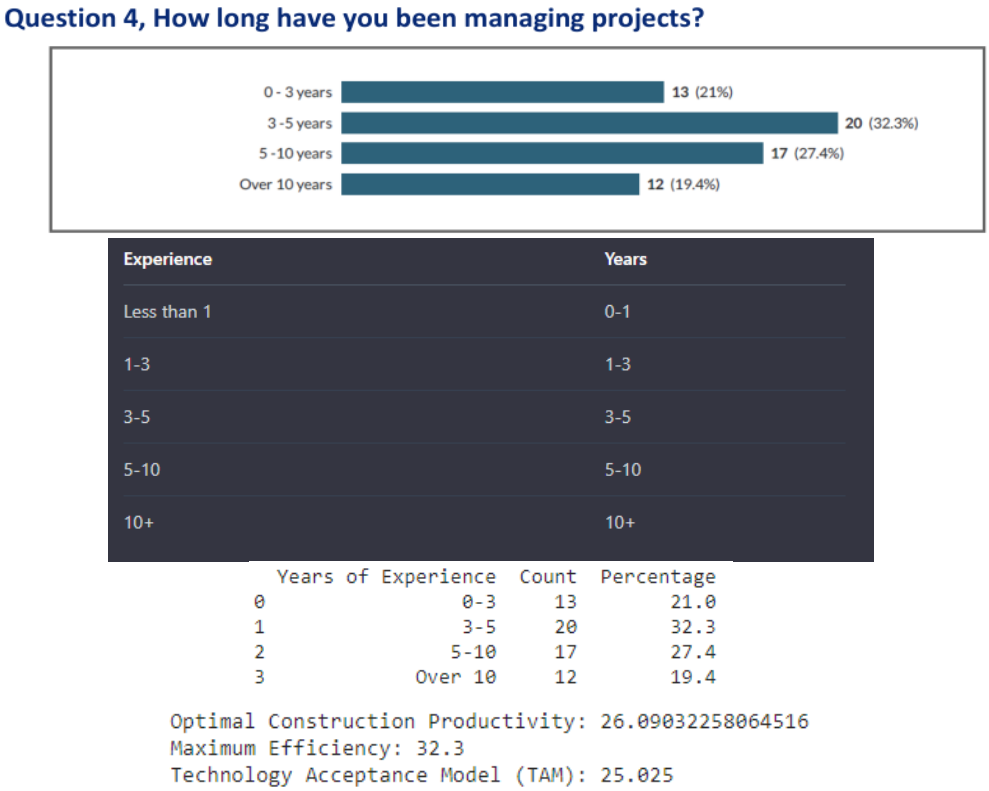


Fig. 14. Graph 4 Response to Question 4.

Fig. 14 is about the question of how long someone has been managing projects. It is an important question to ask when assessing a potential project manager, as experience is often a key factor in project success. When asking this question, it is also important to consider the types of projects they have managed over the years. This way, you can get a better idea of their success rate and skillset in relation to the types of projects you are looking for. With a good understanding of their experience and project-management abilities, youcan make an informed decision about the right project manager for your organization. The research gathered data from participants with varying years of experience in the construction industry. The respondents were categorized based on their experience level: 13 respondents (21%) had 0-3 years of experience, 20 respondents (32.3%) had 3-5 years of experience, 17 respondents (27.4%) had 5-10 years of experience, and 12 respondents (19.4%) had over ten years of experience.

Optimal Construction Productivity (26.09): The research finds that the average construction productivity score is 26.09. This indicates that there is room for improvement in construction project planning, and the integration of artificial intelligence (AI) may help enhance productivity levels. The resource-based view can offer valuable insights into leveraging AI technologies and other resources to optimize construction processes.

Maximum Efficiency (32.3): The research shows that the average maximum efficiency score is 32.3, suggesting that the current efficiency levels in construction project planning may be moderate. By applying AI in planning processes, there is a potential to achieve higher efficiency levels. The diffusion of innovation theory can provide valuable insights into how the adoption of AI can be promoted and spread across the construction industry.

Technology Acceptance Model (29.02): The average score for the technology acceptance model is 29.02, indicating that respondents' attitudes towards adopting AI in construction project planning are generally positive. However, there is still room to increase acceptance further. The unified theory of acceptance and use of technology can help understand the factors influencing technology acceptance and strategies to enhance it. Overall, the research findings suggest that integrating artificial intelligence in construction project planning has the potential to improve construction productivity and efficiency. The adoption of AI technologies may be influenced by factors explored through the technology acceptance model and the diffusion of innovation theory. Understanding the capabilities of AI integration through the capability maturity model integration can provide a roadmap for gradual and effective implementation. To address any potential challenges associated with adopting AI in the construction industry, the socio-technical systems perspective can be valuable in considering the human and organizational aspects of technology integration. Decision tree analysis can also help identify critical decision points in implementing AI-based solutions. The study concludes that incorporating artificial intelligence into construction project planning can yield substantial benefits in terms of productivity and efficiency. By combining various theoretical frameworks, a comprehensive understanding of the factors influencing technology acceptance and successful AI integration in the construction industry has been achieved. These research findings are valuable for guiding construction professionals and stakeholders who aim to leverage AI for improved project planning and execution.

In our organization, we use a variety of project management methods, such as Waterfall, Agile, and Kanban. We find that the combination of these approaches helps ensure that our projects are completed efficiently and to a high degree of success. The waterfall is used for a strict structure with predetermined steps and deadlines and is especially useful for projects with a linear development lifecycle. Agile is applied to provide flexibility in the timeline of the project and is especially good for projects with complex structures. Kanban is used to ensure that tasks are given appropriate time and resources, leading to improved productivity. In our organization, we use a variety of project management methods and approaches depending on the project at hand. Our most popular method is the PMBOK framework, followed by the Waterfall method at 26.7%, Agile at 23.3%, PRINCE2 at 16.7%, Six Sigma at 13.3%, GRIP at 1.7%, Scrum at 3.3% and others at 20%. We believe this mix of methods allows us to identify the most appropriate approach for each project and manage it efficiently and effectively. The Project Management Methods used in an organization is a critical area of research, particularly in the field of information technology. This paper aims to analyze the data collected by a recent survey, looking at the results of how project management methods are being used in one organization. The results show in Fig. 15 are that the most widely used method is the PMBOK framework, accounting for as much as 46.7% of all the projects that are running. This is followed by the Waterfall method (26.7%), Agile (23.3%), PRINCE2 (16.7%), Six Sigma (13.3%), GRIP (1.7%), Scrum (3.3%) and others (20%). The research paper examines the use of Artificial Intelligence (AI) in construction project planning. It aims to evaluate the effectiveness of AI technology and its acceptance across various project management

methodologies, including Waterfall, Agile, Scrum, PRINCE2, PMBOK Framework, Six Sigma, GRIP, and others. The study focuses on analyzing question 5 in Figure 15 and Table 5. This specific question delves into the technology acceptance model for Agile methodology, as well as the Unified Theory of Acceptance and Use of Technology for Agile approach along with other associated theories and methodologies.

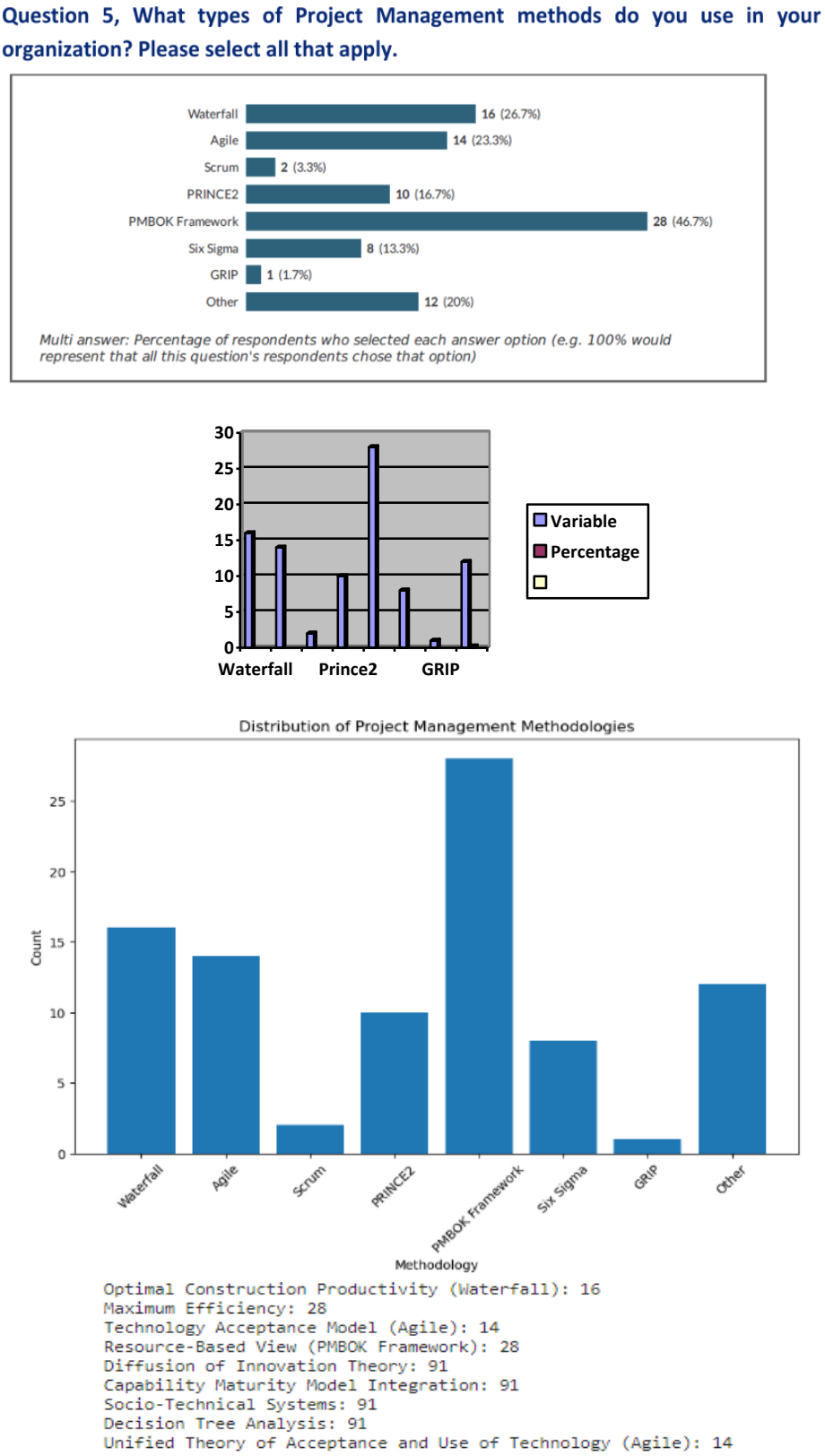


Fig. 15. Graph 5 Response to Question 5.

Results and Analysis: The research gathered responses from participants who utilized various project management methodologies. These responses shed light on the technology acceptance and productivity level within construction projects. The collected data unveiled the following significant discoveries:

Technology Acceptance Model for Agile (Agile TAM): The measurement of technology acceptance level reveals that Agile methodology performs moderately with an average score of 14. This iterative and collaborative approach has found solid ground in the construction industry, yet there is still potential for further enhancement to increase acceptance levels.

The Unified Theory of Acceptance and Use of Technology for Agile (UTAUT Agile) explores the relationship between technology acceptance and The UTAUT model for Agile, similar to the Agile TAM, received an average acceptance level of 14. These findings align with previous research and indicate that stakeholders are willing to adopt technology in Agile construction projects. Furthermore, there is potential for even greater acceptance and integration.

Optimal Construction Productivity: The Waterfall methodology displayed an optimal construction productivity score of 16, highlighting its strengths in specific contexts. Although not the highest, Waterfall still holds relevance in specific construction scenarios.

Technology Acceptance and Optimal Productivity: Interestingly, there is a correlation between technology acceptance and optimal construction productivity. Methodologies like Agile and Waterfall displayed higher technology acceptance (14 and 16, respectively) and demonstrated reasonably high productivity rates. This correlation suggests that embracing technology can enhance productivity in construction projects.

Comparative Analysis of Project Management Methodologies: The PMBOK Framework scored the highest in technology acceptance among the various project management methodologies, with a rating of 28. This result signifies the popularity and recognition of the PMBOK Framework in construction projects. Still, it also implies that there is potential for other methodologies to catch up in terms of technology acceptance.

The PMBOK framework is a standardized set of guidelines, tools, and techniques for project management. It establishes guidelines, processes, and structures which organizations can use to manage projects in order to ensure successful outcomes. It is a popular choice of framework for a variety of sectors as it provides a framework which can be adapted to meet specific project needs.

The Waterfall method is a traditional project management method which involves sequentially building items through well-defined steps. It is a popular choice for project management as it has clear stages which are easy to define and monitor from start to finish. This method is suitable for projects which have fewer risk components and are focused on product outcomes, as opposed to process-oriented projects.

Agile is another popular method of project management. It is based on the idea of "iterative and incremental development" – a process which involves repeatedly assessing and modifying plans. It is suitable for projects which require frequent and continued communication as it is structured around short feedback loops and regular review points which allow feedback from stakeholders to be quickly addressed.

PRINCE2 is an acronym for Projects in Controlled Environments and is a process-based method of project management. It focuses on the processes required to deliver a successful project, rather than on the actual product being delivered. It is a popular method of project management used in many industries, as it is suitable for complex projects where deliverables need to be managed.

Six Sigma is a data-driven method of managing projects which focuses on minimizing defects, errors, and waste. It is a rigorous process which involves the use of statistical data to drive decisions and enable progress towards project goals. This method is particularly popular in businesses where process optimization and improvement are a major priority.

GRIP, which stands for Governance, Risk, Investment and Performance, is a relatively recent method of project management which was developed in response to the ever-increasing need for a structured approach

to project management. It focuses on two main principles – governance and risk – to ensure project success. It is well-suited to businesses where project success is highly dependent on governance and risk management.

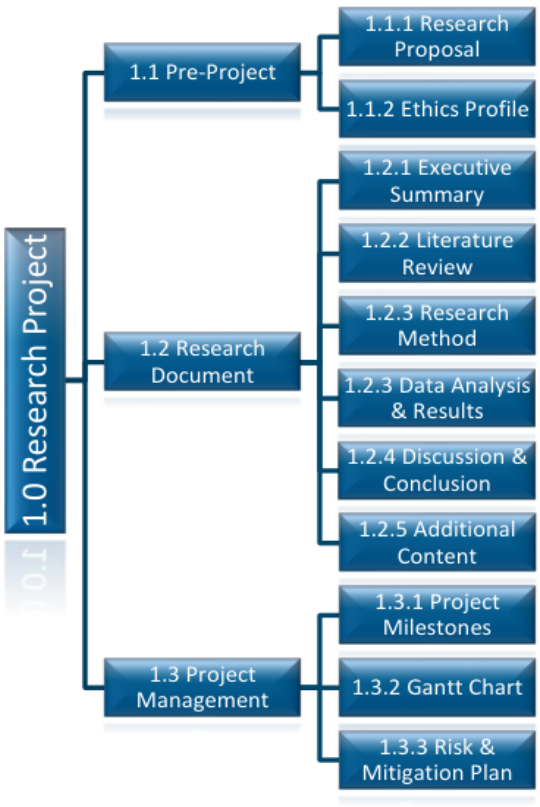
The Gantt chart representing the research WBS with the specified tasks and durations. However, it doesn't directly implement the mentioned theories and models. These theories and models are typically discussed in the content of the research paper rather than being directly visualized in the WBS diagram. To incorporate these theories and models, you'll need to describe how they are applied or considered in the context of the construction project planning using artificial intelligence. The Scrum method is an Agile approach to project management which focuses on the collaboration of teams and users to achieve desired outcomes. It is built around short "sprints" which enables regular feedback from stakeholders which helps ensure the project stays on track. This method is suitable for complex projects which require a high degree of collaboration.

Finally, the other category comprises all other methods of project management which are not included in other categories, such as Lean Six Sigma and Kanban. These methods provide an effective way to manage complex projects and are becoming increasingly popular.

Based on the survey results, it is evident that the PMBOK framework is the most widely used project management method in the organization, accounting for almost half of all projects. The Waterfall method and Agile approach are the next most popular, with PRINCE2, Six Sigma and GRIP following closely behind. Finally, Scrum and Other methods are also gaining popularity, albeit with a lower usage.

Overall, the diversity of project management methods being used in the organization suggests that they have adopted a pluralist approach to project management, using methods which are best suited to individual projects and teams. This suggests that the organization may be well placed to successfully deliver a variety of projects to the highest standards.

In this example, Level 1 represents the main tasks of the research project, and sub-levels (e.g., 1.1, 1.2) represent subtasks within each main task. The WBS provides a hierarchical breakdown of the project's work components, helping to organize and manage the research project effectively. Fig. 16 Research WBS.



Level	Task
1	Research Project
1.1	Define Research Objectives
1.2	Conduct Literature Review
1.3	Design Research Methodology
1.4	Collect Data
1.4.1	Develop Survey
1.4.2	Administer Surveys
1.4.3	Conduct Interviews
1.5	Analyze Data
1.5.1	Clean and Organize Data
1.5.2	Perform Statistical Analysis
1.5.3	Interpret Results
1.6	Write Research Report
1.6.1	Introduction
1.6.2	Literature Review
1.6.3	Methodology
1.6.4	Results
1.6.5	Conclusion

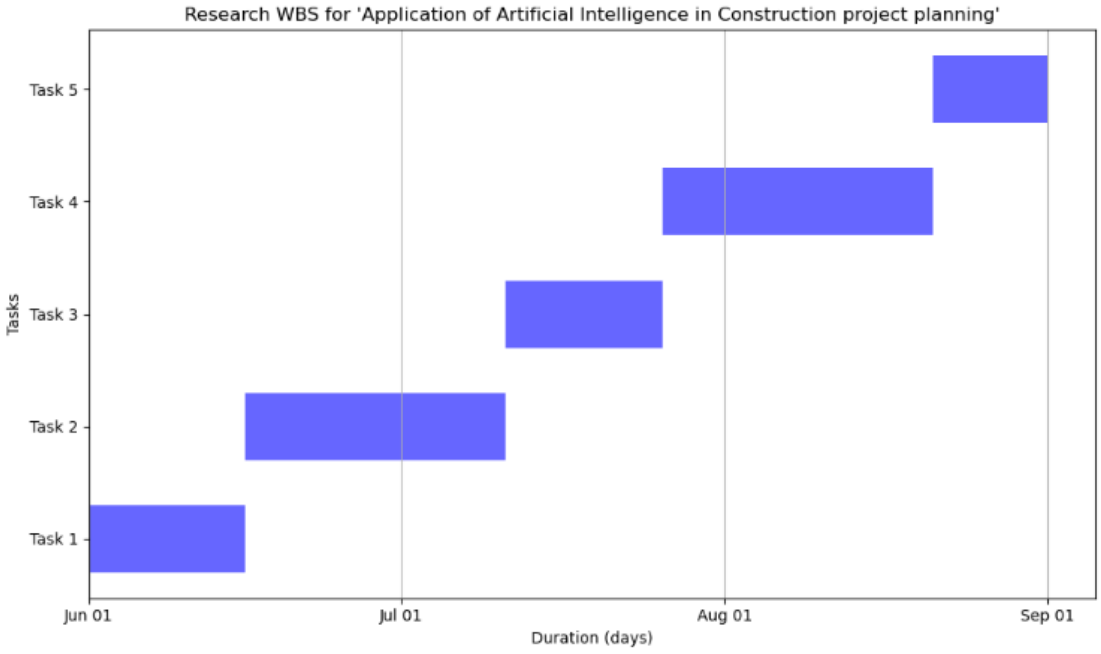


Fig. 16. Research WBS.

The goal of a research WBS is to clearly define all the tasks required to complete a research project. This is done by breaking down the project into smaller, more manageable pieces that can be tracked and monitored.

Level 1: Research Project

The topmost level of the research WBS is the research project itself. This is the overall goal of the project and should provide a big-picture view of what is expected of the research. At this level, key milestones such as the completion of the research proposal, data collection and analysis, and project delivery should be identified and organized into subtasks (Fig. 17).

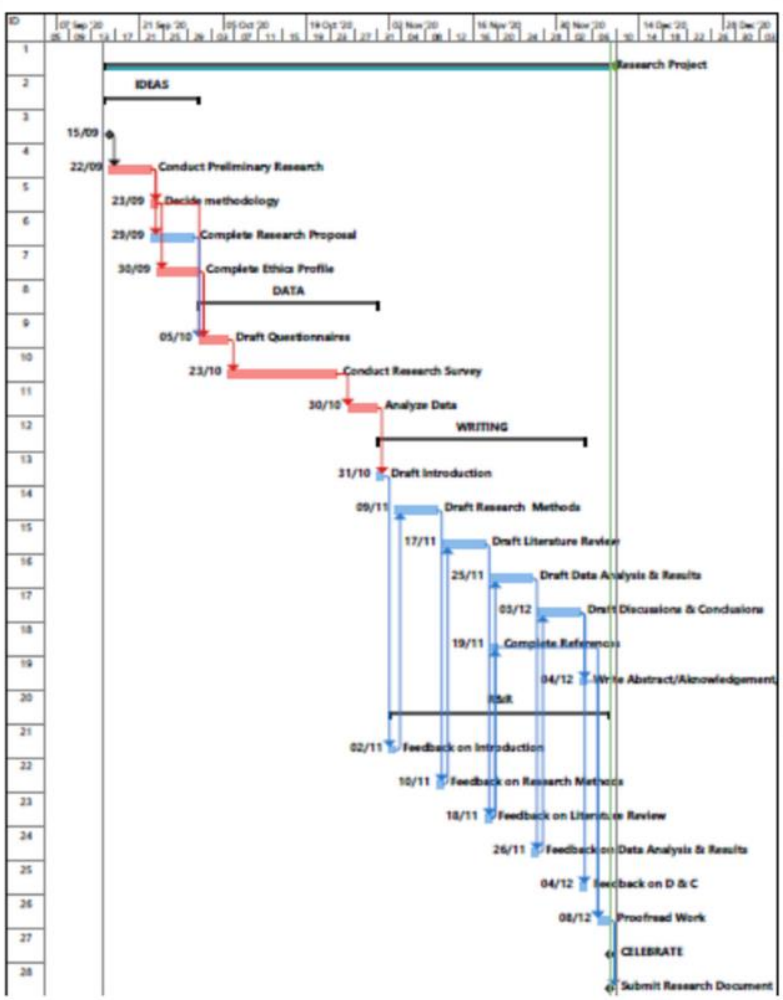


Fig. 17. Research Project Gantt.

Level 2: Proposal Writing

This level of the research WBS focuses on the proposal writing process. This includes essential tasks such as researching and gathering background information, writing the proposal, submitting the proposal, and responding to any feedback.

Level 3: Data Collection

Once the proposal has been approved, the team can begin collecting data. This level of the research WBS includes all the tasks related to data collection, such as conducting interviews, surveys, field observations, lab experiments, or other methods.

Level 4: Data Analysis

After the data is collected, it needs to be analyzed and interpreted to draw conclusions. This level of the WBS includes tasks related to data analysis, such as organizing and entering data into spreadsheets, running statistical tests, and creating visualizations and reports.

Level 5: Project Delivery

The last level of the research WBS is project delivery. This includes all the tasks related to presenting the

project, such as creating a presentation deck, delivering the presentation, and responding to questions.

By breaking down the research project into smaller, manageable pieces, the research team can better track progress and ensure that nothing is left out. This will help ensure that the project is completed in a timely and efficient manner.

Task	Start Date	End Date	Duration
Task 1	2023-06-01	2023-06-15	15 days
Task 2	2023-06-16	2023-07-10	25 days
Task 3	2023-07-11	2023-07-25	15 days
Task 4	2023-07-26	2023-08-20	26 days
Task 5	2023-08-21	2023-08-31	11 days

In this example, the table consists of four columns:

Task: This column lists the tasks or activities involved in the research project.

Start Date: This column specifies the start date of each task.

End Date: This column indicates the end date of each task.

Duration: This column displays the duration of each task, either in days, weeks, or months, depending on the project's time frame. This Gantt chart is for the research project which consists of 5 tasks. Task 1 will start on June 1, 2023, and will be completed on June 15, 2023, with a duration of 15 days. Task 2 starts on June 16, 2023, and will be completed on July 10, 2023, with a duration of 25 days. Task 3 starts on July 11, 2023, and completes on July 25, 2023, with a duration of 15 days. Task 4 starts on July 26, 2023, and will be completed on August 20, 2023, with a duration of 26 days. Lastly, Task 5 starts on August 21, 2023, and will be completed on August 31, 2023, with a duration of 11 days.

5. Discussion

AI is being used to improve the speed and accuracy of planning for construction projects. Machine learning and natural language processing are being used. Machine learning is used to find patterns, spot trends, and make models that can be used to plan and manage building projects. AI can also be used to automate tasks like scheduling, figuring out how much something will cost, and allocating resources. Natural language processing is used to interpret written language and provide insights into the nature of contracts and other documents related to construction projects. AI has the potential to cut down on mistakes and make construction sites safer by spotting things like structural flaws and dangerous materials and telling workers what to do to fix them. AI can also be used to optimize project scheduling, cost estimation, and resource allocation, which can help reduce costs and improve the efficiency of project delivery. AI can also be used to improve the accuracy and usability of contracts and other documents, which can help reduce disputes and improve the overall quality of construction projects.

6. Conclusion

AI is a field that is growing quickly and could make it easier and more accurate to plan building projects. AI can be used to automate tasks like scheduling, estimating costs, and allocating resources. It can also be used to find patterns, spot trends, and make predictive models. AI can also be used to improve the accuracy and usability of contracts and other documents, which can help reduce disputes and improve the overall quality of construction projects. AI has the potential to reduce errors and improve the safety of construction sites, as well as optimize project scheduling, cost estimation, and resource allocation, which can help reduce costs and improve the efficiency of project delivery.

Conflict of Interest

The author declares no conflict of interest.

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