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An exploratory case study on the opportunities of how Artificial Intelligence can contribute to reduce the communication gap and streamline the distribution of resources.

By

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Preface

This thesis is submitted as a mandatory part for our Master of Science in Industrial Economics at the University of Stavanger. The thesis was prepared and completed during the spring semester of 2022 as a final measure to fulfill all requirements.

We wish to extend our deepest gratitude to supervisor, Professor Sigbjørn Landazuri Tveteraas, for valuable guidance, flexibility, and support throughout this project. Without his constructive feedback and discussions, this thesis would not be where it stands today. We would also like to thank all industry experts who took their time to participate in the interviews and shared their valuable experiences.

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Abstract

Executing a project successfully requires companies to initiate the right processes and implement the correct tools. Project management depends on good planning to achieve its strategic goals. It is necessary to have sufficient information that always covers all the elements of a project to be able to make the right decisions. To save time and costs when implementing a project, it is important that the field project management takes a more active role in the digital transformation. It is beneficial for a company to adopt and integrate technological solutions in all aspects to keep up with the development. Today, Artificial Intelligence is the key driver for digital transformation because it can be used for decision-making when combined with big data.

The aim of this thesis is to focus on opportunities on how Artificial Intelligence can improve the planning process of project management and investigate how project managers and organizations can benefit and increase efficiency from it. More specifically the purpose is to take a closer look at what opportunities Artificial Intelligence can contribute to reducing the communication gap and streamlining the distribution of resources. Furthermore, the aim is to explore what digital solutions with Artificial Intelligence integration have been used in project management and the construction industry. There will be an elaboration on the objective and the thesis will address the research questions.

The results are presented using a qualitative approach through in-depth interviews. The interviews are with managers that have experience in the construction industry. The purpose is to get in touch with relevant candidates that can provide insight into what the communication tools are used and the resource allocation process to be able to provide in-depth answers to the problem. In addition, their stance on how the role of a project manager is changing because of the development of Artificial Intelligence. The findings suggest that the adoption and integration of Artificial Intelligence are highly valuable, but there are limitations to how far communication and resource allocation can further digitalize.

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1 Introduction

The purpose of this chapter is to present the project background for the thesis, introduce the problem formulation, research questions and limitations.

1.1 Project Background

Construction management is typically known for being the least digitized industry when compared to other industries (Kymmell, 2007). The lack of digitization is a challenge to implementing Artificial Intelligence (AI) software, as AI relies on digitized information (F. Anglero, 2022). The usage of new digital tools is increasing and the need to implement AI in the project management field must be further researched to improve processes and increase the management efficiency of project plans (Elrajoubi, 2019; Regona et al., 2022).

A project plan is vital for the overall success of a project, and it depends on the project manager's expertise to manage all challenges that occur during the project lifecycle (Chan et al., 2004; Gardiner, 2005a, p. 2). Construction projects are often extremely risky, and it requires the project managers to be structured and effective communicators (Project Management Institute, 2017a; Wu et al., 2017). The communication between the project managers and team member goes on continuously through a project's life cycle, therefore establishing a good communication management with the right digital tools though AI can help avoid project failure, since ineffective communication is one of the leading causes of project failure (Dainty et al., 2006b; Project Management Institute, 2017b).

Resource allocation is described as the most complex element of project planning and can be a very challenging task for project managers (Loosemore et al., 2003a; Schwindt, 2005). According to an international journal for project management, it was described that one of the management issues in a project life cycle was estimating resources required, defining responsibilities and selection of capable participants (Atkinson et al., 2006). Mismanaging resource allocation can lead to the limitation of project progress and the growth of the business (Loosemore et al., 2003b). According to a review where 105 Scopus-indexed articles used to identify AI adoption in human resource management, it was discovered that AI in areas of human resource allocation are in slower progress compared to other human resource management functions (Garg et al., 2021).

Human resource management requires effective communication management to avoid possibly limitations, and it is critical for managers to have good communication and resource management techniques in their respective regions (Loosemore et al., 2003b; Salmon, 2020). According to Gartner analysts (2019), 80 percent of today's project management tasks will be eliminated by 2030 which implies that when Artificial Intelligence takes over the most repetitive functions, it will eliminate the majority of the job done by today's project managers (*Gartner*, 2019). Utilizing AI systems for enhancing the effectiveness of project manager's everyday job is important to improve the low-performance growth the construction industry is facing (Regona et al., 2022). The project manager's role will develop from 'managers' to 'leaders' and depend on their competency and commitment to integrating Artificial Intelligence capabilities into new practices and processes (Chan et al., 2004).

1.2 Problem Formulation

Based on the interest in Artificial Intelligence and project management. It was preferable to focus on the opportunities on how Artificial Intelligence can improve the planning process of project management, to bring it up to a new level from which project managers and organizations can maximize benefits and increase efficiency. By using theory and literature review this thesis will focus on exploring two main areas; communication and resource allocation. An explorative case study is used to review how Artificial Intelligence contributes to reducing the communication gap and streamlining the distribution of resources in the planning process of a project. Additionally, how the construction industry is equipped to handle digital transformation and how far Artificial Intelligence is integrated.

1.3 Research Question and Limitation

The objective is exhaustively broken down into two main research questions for thesis guidance.

1. What are the opportunities to digitize communication and deploy Artificial Intelligence?
2. How can Artificial Intelligence be used to digitalize resource allocation?

The predominant part of this thesis is related to communication processes and allocating resources. Which collectively is to aim at identifying how both areas are managed and

potential improved. The last part of this thesis covers how Artificial Intelligence is implemented today in project management and in project tools. The research questions were answered by conducting a qualitative method through interviewing key personnel with project management experience in the construction industry.

Since these are comprehensive topics, the limitation is necessary to adapt to the assignment's timeframe. Therefore, the research is limited to the construction industry with medium to large projects. Additionally, the theoretical framework when presenting project management is limited to the standard of Project Management Body of Knowledge guide (PMBOK Guide), and the knowledge areas that are regarded as most relevant for the planning process and the research questions.

2 Theory

The purpose of this chapter is to provide a theoretical framework that forms a basis for further discussion. The first part presents theory of project management, specifically the planning process and construction industry with the aim of presenting important elements from knowledge areas, with regards to communication and resource allocation. To build a background and understanding of how the two areas effect projects and set the foundation of results questions. The second part of this chapter investigates how the construction industry has developed and understanding what tools are used today since the digital transformation. Finally, the theory and literature review of defining AI is presented, with important elements related to communication and resource management.

2.1 Project Management Overview

Construction industry is characterized as a project-based industry (Dainty et al., 2006c). A project is defined as:

> "A *unique set of co-ordinated activities, with definite starting and finishing points, undertaken by an individual or organization to meet specific objectives within defined schedule, cost and performance parameters*" (British Standard, 2000, p. 2)

Construction projects are diverse, in both complexity and size, however there are still similar characteristics (Loosemore et al., 2003a). All projects can be described as a short-term

approach to generate value through a product or service with a start and end date (*What Is Project Management | PMI*, 2022). According to the PMBOK Guide, a project can be divided into initiating, planning, executing, monitoring and controlling, and closing processes. PMBOK Guide is the most widely accepted professional standards for project management (Zwikael, 2009). Project management is defined according to Gardiner in the Project Management: as strategic planning approach as:

> *"Its simplest level, project management can be defined as the discipline of managing project successfully."* (Gardiner, 2005b, p. 5)

In aiming for a successful project, the team member must be made aware of the goal and how to proceed towards achieving the goal (Gardiner, 2005b). The overall success of a project relays on the effectiveness of the project planning because each project requires a plan describing the structure from execution and control to closure (Gardiner, 2005a, p. 2). The planning process is defined early in the project life cycle after the initiating process. It is progressively elaborated and specified during the initial stages of each project phase (Lester, 2017).

The project management guide consists of nine knowledge areas which a project manager must focus on throughout the project life cycle. The knowledge areas are integration, scope, schedule, cost, quality, human resources, communications, risk and procurement (Project Management Institute, 2017a).

Figure 1 Project Management Knowledge Areas as explained in PMBOK Guide

2.1.1 Project Manager

The most critical key stakeholder in every construction project is the role of project manager because planning a project is dependent on the project manager's competency and commitment (Chan et al., 2004). The communication interface is consequently vital between the project manager and the organization. Considering the fact that communication is one of leading causes of project failure. It requires that a project manager to be an effective communicator across all levels and to be able to communicate under pressure. Especially since the construction industry is a project-based environment with rigid time and resource constraints (Dainty et al., 2006b). A projects success or failure relays on the communication interface of team members and how well the project manager applies effective network space created for participants to give input on progress and discuss the project objective achievements or concerns. It requires that the project manager should be structured and

practice time management since construction projects tend to hold high uncertainty (Project Management Institute, 2017a; Wu et al., 2017).

The planning necessary to mobilize resources can be challenging for project managers seeing that it requires managing and working with stakeholder like clients, designers, suppliers and constructors each with their individual backgrounds, locations and organizations. Allocating these resources is essential to manage a project withing planning frame (Loosemore et al., 2003a). Therefore, a good communication management is key for enabling effective human resource management and to prevent potentially limiting effectiveness (Loosemore et al., 2003b). Good communication and resource management practices for the respective areas among the managers and complex project-based industries is critical (Salmon, 2020).

2.2 Communication

Communication is a multidimensional phenomenon and varies among individuals in different circumstances. Therefore, it is difficult to have a common definition of it. F. Den Otter and Matthijs Prins (2002) has defined communication as an information exchange between two parties.

> "*A process of exchange of information between sender and receiver to equalize the information on both sides. Within the exchange the following constituent steps can be distinguished: information gathering and transmission (the sender's activity); information receiving and interpreting (the receiver's activity); information storage and retrieval as well as information publication (activities done by sender and receiver).*" (Otter & Prins, 2002, p. 163)

This highlights that communication is a two-way process to identify if the transmitter of the information has been received thus ensuring whether communication has taken place or taken place successfully (Kania et al., 2020). Communication is the foundation of every human interaction, and it can consist of speaking, listening, collecting data and information by several types of media (Dainty et al., 2006a; Kania et al., 2020). Effective communication in the construction industry between the discipline and the client depends on choosing the right media and is determined by the nature of the content and receiver. As well as the desired outcome from the communication, ranging from written communication to computer-mediated communication (Dainty et al., 2006a; Norouzia et al., 2015, p. 8).

Verbal communication is the exchange of information using spoken words, and it is the most straightforward form of communication between individuals or groups. Spoken words or conversation can be formal, informal, long or short. Formal conversation occurs for instance, at meetings and focus groups. Informal as face-to-face conversation. Verbal communication are usually the most effective means of making individuals feel included or informed in a process, and it does not take place in a vacuum; it is frequently combined with nonverbal communication methods (Dainty et al., 2006c; Faizatul Akmar Abdul Nifa et al., 2017).

Nonverbal conveyed communication through behavior or body language as expressions, eye movements, tone of voice, distance or timing of verbal exchanges. It provides direct and indirect indications that either strengthen or contradict the verbal message in a specific situation (Dainty et al., 2006c). Nonverbal indicators vary based on individuals, some can intentionally control and manage while some others express spontaneous 'body language'. In order to communicate successfully project managers must learn to recognize the indication consequently to communicate information and appropriately understand feedback from team member, and to appropriately evaluate events and take action to address any communication issues that may occurs (Dainty et al., 2006a).

While written communication is indirect and offers a permanent record of the information. Numerous forms of written communication are defined by rules and standards by organizations in the construction industry. The standards are provided to manage the interactions between project participants. It allows the writer to wisely reflect about the information they want to exchange and deliver it in a clear and expressive form. Without the requirement for direct interaction with the receiver. In addition, it enables the sender to interact with multiple receivers simultaneously (Dainty et al., 2006a).

Another communication media that does not need direct interaction with the receiver is audio-based or graphical media, that deliver the information briefly and effectively. Audiovisual communications are well used in construction, and sometimes are the only way to interpret meaningfully, for example it is easier for architects to use audiovisual media to show construction detail to the client that trying to use written communication media mainly if the client is unfamiliar with construction language and procedures. Audiovisual communication media are often used in combination with other media to transmit information (Dainty et al., 2006a).

The development of information and communication technology has led to email and web-based tools being essential in nearly all industries. The adaptation of communication technology has been rapid and sped up the rate of information exchange between parties, reducing the cost and impacted environmental footprint related to paper-based communication (Dainty et al., 2006a). Architecture uses electronic communication through design process as a 2D drawings, 3D Volumetric rendering, animations and simulations. In addition to simplifying communication between project participants it has also improved the design process (Norouzia et al., 2015). Email and video conferencing are two examples of technical innovation that allow users to interact from remote locations and sites. Moreover, the ability of visualization tools is now providing real opportunities for construction organizations to overcome many of limitations (Dainty et al., 2006a).

2.2.1 Lack of Communication in Planning Process

As per PMBOK Guide, the aim of a communication process is to maintain the interaction between the stakeholders and the project team, and to make sure they are aligned with the help of tools and techniques that enable successful information sharing. Communication management plan is described as when information is collected through the different communication medium and distributed in a project (Project Management Institute, 2017b).

If the communication management plan is not properly established, it can often lead to project failures. Which has been proven by a study conducted with executives and project managers participants by the Project Management Institute. A project failure is when the intended project goal is not met, schedule delays or completed outside of the project budget (Onal, 2013, p. 10; Salmon, 2020). Poor communication practices lead to significant delimitating and slow down the progress and growth of a project (Dainty et al., 2006a).

> *"Ineffective communication is the primary contributor to project failure one third of the time, and had a negative impact on project success more than half the time."* (Onal, 2013, p. 10)

The vast majority of CEOs agrees on that communication is required for the success of the strategic initiatives, and almost half of the participants believe that communication is essential and fundamental for the planning and execution process (Nevill, 2010). This is supported by the research conducted by PMIs' Pulse research, that shows that 55 percent of

project managers are aligned on the fact that effective communication essential for success in project management (Onal, 2013, p. 10).

The reasons behind poor communication can vary from lack of understanding, too much information or poor quality information over different channels and mediums (Dainty et al., 2006b). Too much information can be overwhelming in a project because information flow sent out to everyone can either be relevant or not, and people learn to disregard the information that does not apply to them. The manager must filter out the non-necessary receivers and forward the information to only the people involved and also to avoid the from the message getting gradually distorted because of information forwarded in a long chain (Dainty et al., 2006b; Wu et al., 2017).

Communication difficulties can also occur due to lack of defined objectives from the transmitter which can result in receiver misunderstanding, or it can also be related to misunderstanding the message because of nonverbal communication (Dainty et al., 2006b). The nature of humans can be a barrier to efficient communication (Kymmell, 2007).

2.3 Resource Allocation

Human resources are the individuals that have knowledge and skills that make up the organizations and industry's workforce (Loosemore et al., 2003a). A more specific definition is Human capital or according to Oxford Learners dictionaries.

> "*People's skills and abilities, seen as something a company, an organization, etc. can make use of"* (*Human-Resources Noun - Definition*, 2022).

It refers to the people hired and their knowledge, capabilities and expertise to an organization. The construction industry is globally implementing human resource management for effective and efficient management of human capital. The advantages to that are minimizing cost, avoiding project delays and optimizing scope of work (Othman et al., 2018). Managing human resources, especially when allocating resources plays an important role in the progress of a project, because it represents a diverse range of people (Loosemore et al., 2003a; Othman et al., 2018). According to the book Human resource management in construction projects:

> "*The industry employs an extremely diverse range of people from a wide range of occupational cultures and backgrounds, including people in unskilled, craft, managerial, professional and administrative positions […] the industry's project-*

> *based structure is made up of many disparate organizations which come together in pursuit of both shared project objectives and individual organizational objectives*." (Loosemore et al., 2003a, p. 14)

An organization needs to have an overview of the resources to ensure the availability of the right employees with the right skills to arrange for the human resource planning. Allocating these resources entails matching your team members skills areas to the appropriate tasks and making sure that they can complete the project they are assigned. To allocate resources tactically should be defined both in the early phases of a project and during the project life cycle (Atkinson et al., 2006).

Beyond that, the planning of allocating resources requires an assessment because of the consequences of distributing employees within the organization. This can set of a chain reaction due to position left vacant or growth in the business. Additionally, it can force organizations to re-evaluate and reassess its succession plans in order to guarantee that its personnel are transferred throughout the organization while meeting their psychological contract needs (Loosemore et al., 2003c). Another aspect is the short notice of contract award during a competitive tendering process, and it is not unusual with limited possibility for thorough planning when allocating resources with skills and abilities to meet the project demand. Resource management has to respond quickly to changes in workload since there are no guarantees of the workload (Project Management Institute, 2017a).

PMBOK Guide defines project Resource Management as identifying, acquiring, and coordinating the resources required for the project's execution. The processes serve to help the project manager and team members have access to the relevant resources when needed (Project Management Institute, 2017a). The role of the manager is to give required resource input to achieve the objective of the project and once the organization is defined, the project cost along with schedule can be determined which is setting the baseline for managing the time, cost and quality (Turner, 2009a). For a project to be successful it requires the ability to retain and develop the employees because the most valuable assets, especially of a low-tech and labor-intensive industry are the people. The industry has good technological and production management techniques growth in recent years but despite that the construction industry is still dependent on the human capital since the majority of a project's cost is represented by human resources (Loosemore et al., 2003b).

Establishing resource management and communication management is essential for utilizing human capital involved in a project. While human resources are one of the most difficult elements in a project, communication is an essential skill to master for avoiding mismanagement of resources (Kania et al., 2020; Loosemore et al., 2003b).

2.3.1 Poor Resource Management

Managing human resources is a challenge for an organization, across the global construction industry, in comparison to physical assets because each individual employee has their own needs, values, perspectives and attributes that has to be acknowledged in order to contribute to the growth and development of the organization. Poor resource management can potentially lead to limitation of the growth of the business. In addition, the complexity and dynamic in the construction industry can threaten the principles of the strategies practiced by resource management, and can cause losses to personnel and organization (Loosemore et al., 2003b; Othman et al., 2018).

Managing resources is essential for project progress. A survey conducted by The State of Project Management with 214 participants in the industry voted that the third-biggest project management challenge is resource management for businesses (Hines, 2021). The obstacle resource management face is aligning the expertise areas of human resources to projects and not having capacity to fully utilizing team members ability and potential or being able to distribute task evenly. According to Schwindt (2005) it is the most complex challenge of project planning elements (Schwindt, 2005). The challenge is supported by a project management network discussion that brought light to fundamental uncertainties in projects. where one of the mentioned uncertainty stages of the project lifecycle was the allocation of resources. The management issues around it was estimating resources required, defining responsibilities and selection of capable participants (Atkinson et al., 2006).

2.4 Primary Project Constraints

Every project is unique, which requires different adaptation of process, tool, techniques, input or output as identified in the PMBOK Guide. The success of a project is impacted by project constraints and the PMBOK Guide identifies scope, quality, schedule, budget, resources, and risk as the six constraints, but the three primary constrains are known as project triangle which is scope, schedule, and cost (Project Management Institute, 2017a). Determining the

primary constrains and performance criteria are strongly intertwined to project fail or success. Unrealistic definition may affect the project expectation, which can lead to project failure. The strategic plan for achieving the project goals must therefore be established thoroughly from the beginning, so any changes of a project goal, scope description and budget criteria must be reviewed (Turner, 2009b).

In the construction industry, scope of work refers to the description of the work planned by project participants that is anticipated to be completed under a certain budget. The clearly defined statement which is prepared by contractor and project management can experience tendency of expansion of the workload which lead to a scope creep and consequently resulting in cost and schedule overruns (Ajmal et al., 2021). Scope creep has caused more than half of construction projects cost and schedule overruns, despite the availability of various solutions to address those issues. Which is one of the primary reasons of project failure (Ajmal et al., 2021).

Project Cost Management is a process of activities a project follows in order to remain within the budget frame. The main objective of project cost management is to determine the cost of the resources required to fulfil the project activities and utilize communication to complete projects on budget as demonstrated by the third global PricewaterhouseCoopers LLC (PwC) survey, which found that good communications are related with a 17 percent improvement in project completion within budget (Onal, 2013, p. 10; Project Management Institute, 2017a).

Modifying the scope will not only have cost consequences but affect the project schedule. Therefore, managing a project schedule is highly important for a project to be completed on time and to offer a detailed plan that illustrates the timing and which method the project will utilize for deliverables (Project Management Institute, 2017a).

Completing the project on schedule and within budget is extremely important and is an undeniable reality that any project-based industry is constrained by. The project manager should then establish a communication and resource allocation plan that provides the necessary information quickly and precisely to assure that activities are performed in a timely and cost-effective manner throughout the project (Dainty et al., 2006c; Nagaraju et al., 2012). In addition, the project manager should have the capability to recognize the interdependencies of the different resources to establish the optimal resource combination to be used for a construction project, since both schedule and cost are directly influenced by the availability of resources (Nagaraju et al., 2012).

2.5 Construction 4.0

Compared to other industries the construction management process is least digitized (Kymmell, 2007). According to Statistics Norway, the construction industry has been through a low level of productivity since the beginning of 21st century (Todsen, 2018). The construction industry has seen notable change since the global pandemic which has caused it to rapidly transform digitally. Digital transformation has been embedded in the majority of industries (Regona et al., 2022). A report by Mckinsey (2020) has shown that 85 percent of the survey participants have expressed that their businesses have somewhat or greatly increased in the implementation of technologies since the start of covid-19 (McKinsey Global Institute, 2020). The pace of digital adoption has been faster than planned according to experts, but the pressure has affected businesses in a positive way (Regona et al., 2022).

Construction 4.0 is a new revolutionary approach to the building process presenting a variety of opportunities for construction projects (Casini, 2022c). It provides a competitive edge to businesses by reducing risks of unforeseen costs and improving efficiency by for example integrating 4D and 5D visualization to combine planning, design, and construction tasks (Regona et al., 2022). Additionally, digital transformation enables a more sustainable way of working in the construction industry. A full digital transformation leads to a greater integration of various phases of the construction model towards a "new operating model" (Casini, 2022c). To effectively incorporate new technologies into projects, users must recognize the benefits and performance enhancements that digital transformation may offer to the project life cycle (Regona et al., 2022).

Building information modeling is under the umbrella of digital transition which has affected all the phases of a construction project by illustrating 3D representations, with information flow that is centralized and updated in real-time. The added dimension of time is represented as 4D.

> *"BIM is a collaborative process in which all parties involved in the project use 3D modeling applications which integrate geometry with additional information about assets' scheduling, cost, sustainability, operations and maintenance. This way, BIM ensures information is shared accurately and consistently throughout assets' life cycles."* (Casini, 2022a, p. 153)

Through the 3D model, all stakeholders involved gain visual knowledge of the building and relevant information in a simple and effective way. Implementing communication in a project with full transparency is a key quality of project management. As a result, the integration of BIM has also led to good coordination. A good collaboration provides better coordination between contractors and subcontractors. 4D-BIM is used to give various stakeholders a better insight into the work sequence. In other words, the use of BIM in the coordination process will lead to simpler project planning. The benefits mentioned can help reduce unnecessary waste and achieve an optimized design. For example, it will be easier to extract information about elements with increased accuracy that will ensure a reduced cost. Frequent updates of information in the models also give project managers the opportunity to make decisions faster, which will reduce time.

BIM represents a revolution that highlights important aspects along the whole value chain, both in the work performance and tools that may be utilized, to pave the way for additional digital transformations (Casini, 2022b).

2.6 Artificial Narrow Intelligence

The term AI is a software program that utilizes algorithms that process information to provide an answer. Information accumulated is called big data which refers to a large amount of information that is digitized. Anglero (2022) describes big data as food for AI and that can be ranging from personally saved pictures, home videos and online activities using Microsoft, Google, or other cloud computing platforms. The goal of AI is to build an intelligent machine by using complex algorithms and methods that have self-insight, can observe and act to obtain specific goals or tasks that typically require human intelligence (F. Anglero, 2022).

AI can be categorized into three different types, only one is used today while two others may potentially become feasible in the future. Distinguishing between the three types will provide a clearer picture of AI capabilities. The Artificial Intelligence types based on capabilities are categorized as "Narrow", "General" or “Super” (Gurkaynak et al., 2016). Every sort of AI that surrounds us today is Artificial Narrow Intelligence (ANI) (Lahmann et al., 2018). Meanwhile, Artificial General Intelligence (AGI) refers to a system that capability of solving intellectually problems as humans (Gurkaynak et al., 2016). AGI is expected to be capable of creativity and imagination and could take on a far wider range of tasks than ANI can (*Hva er kunstig intelligens?*, 2022). Artificial Superintelligence (ASI) is a term that refers to the time

when the ability of the computer will surpass humans. ASI goes a step further and constitutes a world where the cognitive ability of a computer is better than that of a human being (Gurkaynak et al., 2016).

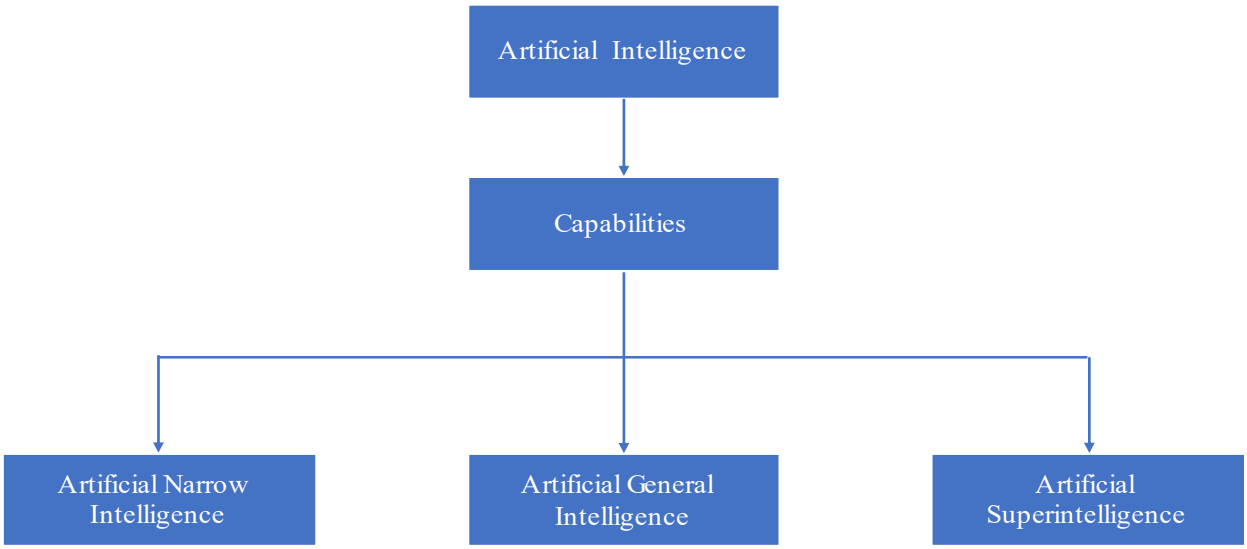

Figure 2 Artificial Intelligence Types—Based on Capabilities

2.6.1 Artificial Narrow Intelligence in Project Management

Artificial Narrow Intelligence is the greatest degree of AI that humans have achieved, and it is used in Apple's Siri, search engines, social networks, online advertising services and web cookies. ANI is a computer system that can perform a complex task autonomously using human-like abilities. ANI is referred to as limited range of capabilities, the computer makes decisions within a predetermined framework and cannot do more than what is programmed for (Gurkaynak et al., 2016).

The development of recent technologies and AI has formed business methods in the direction of digital transformation (Kot et al., 2021). It is becoming continuously more popular in companies. Companies are using AI technologies to significantly accelerate value creation in the business model to increase scalability, productivity, customer engagement, and efficiency. Additionally, companies are using large amounts of data to enhance system performance and enhance company development (John et al., 2022).

Companies in the construction industry are usually characterized as project-based (Dainty et al., 2006c), and in order to successfully execute projects it is essential to incorporate project management in the center of the work (Elrajoubi, 2019). According to a report published by PWC, AI will change the practice of project management outside the limitation of data integration and automation of tasks. AI will change the project management time period from being traditional to include and utilize integration and automation, chat-bot, machine learning based and autonomous project management (Lahmann et al., 2018). On the contrary, the application of AI in project management is an area that has to be researched and studied further, especially given the increasing usage of digital technology (Elrajoubi, 2019).

2.6.2 Managing communication and resources with Artificial Intelligence

Communication

The technological implementation is functioning as communicators and has gradually entered the field of business in a numerous way (Guzman & Lewis, 2020; Naidoo & Dulek, 2022). Today AI does not only facilitate communication but also automates communication that social interaction relies on (Guzman & Lewis, 2020). Users are interacting more and more with digital entities through natural language or speech because of the technological development in the AI area (Smutny & Schreiberova, 2020). What was previously associated with human communication can now be carried out through practical applications such as conversational agents automated-writing software's (Guzman & Lewis, 2020).

A dialogue system is a common term used to describe devices such as Conversational Agent, Chatbot and virtual assistant. A conversational agent is an AI assistant with a completely conversational interface that supports text, and this form of assistant is known as a chatbot (Freed, 2021a). The interface is taking place synchronously in real time with the automated program posing as human conversational partners (Guzman & Lewis, 2020; McTear, 2021). Chatbots are gradually being utilized in fields such as education, information retrieval and business functioning as automated online assistants to supplement or even support the services given by humans in customer service (McTear, 2021).

A typical chat with a conversational agent begins with the user interacting through natural language. The user's input is the utterance, which is essentially what the user enters in the chatbot. Then, the assistant decides what the utterance implies or what the user is attempting

to achieve. Thereafter, the conversational agent uses natural language understanding engine to extract meaning from the user's utterance. Utterances are expressed in natural language with practically unlimited variations, and it is difficult to program enough rules to cover every single text change. However, machine learning is used by classifiers to interpret text which is more scalable than applying rules (Freed, 2021b). Arthur Samuel, a developer in the field of machine learning defined it as the

> "*Field of study that gives computers the ability to learn without being explicitly programmed.*" (Bhavsar et al., 2017, p. 283)

The fundamental of which machine learning stands on, is to utilize statistical learning and optimization methods that allow for examining data sets and finding patterns. The algorithm used in machine learning is dependent on data availability and the research question (Katherine et al., 2019).

The last step of the interaction is then the conversation agent formulates a response and forwards it to the user. It can either be an answer or a question asking for further information (Freed, 2021b).

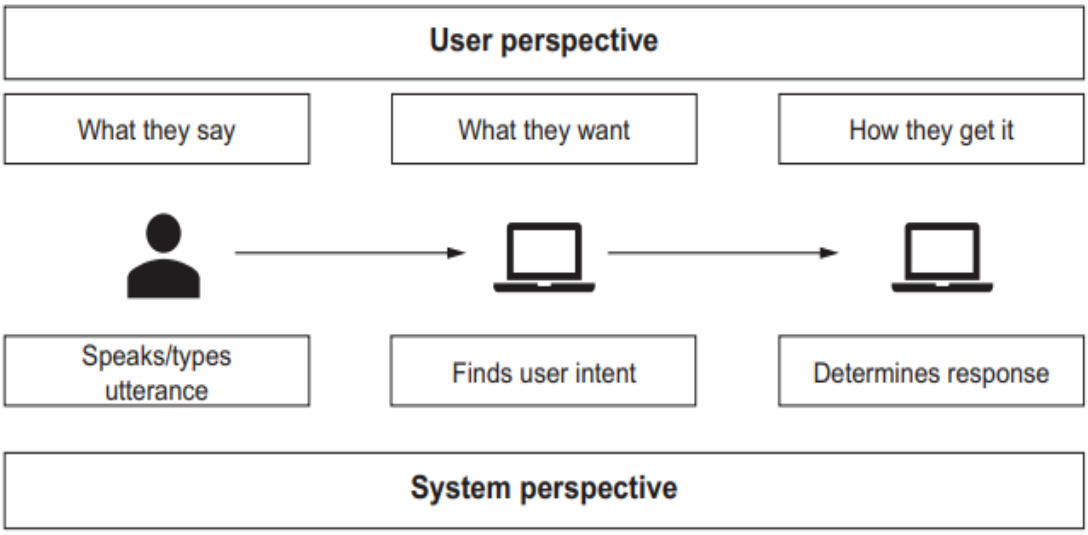

Figure 3 One turn of a conversation, from the user and system perspectives (Freed, 2021b).

Resource allocation

The evolution of technology presented in industry 4.0 has reshaped recruitment processes as well as various human resource processes supported by enterprise resource planning, big data

analysis and AI (Oswal et al., 2020). Today AI enabled application in human resource management, is in initial phases and relativity new for machine learning applications (Garg et al., 2021; Oswal et al., 2020). This exist when specifying a job specification using algorithms for example to select the most suitable candidates for any vacant position (Wheeler & Buckley, 2021b). Intelligent algorithms, developed on the basis of AI and machine learning, have proven its potential to increase rapidly, reduce costs, prevent risks from growing and improve the quality of human resource management. Business leaders are gaining benefits of intelligent automation capabilities with improved accuracy, constant process and approaches as Microsoft and IBM (Garg et al., 2021).

According to research conducted with the objective on how human resource management functions are witnessing machine learning adoption, it was discovered an increasing implementation of machine learning. The adoption of machine learning is mainly used in processes with large data sets available with an opportunity for standardization, in areas like recruitment and selection. In complex processes, the implementation of machine learning needs coordination between human resource managers and professional experts in order to facilitate for assessment of various parameters and data exchange (Garg et al., 2021). On the other hand, human resource allocation or workforce planning requires reviewing and analyzing historical business data, to determine appropriate staffing levels and selecting the employees for a position (Wheeler & Buckley, 2021a).

Human resource management functions can be split into eight categories: recruitment, selection, employee engagement, training and development, performance management, employee turnover, team dynamics and human resource allocation. Each function has its respective objectives for machine learning. According to the review, it was discovered that machine learning in areas of recruitment and performance management is strongest because of its measurable nature. Meanwhile, machine learning applications in recruiting are strengthened by the availability of information and data required for sorting for job applications. Which shows the distribution of research publications over the identified human resource management functions. According to the same review the progress of machine learning application in human resource allocation is slower compared to recruitment (Garg et al., 2021).

2.6.3 Integrations of AI in Project Tools

The beginning of AI evolution in project management is the integration and automation across organizations (Lahmann et al., 2018). Integration and automation are focusing on efficient and automated projects through simplifications of processes and workflow, that were otherwise manually done or based on obsolete systems. Working on traditional integration can be resource-intensive, expensive and vulnerable to human error (*What* Is *Intelligent Automation? | IBM*, 2021).

Microsoft Office 365 is a digital workspace that comprises a variety of software tools designed to improve team collaboration in any type of company (Michalak, 2015). During the technological evolution, Office 365 integrated AI and developed Microsoft 365 to deliver cloud and templates solutions for allowing user to collaborate. Also using tools in an easier way. The cloud solution has a significant effect on information flow within a business and changed the way projects are managed (Katzer & Crawford, 2013). The digital transformation has pressured Microsoft to integrate AI and developed a variety of tools to help companies be more efficient and profitable (Katzer & Crawford, 2013; McKelvey et al., 2021). The PowerPoint design is one of the AI integrated tools to help build presentations with recommended slide designs. AI efforts different Designer for variety needs as branded templates. Where companies got offered automatically intelligent and relevant design for the content within company guidelines and branded. It has been shown that 84 percent of leaders see it is necessary to integrate AI into applications to keep a competitive edge (*Technical Leaders Agree*, 2022).

> *"In a world that is increasingly becoming digital, the one need every business has is for more business process automation. In fact, it's not just about accumulating more business applications; you want to be able to connect these business processes end-to-end, create these systems of intelligence, systems of action." Satya Nadella, Microsoft CEO* (*Technical Leaders Agree*, 2022, p. 1)

Another capability PowerPoint has created with AI is Presenter Coach. It helps users to improve their speaking abilities with intelligent tips while presenting. The tool gives real time feedback on the user's screen recommendations about the presentation pacing. It warns the users if they are using filler words as "ahh" or "umm", and it gives detailed rapport at the end of each preparation session with metrics for further training to improve the presentations skills (Villaron & Manager, 2019).

Microsoft has also created a capability that provides high quality content and optional presentation for quantitative content through Word, turning the document into presentations in PowerPoint by just using the AI based feature called Export to PowerPoint presentation. The AI features recommend presentation based on keyword and the summarized sections in the users document file (Eoanou, 2021).

Another example of AI which businesses benefit from is email spam filtering (Dada et al., 2019). Unwanted spam mail has a destructive effect on global security and economy. Not only does it waste the users time but also consumes network bandwidth and takes up storage capacity (Gangavarapu et al., 2020). Research conducted by research firm Gartner Inc revealed "*Thirty four percent of the internal business email they receive is unnecessary*" and categorizes these emails as "*occupational spam*". They recommend that managers take actions to reduce it (Anonymous, 2001, p. 12). Email tools such as Gmail, Yahoo mail and Outlook have implemented different machine learning techniques like Neural Network for filtering out spam. Neural network has the ability to identify and comprehend spam and phishing messages by analyzing big data holding these types of mails (Dada et al., 2019). The spam filter also has the capacity to generate new rules for the model to work independently based on patterns and information it discovers (Russell & Norvig, 2022). With the help of unsupervised learning techniques. It is a form of analysis that organizes unlabeled datasets using machine learning algorithms, and it identifies similarities and dissimilarities in data which makes it a great tool for large datasets, pattern and picture recognition (Katherine et al., 2019).

2.6.4 Human factor

The capabilities of AI can be implemented and used in recruitment, but it does not replace the need for humans in the process. Automated systems and AI applications eliminate repetitive and low-skilled aspects of jobs that recruitment agencies used to do. Such as responding to emails, verifying applicant's information, distributing candidate information internally within the organizations. Which is making the process faster and efficient. The most advanced algorithm-based solutions in the recruitment environment still require human interaction. Effectivization in recruitment processes through AI will increase the use of recruitment function, but at the same time increase data scientists to build software solutions that

recruiters use to employ. Which changes the structure of human resource management departments (Wheeler & Buckley, 2021b).

Furthermore, AI systems will not only change human resource management, but also how projects are being managed and delivered. While elements of project management can be replaced by AI. The core of project management cannot be replaced and the cognitive skills like leadership, emotional intelligence and empathy will still require human interaction. Specially, project managers have to prepare efficiently in the human machine collaborative environment. The report concludes that AI systems will aid project managers rather than replace them, and that only those who appreciate the genuine value brought by AI systems will survive in the future (Lahmann et al., 2018).

> *"I think that human talent is irreplaceable. You can automate processes. You can have technology as a very significant enabler of business relationships, but human warmth, warm relationships between two people, the ability to create and visualize business models, the ability to develop strategies, to define and contribute to a better society, are very difficult to replace with machines. In this sense, I believe that human talent in organizations is the great distinguishing feature, it is the great enabler of growth."* ("CEO Survey," 2017, p. 22)

3 Method

In order to arrive at answers to the research questions. A research design is developed - which is a logical plan formed to guide researchers in collecting, analyzing and understanding data from the start to the end of the project. The choices of methods will be explained and described, along with an assessment of the reliability and validity of the methods.

3.1 Methodology description

Based on the research topics it was of interest to interview a focus group with experience in project management. The focus group experiences and opinions will have valuable impact on the research's data collected. The information gathered is not necessarily possible to obtain in a quantitative method that is often linked to measurable variables (Dalland, 2017a). Therefore, the qualitative method was chosen as the research method. A good qualitative study uses several data collection methods. The need for different methods brings out new

knowledge and to verify the extent to which claims are reliable and valid according to Dalland (2017). The methods case study, literature study and in-depth interviews have been carried out.

3.1.1 Case study

The case study used to approach the appropriate design for the research is an exploratory case study. The exploratory case study answers the "How" and "what" questions and are used when there is no single set of outcomes. Yin definition of a case study is twofold. The first definition describes the scope of a case study

> "*A case study is an empirical inquiry that investigates a contemporary phenomenon (the "case") in depth and within its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident."* (Yin, 2014c, p. 38)

Meanwhile, the second part of Yins definition is characteristics of a case study due to phenomenon and context not clearly distinguishable in real- word circumstances.

> "*A case study inquiry copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result benefits from the prior development of theoretical propositions to guide data collection and analysis.*" (Yin, 2014c, p. 54)

It was of interest to look at which critical factors influence projects delays to define scope and boundaries between the phenomenon and its context. As supported by Yin preferences - the origin of a case study start with the researcher stumbling over subjects and resource questions that proves to be important, but not intended to be a part of problem formulation. Therefore, a theory and theoretical framework has been presented to illuminate the problem and specify what it needs to be investigated in the explorative study (Johannessen et al., 2010a). The units of analysis in this study is to explore lack of communication management and poor resource allocation in the planning process specifically in the construction industry. Furthermore, it was natural to involve managers in that industry to get a holistic picture of the real-world context. Hence, the experience and opinion of a leader in the construction industry would be valuable when accumulating data for the research at hand. The starting point of the

thesis has been theoretical, but the research question has required an in-depth method of the various direction describes in problem formulation. On the basis of this, it was decided to conduct a case study.

The planning process of a project is a relatively complex process that can be presented in different ways considering the framework. A qualitative method such as in-depth interviews is used to give a thorough and thoughtful answer in relation to research questions and issues at hand. Additionally, an analysis of the standards along with relevant documentation was used.

3.1.2 In-depth interview

The reason for choosing a particular method is because it is believed that this particular method is best suited to shed light on the question or problem in the best possible way (Dalland, 2017a). The qualitative methods aim to capture meaning and experience that cannot be quantified or measured, and to achieve in-depth knowledge and comprehensive understanding of specific context thorough (Dalland, 2017a; Grønmo, 2020). A research interview, a form of a qualitative method, is appropriate to use in qualitative research where the goal is to obtain comprehensive information about the informant's understanding, feelings, perceptions, opinions, reflections and experiences related to a phenomenon. To get an overall understanding of the topic as well as the research question depends on the experiences and impressions of people involved in project management in the construction industry. Naturally, informants from this industry were chosen to contribute to obtaining specific knowledge expressed in the informant's own words (Leseth & Tellmann, 2014).

Selection of informants

Through network contacts were established, and informants working in a construction company with project management experience were invited to participate in interviews. Reasons for the selection of informants were time disposition, position and experience. According to Johannessen Tufte and Christoffersen (2010), it can be useful to use the snowball method. Initially by starting with informants that gradually grow as the researcher receives tips for new informants (Johannessen et al., 2010b). It was of interest to interview people who had experience that was not generally available, precisely to gain a deeper understanding of what is being studied. Such informants are resourceful and can give

researchers reflections and related knowledge to the unit of analysis. Originally, only project managers were to be considered for the interviews but after being aware of the organizational chart for the company. It was clear that department managers as well as division managers were equally linked to project management. The research question also involves the interface towards AI and to get more angles and finding the critical factors; it was also advantageous to interview an informant familiar with AI in the business field.

Information for informants

Initially the interviews started with presenting the researchers and the topic of this project following up with the guaranteed anonymity for the person being interviewed, and it was also informed that all material would be treated confidentially. The informants gave consent to the interviews being audio reordered, because to be able to process personal data, according to the Personal Data Act § 8, one must have obtained consent from the interviewee (*Personopplysningsloven*, 2018, §8).

Interview guide

When choosing the process of data acquisition, the plan was to send enquiry about the research question to the informants by mail. In consultation with the supervisor, it was discussed that using an in-depth-interview would be beneficial for the case study. For the reason that the interviewer can register and interpret the meaning of what is being said and the way it is being said, but also observe and interpret the use of voice, facial expressions and other bodily expressions (Dalland, 2017c). In addition, during the interview it was easier to ask follow-up questions right away and to ask open questions which allowed the participants to fully express themselves. The in-depth interviews conducted were semi-structured, the questions were defined in advance as an interview guide and the questions asked through the interview were adapted to the individual situations (Leseth & Tellmann, 2014). A theme guide was sent by email to the informants to prepare them for questions during the in-depth interviews. In order to ask relevant interview questions regarding project management, digitization and AI it was of advantage to read to gain a pre-understanding, as well as link the questions to the research question (Leseth & Tellmann, 2014). The semi-structure interview guide was divided in three parts, introduction, main part and conclusion, supported by Leseth and Tellman (2014). The guide had several themes with specific questions under each theme.

The initial stage of the interview guide was about AI, but after the second interview it was obvious that the direction of the interview was not aligned with the interview guide. Strategically the order of the questions was adjusted to steer the conversation in the desired direction. Additionally, there was room for discussions during the interviews, to facilitate the informants, elaborate on their answers and reflect on the different themes. See Appendix B for the interview guide.

Execution

To be efficient the interviews were conducted virtually using the application Microsoft Teams, and the invites were sent out in advance. At the beginning of the interview, the subjects approved the recording of the interview and supplemented it with notes to keep reliability. The interviews varied in duration but lasted approximately one hour and were within the same scope. Meanwhile, the interview with the informant familiar with AI in the business field was specifically goal oriented towards the subject Artificial Intelligence.

The next step in processing the data was to transcriber and in total there was 260 number of pages. Thereafter, the transcription was categorized and grouped into relevant themes, because it would make it easier to see the connections, similarities and differences among the interviews. The next step was to use the data to write results and discussion. At the end, the audio recording along with all the written materials were shredded after analysis and processing of the content.

3.1.3 Validity

Validity stands for relevance, and what is measured must be relevant and valid for the problem being investigated according to Dalland (Dalland, 2017b). The purpose of AI was to use as much new literature as possible since AI is updated often, and therefore the theory can quickly become outdated. Contrary to project management, where both older and new literature were used, due to the literature on project management is still based on the same principles. One challenge was how to find correct observational targets for the concepts being studied, but by using the analysis of unit method the picture of the phenomenon was clearer.

The factors that impact the phenomenon in this case study are different and the research design is not an internal validity because it failed to deal with other threats that causes the

phenomenon. According to Yin (2014), internal validity is unsuitable to case study because it is not afraid of different threats and factors thar causes the situation (Yin, 2014b).

3.1.4 External Validity

An uncertainty factor was that the research was based on a single-case study which was weakening the reliability of the research, contrary to a multiple-case study where it yields more robustness. For a case studies, a statistical generalization is preferred, where the inference is made of a population using data from a sample of that universe (Yin, 2014a, p. 78). Hence, the research is valid for the chosen individual case company, finding and results is not applicable for all construction industries with project management principles.

3.1.5 Reliability

Reliability is about those measurements that must be performed correctly, and that any margins of error are stated (Dalland, 2017b). When reviewing the reliability of this project it was important that the researchers showed all the steps that have been reviewed in the case study. Because the objective of reliability is to confirm that if a later researcher followed the same procedure as described by the original researcher and conducts the same case study, the later investigator should arrive at the same result and conclusions. Furthermore, the aim of reliability is also to reduce the errors and biases in a case study (Yin, 2014b). Documenting the interviews contributes with minimizing the participants and researcher's margin of error. Nevertheless, the data material is not valid if the participants do not speak the truth. While the interviews were happening, it was important that the researcher were aware of conscious biases and stayed objective. To avoid research error the interviews were distributed over several days. Hence, ensuring reliability in the empirical data was a key factor. To strengthen the reliability The University Library's resources were mainly used.

4 Results

In this chapter, the results and findings from the interviews will be presented. The results are based on the answers given during the interviews with representatives from the construction industry and one representative from an innovation organization as presented in the previous chapter. The interview guide containing the questions asked can be found in Appendix B. The

interviewees are listed in the following subchapter. However, this chapter will not be alluded to who is responsible for the various results or statements. It will, however, be tried to make a comparison of the results from the participants.

4.1 Organization and Roles

The organization used in this case study is a management and consultancy services organization. They have experience from several projects in many different areas with variation in terms of size and complexity. The organization consists of disciplines across all spectrums such as architecture, electrical engineering, construction engineering and HVAC engineering. Each discipline has its own department responsible for their own respective area in a project. The project sizes are of the smaller scale for the department the informants allocated to.

The managers participants in the in-depth interviews are employed with different roles. The hierarchy of each discipline starts with the division manager, following the department managers and then the professional team members. One informant is the division manager, a significant and unique role who sets the direction for the division and is ultimately responsible for the division's success. The division manager's responsibilities are planning, organizing, and allocating resources along with managing the daily operations. Meanwhile, the responsibilities of three informants as department managers are to achieve the goals established and set out in plans. Along with managing the departmental budget they are also responsible for keeping up with the administrative and academic tasks. The role of the fourth manager is divided between two roles as project manager and assignment manager. The project manager's responsibility is to manage a project from start to finish, and to ensure that the work is done within the framework conditions agreed upon contractually for cost, quality and time. The assignment manager has to carry out risk assessment while developing a security plan and site instructions. The last informant is an expert in AI, digitalization and business strategy, working as a chief technology innovation officer with responsibility to manage the process of innovation and change management in organization outside of the construction industry.

The following table is an overview of the participant’s roles, years of experience and meeting information:

Date	Identification	Role	Years of experience	Meeting duration
05.04.22	Informant 1	Department manager	23 years	Approx. 1 hour
05.04.22	Informant 2	Department manager	24 years	Approx. 1 hour
06.04.22	Informant 3	Department manager	19 years	Approx. 1 hour
06.04.22	Informant 4	Project manager / Assignment manager	40 years	Approx. 30 minutes
07.04.22	Informant 5	Division manager	25 years	Approx. 1 hour
29.03.22	Informant 6	Chief technology innovation officer	31 years	Approx. 1 hour

Table 1 Overview of informants

4.2 The Planning Process

The interviewees are aligned when asked if the planning process of a project is executed in line with the PMBOK Guide. The interviewees highlight that each project must be discussed when defining the momentum. Therefore, having a common goal and understanding the scope of work along with the budget and timeframe is highly important for all parties.

> "The *planning process in a project is firstly that someone has defined the task. Then he must find out if he or the person concerned has the same perception of the task agreement*."

Hence, the main objective of the planning process is to plan the work, allocate resources, define the schedule and budget. The timeline of the momentum is dependent on when the construction phase starts. One interviewee's opinion that the planning process should happen in plenum and aligned with the momentum which is a success factor for the project.

The organization method for a project life cycle is split into different phases. It starts with the initial concept, sketching phase, pre-project, detailed project and finally the construction phase. Each transition phase marks important decision points and phase approval which often forms the basis for planning and implementation of the next phase. Before each phase the planning process is initiated and established but prior to the sketching phase.

Furthermore, the interviewees are underlining the challenging parts of planning a project for the misalignment between the contractors and company's expectations.

> "*So, it is very often that there are slightly different opinions around the expectations.*"

When the contractor's expectations are not clearly defined it is often due to lack of knowledge of the disciplines included in the project. Meaning that those disciplines must explain what is possible and profitable to achieve in relation to capacity, future and environment.

> *"Contractors do not always know what kind of tools are used and the purpose of the tool. Project manager may need to define it."*

Companies and contractor's ambitions are not equal, because the company's ambition is focused on branding, strategic design and final solution that will benefit the company in the future. Meanwhile, the contractor thinks about square meters and budget, as an interviewee expressed. Consequently, not meeting the contractor's expectations can result in project delays or affect the project success.

4.3 Communication

The interviewees agree that communication can be divided into internal and external communication. Internal communication is between professional groups within the company, and good internal communication according to the manager is familiarization with the team member's background and experience to establish a plan based on the experiences.

> "*Depending on how well you know the people you are going to work with, and how much you have worked with them before - you can plan based on experience. But if you have not worked together and do not have experience, you as a leader need to talk to the rest of the project to form a picture [...] You have to communicate both internally and externally, but if you have a lot of experience, you do not need a lot of communication internally."*

Good external communication is equally important. External communication happens between the customer, client or their representatives. What characterizes easy communication flow is teamwork skills and personal chemistry. The interviewee points out the importance of achieving good communication and cooperation through trust with the team members. Hence, communication is at the center of a good collaboration.

The division manager's experience in the case company is noteworthy since the manager recently stepped into the role. It was mentioned that some time has been invested to build relations and understanding of how people work. Which is supported by the department manager's experience, that creating a personal relationship, trust and the same goal are the most important qualities for a multidisciplinary project to succeed.

Contrary when a project delays or fails is often due to not defined scope of work in early phases resulting in ambition misalignments. This affects not only the planning process but also communication between the participants throughout the project. The interviewees are linked to a specific discipline in the organization, which are traditionally dependent on having early expectations clarified so that every participant has the same starting point. This issue was well reflected when the interviewees spoke about their experience.

> *"If someone has a significantly higher level of ambition, it will affect the project. It is not always the level of ambition that matches what the contract allows, it can often lead to poor communication when someone has ambitions that are beyond what is actually agreed in the project. Can also be the other way someone does not bother to deliver to the agreed level or too low in the line where then it will be a problem."*

A team can also consist of different nationalities and cultures, and this has to be considered when communicating. An interviewee mentioned having experienced working with team members who had different backgrounds. Describing the communication methodology and culture in Norway, where the communication is informal and casual. While compared to the country the other team members are from, it is a hierarchical system and very formal. This

created an obstacle to being able to communicate freely and allowing participants to contribute without restriction.

> "*If they are having too much respect for the hierarchy in the conversation, then the gold that lies underneath people does not come out and that is what I want to get when I work with a building or a project. What is exciting is what goes into people's heads, their ideas and what they want. It is not always certain that everything fits what people want, but if you know it then you can manage it.*"

In order to obtain and convey necessary information, good communication and a good flow of information is needed. Department managers often experience difficulties finding the balance when deciding how much information should be shared and what information is relevant. The department managers who are responsible for several projects at the same time expressed that they are incapable of having a detailed overview of each project.

> "*As a leader, I run from one project to another, and I cannot have a detailed overview of each project, but I must have a ballpark overview. I do not know everything that happens in a project, e.g., the technical things, therefore I trust my team with accurate skills orient themselves and I am confident that they will tell me if they are struggling*."

In contrast to the division manager communication is not challenging since it is strategically planned to have weekly meetings to inform about upcoming tasks and schedule update. The division manager's role is to lead the department managers without interfering with the technical side, meaning that the information flow and communication is easier. Additionally, the division manager expressed that each department manager is free to manage as their leadership skills are trusted.

Communication and information flow is relative to which project one is working on according to the project manager. The case company has currently a confidential project requiring special needs due to the requirements sent by the contractor. Each form of communication is carefully analyzed and processed before it is passed to the next in line. The time and resources necessary to communicate considering the restrictions is challenging.

Communication and Project Triangle

Scope of work is an agreement on the work to be performed and therefore it is necessary to have a mutual understanding of the project ambitions as the interviewees agree on. Based on scope of work it is easy to delegate tasks and estimate the time of each activity. Setting up an overview is not challenging for the managers but knowing what has been executed and the actual work hours along with how far they have come is challenging. It is easy to see the budget but not the actual earned hours and keep track of planning because it is not measurable.

> "*I have spent half the time, but have I done half the work?*"

The department manager finds it strategically beneficial to spend only 80 percent of the project budget to avoid going over the budget. But in principle, having good communication means reaching the goal faster and therefore more likely to achieve financial goals.

Communication in the Construction Industry

The construction industries are facing slower progress compared to other industries because of different factors. One being that those in leader roles are of the older generations not up to date or familiar with new systems. Another factor is foreign workers with different educational backgrounds while communicating in different languages. Thirdly, there are many people on the construction site who do not keep up with today's technology.

Ineffective communication

The interviewees were informed of the study that one third of project failure is due to ineffective communications (Onal, 2013, p. 10). It was further explained that it could be everything from the project not being completed, delays, and part of the project not turning out as expected. As a response to the study, the interviewees were not surprised of the high percentage, and many expressed that they had personally experienced it. An interviewee mentioned an example of a multidisciplinary project with technical subject and project management joining forces and creating over a thousand square meters project. During the project kick-of meeting the conversation leaned towards file exchange, storage locations, which excel sheet to exchange information through and requirements to complete the project.

In this scenario, there is a risk of tunnel ambitions and not having a common understanding of the project and delivery.

The interviewees agree that one spends a lot of time understanding each other to avoid misunderstandings. If one does not understand what to do and has not properly and correctly formulated in the first place, it can lead to many misunderstandings and wrong results.

> "*Spending a lot of time on something that is not properly defined leads to a basis for something else that someone else builds on, and which also does not become correct."*

Having the correct system to find and recognize the failure early and fast enough is important before it results in time-consuming consequences. Another interviewee has experienced that through communication and the correct use of tools the income greatly increased compared to other projects where communication was not at the center.

Communication and Digitalization

Some of the interviewees agreed that communication through human interactions is impossible to digitize. Human interaction is about seeing each other physically to recognize expressions and attitudes. Interaction should take place across a room and not through a computer or monitor. It is easier to have it over Microsoft Teams, but meetings, reviewing and coordinating under the same roof and at the same time is more efficient.

> "*I am not against digitization and digitalization, but interaction is much easier to achieve under the same roof by involving all partners and reaching an agreement together*."

Outside of digital solutions, keeping in touch with the customer through physical interactions is important to build trust and at the same time helps to ensure that everyone is seen and heard. Physical meetings create a safe space where all members have the same end goal intentions, while helping to reduce conflicts and better understanding of each other.

> "*The project is created by people, and it is extremely important to get into people's heads and see what ideas they have […]and this comes out with good communication. I do not think this can be digitized.* "

Meanwhile, a department manager is positive about using communication and digitalization in interaction to get the best out of people. By describing a concept, everyone in the project

can form an image, but by doing it visually, collectively the team can come to an agreement and thus avoid misunderstandings and dissatisfied customers.

Communication through digitalized channels such as Microsoft teams, Email and BIM has been used more frequently since the pandemic. The managers had different attitudes about further digitalizing the channels currently used. The others wanted to go back to physical meetings and to use Microsoft Teams for clarification meetings when necessary. The rest were positive to utilizing and digitalizing the communication channels. Nevertheless, there should be limits and boundaries to how far digitalization should be implemented considering the risk of surveillance and exploitation of data, was a department manager's response when asked if communication should be further digitalized.

4.4 Resource Allocation

If there is demand for one specific profession it is easier to allocate the resource because there is no competition. With resources who have the same experience and same area of educational background it is quite challenging. In some scenarios there are team members who have the same skills to complete a task, but their educational background is different which will affect the way they complete the task. The difficulty level of resource allocation varies based on the number of projects and the number of people working in a department. It is difficult to have an overview of available capacity and whether they have the right knowledge.

Resource allocation planning

The case organization allocates resources based on demand. When allocating resources in a project, they need to plan to find a resource for a project at the right time. The department manager and division managers are describing resource allocation as when assigning the best fit resource depending on competence, characteristics, experience, and availability to match the needs of a project.

> "*You can allocate the right resource for a job by looking at experience and characteristics of the individual"*

Often resource allocation is based on whether the resource has experience of a certain job, how they executed the previous projects and hours used to complete the job. Based on those parameters, they can allocate as well as consider individual development and desires. Adapting to the needs and desires of individuals can affect the project and the effort individuals put in the task. Some people enjoy getting the same tasks, others do not, based on the experience of the department manager, most people want to have a variety of work assignments.

> "*Most people like to have variety of tasks to experience something new, learn something new and feel that they are developing.*"

Project managers must consider individual development when allocating resources to strengthen the organization. However, the individual's request should be aligned with the organization's goals expressed by the department manager. Another necessary factor to take into consideration when allocating resources in a project is the level of emotional intelligence. Emotional intelligence is important when establishing a well-functioning team with common goals. One department manager highlighted:

> *"A good collaboration is about personal chemistry."*

Furthermore, allocating resources requires managers to have a continuous overview of everyone. All interviewers agree that it is challenging especially when there are many projects.

> *"We choose the people we think are best suited for the task, and since we do not have their CV 100 percent in mind all the time, it often happens that you have forgotten what individual has done. We try to stay up to date and be able to remember what each one has done."*

The personality of individuals plays a role in the ease of forgetting certain people.

> *"It is easy to forget some people [...] Because not everyone stands out very clearly and not everyone takes up the same amount of space in the room. Some are sitting at the very back and some like to sit at the very front. Those who are in front are always visible for better or worse*"

During the covid-19 pandemic, the department manager experienced that it was easier to forget some people since everyone worked from home. The opportunity to see and talk to

people was less, so it was difficult to know if team members were well, if they did their job and if they had the capacity to do more work.

> *"Resource planning has changed during the pandemic […] How we will work in the future and communicate has clearly received a different focus now."*

For managers to keep track of individual experience and knowledge, a program called CV-partner is used, where individuals in the team update their curriculum vitae (CV) after each project, they have been part off. Department managers expressed that CV-partner are not detailed enough to find out what types of job have been done or get a clearer picture of their capacity.

The time managers spend allocating resources depends on the project size, but normally they meet once a week to allocate the team to different projects. If a project lasts for one year, then less time goes to resource allocation, but if there are multiple and smaller projects it requires more planning and time.

Through weekly meetings, department and division managers discuss and share experience to establish a plan organized and facilitated through Microsoft Excel. Based on the time estimated and experience numbers for everyone, an overview is created. The managers get a chance to balance the tasks between all team members equally.

> "*We have a resource allocation sheet, so we can see every week if there is someone who has too much to do, we try to outsource it to someone else so that you do not overload.*"

To maintain the resource allocation plan it is very important that the manager and team members communicate and inform each other how much time is estimated for the task. Especially if there is a need for more time and to also report on progress. This information does affect the resource plan, mainly if a team member reports back needing more time on a task and while the base case has an earlier finish date. In that scenario it will affect the task planned after. For the manager it is crucial to adjust the resource allocation plan continually, so the work tasks are distributed approximately and not detailed, to make room for delays.

> **"***There must be some slack, and the schedule must not be entirely filled because if something happens, everything will fall apart.*"

One division manager mentions another way to see how much time people spend on a project or task is by looking at previous hours from previous projects.

"You can either talk to people or look at experience numbers."

Planning based on experience depends on how well you know those who will work with you in the team. In cases where the project consists of teams the manager has not worked with before, they must communicate with them to form a picture. Communicating externally and internally is necessary to be able to allocate resources evenly and to build relations with every stakeholder.

Resource allocation and digitalization

The interviewees experience that the digital solutions available in the company has not helped to make the process for allocating resources easier, and allocating resources falls back to managers and communication about who fits when and how. Additionally, they are using the program CV-partner, which could have been better if the resources did not have to manually write their booked hours. Instead, it will be easier if the hours came in automatically as experience in CV-partner. The department manager believes that such process can be digitalized and much needed. All the interviewees agree that allocating resources can be digitalized, but one thing that is hard to measure is emotional intelligence which is what goes on between people.

"*Emotional intelligence is an important keyword that is difficult to digitize*"

Furthermore, department manager adds that resource allocation cannot be completely digitalized in the construction industry because communication is the main component. The department manager believes that with resource allocation it depends on which industry you work in and which task you are to perform. A plumber has tasks to perform based on knowledge and does not rely much on communicating with manager. Resource distribution can therefore be digitalized completely, mainly because communication and emotional intelligence does not need to be taken into consideration:

4.5 BIM

BIM is one of the digital transformations that has been integrated into the construction industry and has a significant impact on managers workdays. At the beginning of this topic the managers were asked what BIM is for them. The leaders define BIM in different ways, but everyone agrees that the main purpose is the information the model is enriched with. Furthermore, adding how a BIM model should be able to describe each individual element for itself without human interaction, and in addition to being used to extract quantity lists, collision checks, data and much more.

> *"BIM contributes to errors being detected in an earlier phase of a project. We have been working with 3D for a long time but adding information to the elements is new with BIM. This information is used by other disciplines as a means of communication for when the building is to be built or maintained, but it is important that the data contained in the model is correct and is processed correctly so that it is credible and can be used by others."*

Moreover, BIM is used for information exchanged between different disciplines. The department managers add that this has fixed a major challenge experienced before BIM, as a loss of information has previously contributed to valueless drawings that can neither be used for maintenance nor renovation. A department manager adds that BIM is an intelligent model with built-in data that must be used in an intelligent way and will makes room for innovative solutions.

BIM as a communication tool

The interviewers agree that BIM is an important tool and that it has contributed to increasing communication flow in the work between project participants and digital tools. A department manager adds that the communication between different digital tools with different purposes has contributed to increased efficiency in the work the participants carry out. The ability to see the model in 3D has contributed to easier collaboration between project managers and entrepreneur during the planning process.

> "*Visual communication has definitely contributed to common understanding and better collaborations*."

Challenges related to BIM according to the department managers is how it is not fully utilized in an optimal way. There are many suppliers and construction client who do not clearly define what kind of information the model should include, and to what professional degree. BIM capacity is often underestimated by stakeholders.

4.6 Artificial Intelligence

The chief technology innovation officer with specialties in the field of AI expressed that AI works by collecting or entering data, and training AI based on the input. The more data and training provided for AI the better it will work. To further illustrate how AI works, the interviewee compares AI to the cognitive learning capabilities of a toddlers. More specifically when learning from experience about explaining the difference between good and bad actions. Equally, AI must be trained and taught the difference between preferences.

A number of well-known companies such as Microsoft and Google have many AI services built and integrated into their public platforms, that almost everyone has or are using. The interviewee expressed that the way people are thinking of AI is changing in comparison to five years ago. Previously the integration of AI was an option, but today AI is already a part of Microsoft, Google and general services.

AI in construction industry

Several of the interviewee pointed out that the progress of AI is happening at a slow rate in the construction industry**.** The AI expert explains further that the reason is because it is not a digital industry by nature, especially the field of construction management. The advanced level of AI in an industry depends on if it is digital versus non-digital, and the level of human interaction. Project management is a field that depends on a high level of human interaction, and it is non-digital.

> "*In a digital field, AI is very advanced. In a non-digital field, AI is still in the beginning, and it needs a lot of training and work. That is why we do not see advanced AI in the project management field."*

The other interviewees gave the impression of how project management is a field that has the potential to be optimized by AI, but it is just a matter of time according to the chief

technology innovation officer. To fully optimize a project by AI, it is important to optimize all elements to get the best results. Because optimizing schedule alone will not have enough impact on a project since it is affected by other area such as cost, scope and risk, as an example given by the interviewee.

AI in communication and resource management

The interviewee with specialties in the field of AI points out that for AI to innovate communication management or resource management. Companies must invest tremendous number of hours to train AI to specialize in those areas. Companies usually restrain from innovative investments in the bigger scale, but rather utilize AI services from suppliers as Microsoft and Google. Businesses are interested in incorporating AI in the small scale such as using Chatbots described as commercial AI by the chief technology innovation officer.

The interviewee is positive to AI capabilities of providing advisory service in real time with regards to distributing resources. For AI to be able to give advice, it needs to have data. The data can be information such as work experience, qualification, or the persona of each individual employee. Based on the input, AI will provide an assumption of which employee will be best qualified for a specific project. If the parameters are not established well enough, it will not provide optimal solutions.

In contrast to digitizing communication which is at the cutting edge of AI capability. Human interaction is one aspect regardless of any industries, that cannot be optimized by algorithm, because AI does not recognize or identify non-verbal communication. The part of project management involving human interaction can only be optimized by team members, good leadership and good culture. Digitalizing non-verbal communication at this stage is too complex, expensive and will provide poor result. The other aspects of communication with the potential to be digitalized is hard communication skills. The substantial data necessary to integrate AI in communication management can be different from past projects with description of how communication flow went, where the communication inefficient and a clear description of which of the project were successful. Based on the input AI will be able to predict project managers with optimal advice and guidance. The managers mentioned the same benefits of achieving digitalization especially in the planning process which can be time consuming.

The interviewees were informed of a Gartner analysis that 80 percent of today's project management tasks will be eliminated by 2030 and how AI will replace the majority of the job done by today's project managers. The interviewees all agree that the traditional project management tasks have the potential to be eliminated, but the interaction between team members and project managers cannot be digitized. On the other hand, a department manager expressed concerns regarding the pace of technological development that is rapidly increasing and creating a distance between technology and human evolution. The interview participants had divided opinions about how prepared project managers were for the predicted technological development.

5 Discussion

The objective of this chapter presents the discussion with connection between theory and result from the interviews. To be able to answer the problem the discussion structured around overall opportunities AI have in the construction industry. In addition, discussing two research questions. The first research question describes the opportunities AI system has contribute to effective communication between project managers and team members, based on interviewer's experience compared to theory. The second research question is about investigating if there is room for further digitalize resource allocation through AI.

The result describes construction management as progressing slowly in the digital development because it is not digital by nature, and this is supported by theory. According to the report from Mckinsey (2020), since the pandemic outbreak business have increased technological adaptation, and this is also noticed by the interviewees (McKinsey Global Institute, 2020). The result indicates that there are opportunities to further digitalize project management through AI.

The managers expressed optimism toward optimizing solutions by AI. However, they are still skeptical and have a picture that AI will become increasingly impersonal and automated in workplace. Based on the literature review presented earlier AI is already well implemented and will continually grow. The literature reassures that manager will still have the opportunity to intervene, correct and influence.

1. What are the opportunities to digitize communication and deploy Artificial Intelligence?

This subchapter introduces the important of communication, what role communication has in connection with project success and introduces opportunities for digitalization through AI. The results indicate that communication has an impact on projects, whether it is through challenges that might arise or to help team members perform their jobs and responsibilities better. Good communication management is one of key factors for project success.

The outcome of ineffective communication aligns with the findings of similar studies. Lack of communication in the form of misunderstandings or using incorrect communication media is one of the major concerns for the success of a project which verifies the pulse study (Onal, 2013). It affects interdependencies and the development of knowledge areas such as undefined scope of work or budget overruns. However, the results also indicate other reasons for project failure besides ineffective communication as equally important as lack of defined goals or tunnel vision ambitions from both manager and entrepreneurs.

The research questions were interpreted differently which laid the foundations for the answers. The answers gathered by the result chapter were divided into two different directions of communication that can be digitalized and not be digitalized. The non-digital communication was based on the importance of human interaction that includes human expressions, attitude and making space for easier access to build relations. The interviewers believe this side could not be transformed to any software. The results do fit with the theory as indicated that non-verbal communication has an impact on the verbal message exchanged during the human interaction.

A manager must be able to handle the dynamics of a team and sometimes it can be challenging since people are so different and communicate differently. The data contributes to a clearer understanding that the nature of humans can be a barrier to efficient communication (Kymmell, 2007). Building a relation both internally and externally contributes managers to a better understanding of individuals for managers to lead a department.

The interviewers had many years of experience as managers and were comfortable with planning projects and managing team members in the traditional way. The demand for enhancing the integration of digital solutions were quite low and consequently the thought of digitalizing communication was not preferred. But due to covid-19 outbreak which changed the shape of work and society, the use of digital solutions accelerated overwhelmingly.

Project managers experienced pressure to change the work arrangement and to take more flexible approaches for internal communication and remote working.

Meanwhile, the purpose and intent of digitalizing communication did not align with all the managers as the methodology practices for management differs. Therefore, rather than focusing on the disadvantages on digitizing the human interaction side of communication, the approach is to use digital tools for the benefits of streamline the workflow and cost effectiveness.

Literature review point out that digital tools are functioning as communication tools in numerous ways (Guzman & Lewis, 2020; Naidoo & Dulek, 2022). In the construction industry, BIM is one of the digital tools that has increased communication flow and contributed to better collaboration according to the mangers. Digital transformation has pressure in organizations and managers to implement AI to be able to keep the competitive age. The results contribute that using AI to innovate communication management requires large investment from organizations, the larger the investment is the bigger scale of automation. The risk of high investment is that the outcome does not align with the expectations. Therefore, it is more preferred using AI services on smaller scale such as chatbots or add-ins from suppliers such as Microsoft. The part of communication that can be digitalized through AI has come a long way with conversational agents, where the user can interact through natural language. As it looks today, AI has not only facilitated communication but also automated communication that social interaction relies on.

To achieve the aim of the research, the limitation of overall research question is leaving room for interpretation of the questions during the qualitative study. The question was wide, it did not provide the opportunity to discuss and elaborate how communications could be digitalized further. Additionally, due to the lack of data on managers in different age groups and departments the results are less nuanced.

2. How can Artificial Intelligence be used to digitalize resource allocation?

This subchapter presents the planning process for allocating resources, what role project manager has in connection with distributing resources and identifying challenges for resource allocation. Introduces whether resource allocation can be digitalized through AI. The results indicate that resource allocation depends on different factors such as availability, visibility and their experience. The project manager must take the factors into account to ensure the

development of both the employee and organization. The findings suggest that there are opportunities to digitalize resource allocation through AI if there are measurable parameters.

Project manager responsibilities entails planning resource allocation in early phases to avoid circumstances in changes in workload or increasing resources demand from projects. Turner (2009) supports the result and adds that the intention is to achieve the project's objective and to set the baseline for the important constrains of knowledge areas in projects (Turner, 2009a). Project managers consider previous durations of completing similar task when estimating and planning resources. Meanwhile, a literature study presents that estimation of resources is one of the project management fundamental uncertainties (Atkinson et al., 2006).

The interviewees are experiencing challenges with maintaining an updated overview of each individual resource experience and capacity. While they are using the cv-partner program to keep an overview, it is not efficient for gathering experiences while continuously updating. The next step is allocating the resources based on the demand and the organization that was interviews used simple Microsoft excel sheets for even distribution of work.

The organization revealed their methods for keeping track of resources is through Microsoft Excel. It provides an overview of the whole team to help project managers avoid overworked. Even with access to CV-partner and resource distribution overview, interviewees still face challenges with remembering everyone. This problem has increased during the pandemic, because working remotely has decreased the visibility over what employees are doing. Hence, theory contributes with a clearer understanding of how communication management is essential to prevent poor resource management (Kania et al., 2020).

The interviewers express that there are opportunities to further digitalizing resource allocation through AI based on parameter that are digitized. However, while the organization have available data according to a review machine learning in resource allocation have shown low progress due to not measurable nature (Garg et al., 2021). The process of distributing resources and keeping track is complex and the data available is not at the ANI stage sufficient for digitalization. Continuously working in the traditional way has consequences and not efficient in the long run. An interviewee expressed the opportunities individual organization have to innovate resource allocation, if the data are well established and available. Meanwhile, in the field of recruitment, which also a function of human resource management, machine learning is at the strongest because of measurable possibilities.

The interviewers draw parallel link to the Emotional intelligence and communication regarding the inability to be digitized. However, it is expected that Artificial General Intelligence will reach a stage where it is capable of understanding the world as well as human. This raises the concern among a few of interviewees that this development can create a gap between technological development and human evolution. Today, the digital transformation is growing, and it raises the question of whether managers are equipped and capable for this development. Since literature studies are indicating that many of project managers tasks will be eliminated in the next coming years.

6 Conclusion

This research aimed to investigate the opportunities for how AI can improve the planning process of project management, especially communication management and resource allocation. To determine whether there are opportunities, it was necessary to understand the challenges that arise during the project directed towards communication and resource allocation. Based on the qualitative method and the literature review. We can conclude that communication and resource allocation are critical knowledge areas as it affects the overall planning process in construction projects.

The overall result points towards that AI is capable of innovating communication and providing advisory services in real-time in terms of resource distribution. However, that is possible under circumstances of having enough digitized data and well-trained data to provide the optimal advice and solutions. The challenge with implementing AI to innovate communication and resource allocation is that not all information, methods and processes are digitized. Considering that project management is a field that depends on a high level of human interaction, and it is non-digital by nature. Without digitized data, AI will be unable to assist managers.

AI is already integrated into many software and applications everyone is using on a daily basis. The lack of integrating AI to decrease the communication gap and streamlines the distribution of resources during the planning process of a project, is due to companies unwilling to invest on a larger scale as it requires an enormous number of hours to train the AI. Companies prefer incorporating AI on a small scale such as using Chatbots, as it is a perfect example of a small scale of AI that organizations can implement anywhere. However, Chatbots do not provide organizations with an optimal solution in the long run. The research also emphasizes that the core of project management cannot be replaced by AI and cognitive skills like leadership, emotional intelligence and empathy will continue to require human management because they are on the cutting edge of what AI is capable of.

Several interviewers used Excel as the main program to distribute resources equally to the employees. The information about time estimation on a different task is digitized. This provides the organization with enough data to integrate AI and improve resource distribution. The integration of AI will provide space for project managers to have more time focusing on the human side of a project by strengthening relations with the team members to build trust and understand their psychological contract needs.

As observers the organization has enough available data to take the next step to keep up with digital transformation. There is limitation to AI capabilities, but utilizing what AI is capable of should be taken advantage of to improve working methods. There are solid opportunities to exploit AI for adaptation and integration in the planning process. Additionally, the managers are open to such changes, but it depends on the willingness and ability to take investment risks by the organization.

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Appendix

Appendix A

Project management Overview

Some of project management standards used are ISO21500 and PMBOK. The ISO 21500 and PMBOK standards are nearly identical. The collection of procedures is organized similarly, but the approaches of the standards are not.

> "*Project management is the application of methods, tools, techniques and competencies to a project. Project management includes the integration of the various phases of the project life cycle. Project management is accomplished through processes"*

According to International Organizational for Standardization, The ISO 21500 standard covers the process in introduction as well as the project inputs and outputs (*ISO 21500*, 2012).

Meanwhile, the PMBOK provides a more specific description of project management processes, with inputs and outputs as well as techniques and tools (Čabarkapa & Belgrade, 2019). Project management in PMBOK is defined as

> "*Project management is the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements. Project management is accomplished through the appropriate application and integration of the project management processes identified for the project."* (Project Management Institute, 2017a)

A project can be divided into five processes following the Iso 21500 standard, similarly to PMBOK. The apparent difference are the term used for each process (Čabarkapa & Belgrade, 2019):

PMBOK	ISO 21500
Initiating	Initiating
Planning	Planning
Executing	Implementing
Monitoring and controlling	Controlling
Closing	Closing

The manpower assigned to work on a project must work in accordance with the project plan continually. Project Management knowledge is referred to as Subject Groups in ISO 21500 and Knowledge Areas in PMBOK Guide 6th. However, the essence stays the same. The following table present the ten items in both standards:

PMBOK Knowledge Areas	ISO 21500 Subject
Integration	Integration
Stakeholder	Stakeholder
Scope	Scope
resource	resources
Schedule	Time
Cost	Cost
Risk	Risk
Quality	Quality
Procurement	Procurement
Communication	Communication

In comparison the primary distinction is that ISO 21500 does not include tools and techniques, and the description of project processes. The PMBOK explanations are likewise significantly longer than those in the ISO 21500 standard, which provides a better understanding of the project processes and project management knowledge (Gasik, 2009, p. 11).

Artificial intelligence Types based on functionalities

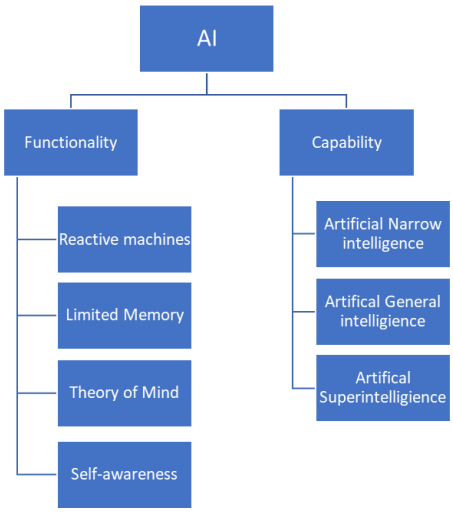

Figure 4 A overview of Artificial intelligence types

Reactive Machines

Reactive machines are the original AI systems, and their capabilities are minimal. They simulate the ability of the human mind to respond to various stimuli, and a memory-based functionality is not available on these devices. This means that such robots are unable to use previous experiences to guide their current behaviour, i.e., they lack the ability to "remembering and learning" These machines could only be programmed to respond to a restricted number of inputs or combinations of inputs. They are unable to rely on memory to improve their operations. IBM's Deep Blue, which defeated chess Grandmaster Garry Kasparov in 1997, is a popular example of a reactive AI machine.

Limited Memory

Limited memory machines are machines that can learn from previous data to make judgments in addition to having the characteristics of a reactive machines. This category of AI encompasses nearly all present applications that we are aware of. All modern AI systems, including deep learning systems, are taught using vast amounts of training data that they store in memory to create a reference model for future models. Almost every AI application today, from chatbots and virtual assistants to self-driving cars, is powered by limited memory AI.

Theory of Mind

Researchers are now working on developing Theory of mind, which is the next level of AI systems. A theory of mind level AI will be able to identify the needs, emotions, beliefs, and mental processes of the human beings with whom it interacts. While artificial emotional intelligence is now a growing business and a focus for prominent AI researchers, reaching the level of Theory of Mind AI would need advancements in other AI areas as well. Because AI computers will have to view humans as individuals whose brains may be changed by a variety of elements in order to genuinely grasp human needs, they will have to "understand" humans.

Self-awareness

This is the last step of AI development, which exists only in theory at the moment. Self-aware AI is an AI that has matured to the point where it is so similar to the human brain that it has gained self-awareness. The ultimate goal of all AI research is and will always be to create this form of AI, which is decades becoming a reality. This form of AI will not only be able to recognize and generate emotions in individuals with whom it interacts, but will also have its own emotions, wants, beliefs, and maybe goals (Joshi, 2019).

How Artificial intelligence works

Deep learning

Deep learning is a learning process used in machine learning, which involves teaching "deep artificial neural networks". This is a key strategy in machine learning, where it is a fundamental rule that computers should seek out knowledge about subjects known or not. The history behind Deep learning according to Artificial intelligence a modern approach

> "*Deep learning has its origins in early work that tried to model networks of neurons in the brain with computational circuits. For this reason, the net-works trained by deep learning methods are often called neural networks, even though the Neural network resemblance to real neural cells and structures is superficial*." (Russell & Norvig, 2022, p. 802).

A neural network is a collective term for computer structures with algorithms, which is inspired by the way the nerve cells in a brain are arranged (Tidemann, 2022).

Computer Vision

Computer vision develops techniques, based on deep learning fundamentals, that works similarly as the human vision. It can process and understand the content of digital images such as photographs and videos. It takes meaningful information from visual input where it deconstructs it and assesses whether the elements in the visual input can be linked to something that the system already knows and provides recommendation or respond based on that. This technology is used, among other things, for face recognition and diagnosis of diseases (*What Is Computer Vision?*, 2022).

Appendix B

Interview guide for managers

There will first be a brief introduction of the thesis and the interview situation. You will then be asked to briefly tell us about yourself and your background in the company before we move on to the interview questions. Audio recordings will be made of the interview. And it will be conducted completely anonymously. Names or other sensitive information that comes out of the interview will not be used. It is designed as a semi-structured interview where the topic and to some extent also the questions are prepared in advance. In order for my recommendations and conclusions in the thesis to be as good as possible, I want as honest and subjective opinions as possible during the interview. I would like to take this opportunity to thank you for your time and not least your desire to contribute.

NR.	Questions	Relevance
1	What is BIM for you?	General
2	How has BIM affected your management role? • With planning's process? • What do you think about BIM being used as a planning tool?	General
3	Has BIM helped increase communication management and information flow?	General
4	Has BIM been used much more after the covid-19 pandemic?	General

5	What are the most common challenges you have as a project manager / division manager / department manager in a project?	General
6	Have you experienced that the requirements for being a project manager have changed due to the digital development that has taken place since Covid?	General
7	How has digitalization affected the scope, schedule and cost in the planning process?	General
8	*"Ineffective communications is the primary contributor to project failure one third of the time, and had a negative impact on project success more than half the time."* Do you have any experience with it and what are your thoughts on this?	Research question 1
9	Can communication be digitized? • How do you see technology helping?	Research question 1
10	Do you have challenges with people staying up to date when it comes to project changes?	Research question 1
11	What challenges do you experience with resource allocation in the planning process? • How has technology helped or contributed?	Research question 2
12	According to a research report, 80 percent of project manager tasks will disappear by 2030. According to Gartner, artificial intelligence will eliminate 80 percent of today's project management tasks by 2030. • What are your thoughts on this? • How much of your workload of AI Today?	Research question 1 and 2
13	What is your relationship with AI as a manager?	Research question 1 and 2

Appendix C

A Guide to the Project Management Body of Knowledge - Sixth Edition

PMBOK® GUIDE 6TH EDITION
PROCESSES FLOW

RICARDO VARGAS

Based on the *A Guide to the Project Management Body of Knowledge* (PMBOK® Guide) - Sixth Edition, Copyright: Project Management Institute, Inc., (2017). All rights reserved.

INITIATING

4.1 INTEGRATION — Develop Project Charter
- INPUTS: 1. Business documents; 2. Agreements; 3. Enterprise environmental factors; 4. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Data gathering; 3. Interpersonal and team skills; 4. Meetings
- OUTPUTS: 1. Project charter; 2. Assumption log

13.1 STAKEHOLDER — Identify Stakeholders
- INPUTS: 1. Project charter; 2. Business documents; 3. Project management plan; 4. Project documents; 5. Agreements; 6. Enterprise environmental factors; 7. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Data gathering; 3. Data analysis; 4. Data representation; 5. Meetings
- OUTPUTS: 1. Stakeholder register; 2. Change requests; 3. Project management plan updates; 4. Project documents updates

PLANNING

5.1 SCOPE — Plan Scope Management
- INPUTS: 1. Project charter; 2. Project management plan; 3. Enterprise environmental factors; 4. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Data analysis; 3. Meetings
- OUTPUTS: 1. Scope management plan; 2. Requirements management plan

5.2 SCOPE — Collect Requirements
- INPUTS: 1. Project charter; 2. Project management plan; 3. Project documents; 4. Business documents; 5. Agreements; 6. Enterprise environmental factors; 7. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Data gathering; 3. Data analysis; 4. Decision making; 5. Data representation; 6. Interpersonal and team skills; 7. Context diagram; 8. Prototypes
- OUTPUTS: 1. Requirements documentation; 2. Requirements traceability matrix

5.3 SCOPE — Define Scope
- INPUTS: 1. Project charter; 2. Project management plan; 3. Project documents; 4. Enterprise environmental factors; 5. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Data analysis; 3. Decision making; 4. Interpersonal and team skills; 5. Product analysis
- OUTPUTS: 1. Project scope statement; 2. Project documents updates

5.4 SCOPE — Create WBS
- INPUTS: 1. Project management plan; 2. Project documents; 3. Enterprise environmental factors; 4. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Decomposition
- OUTPUTS: 1. Scope baseline; 2. Project documents updates

6.1 SCHEDULE — Plan Schedule Management
- INPUTS: 1. Project charter; 2. Project management plan; 3. Enterprise environmental factors; 4. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Data analysis; 3. Meetings
- OUTPUTS: 1. Schedule management plan

6.2 SCHEDULE — Define Activities
- INPUTS: 1. Project management plan; 2. Enterprise environmental factors; 3. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Decomposition; 3. Rolling wave planning; 4. Meetings
- OUTPUTS: 1. Activity list; 2. Activity attributes; 3. Milestone list; 4. Change requests; 5. Project management plan updates

6.3 SCHEDULE — Sequence Activities
- INPUTS: 1. Project management plan; 2. Project documents; 3. Enterprise environmental factors; 4. Organizational process assets
- TOOLS & TECHNIQUES: 1. Precedence diagramming method; 2. Dependency determination and integration; 3. Leads and lags; 4. Project management information system
- OUTPUTS: 1. Project schedule network diagrams; 2. Project documents updates

6.4 SCHEDULE — Estimate Activity Durations
- INPUTS: 1. Project management plan; 2. Project documents; 3. Enterprise environmental factors; 4. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Analogous estimating; 3. Parametric estimating; 4. Three-point estimating; 5. Bottom-up estimating; 6. Data analysis; 7. Decision making; 8. Meetings
- OUTPUTS: 1. Duration estimates; 2. Basis of estimates; 3. Project documents updates

6.5 SCHEDULE — Develop Schedule
- INPUTS: 1. Project management plan; 2. Project documents; 3. Agreements; 4. Enterprise environmental factors; 5. Organizational process assets
- TOOLS & TECHNIQUES: 1. Schedule network analysis; 2. Critical path method; 3. Resource optimization; 4. Data analysis; 5. Leads and lags; 6. Schedule compression; 7. Project management information system; 8. Agile release planning
- OUTPUTS: 1. Schedule baseline; 2. Project schedule; 3. Schedule data; 4. Project calendars; 5. Change requests; 6. Project management plan updates; 7. Project documents updates

7.1 COST — Plan Cost Management
- INPUTS: 1. Project charter; 2. Project management plan; 3. Enterprise environmental factors; 4. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Data analysis; 3. Meetings
- OUTPUTS: 1. Cost management plan

7.2 COST — Estimate Costs
- INPUTS: 1. Project management plan; 2. Project documents; 3. Enterprise environmental factors; 4. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Analogous estimating; 3. Parametric estimating; 4. Bottom-up estimating; 5. Three-point estimating; 6. Data analysis; 7. Project management information system; 8. Decision making
- OUTPUTS: 1. Cost estimates; 2. Basis of estimates; 3. Project documents updates

7.3 COST — Determine Budget
- INPUTS: 1. Project management plan; 2. Project documents; 3. Business documents; 4. Agreements; 5. Enterprise environmental factors; 6. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Cost aggregation; 3. Data analysis; 4. Historical information review; 5. Funding limit reconciliation; 6. Financing
- OUTPUTS: 1. Cost baseline; 2. Project funding requirements; 3. Project documents updates

8.1 QUALITY — Plan Quality Management
- INPUTS: 1. Project charter; 2. Project management plan; 3. Project documents; 4. Enterprise environmental factors; 5. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgement; 2. Data gathering; 3. Data analysis; 4. Decision making; 5. Data representation; 6. Test and inspection planning; 7. Meetings
- OUTPUTS: 1. Quality management plan; 2. Quality metrics; 3. Project management plan updates; 4. Project documents updates

9.1 RESOURCE — Plan Resource Management
- INPUTS: 1. Project charter; 2. Project management plan; 3. Project documents; 4. Enterprise environmental factors; 5. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Data representation; 3. Organizational theory; 4. Meetings
- OUTPUTS: 1. Resource management plan; 2. Team charter; 3. Project documents updates

9.2 RESOURCE — Estimate Activity Resources
- INPUTS: 1. Project management plan; 2. Project documents; 3. Enterprise environmental factors; 4. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Bottom-up estimating; 3. Analogous estimating; 4. Parametric estimating; 5. Data analysis; 6. Project management information system; 7. Meetings
- OUTPUTS: 1. Resource requirements; 2. Basis of estimates; 3. Resource breakdown structure; 4. Project documents updates

4.2 INTEGRATION — Develop Project Management Plan
- INPUTS: 1. Project charter; 2. Outputs from other processes; 3. Enterprise environmental factors; 4. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Data gathering; 3. Interpersonal and team skills; 4. Meetings
- OUTPUTS: 1. Project management plan

EXECUTING

9.3 RESOURCE — Acquire Resources
- INPUTS: 1. Project management plan; 2. Project documents; 3. Enterprise environmental factors; 4. Organizational process assets
- TOOLS & TECHNIQUES: 1. Decision making; 2. Interpersonal and team skills; 3. Pre-assignment; 4. Virtual teams
- OUTPUTS: 1. Physical resource assignments; 2. Project team assignments; 3. Resource calendars; 4. Change requests; 5. Project management plan updates; 6. Project documents updates; 7. Enterprise environmental factors updates; 8. Organizational process assets updates

9.4 RESOURCE — Develop Team
- INPUTS: 1. Project management plan; 2. Project documents; 3. Enterprise environmental factors; 4. Organizational process assets
- TOOLS & TECHNIQUES: 1. Colocation; 2. Virtual teams; 3. Communication technology; 4. Interpersonal and team skills; 5. Recognition and rewards; 6. Training; 7. Individual and team assessments; 8. Meetings
- OUTPUTS: 1. Team performance assessments; 2. Change requests; 3. Project management plan updates; 4. Project documents updates; 5. Enterprise environmental factors updates; 6. Organizational process assets updates

9.5 RESOURCE — Manage Team
- INPUTS: 1. Project management plan; 2. Project documents; 3. Work performance reports; 4. Team performance assessments; 5. Enterprise environmental factors; 6. Organizational process assets
- TOOLS & TECHNIQUES: 1. Interpersonal and team skills; 2. Project management information system
- OUTPUTS: 1. Change requests; 2. Project management plan updates; 3. Project documents updates; 4. Enterprise environmental factors updates

8.2 QUALITY — Manage Quality
- INPUTS: 1. Project management plan; 2. Project documents; 3. Organizational process assets
- TOOLS & TECHNIQUES: 1. Data gathering; 2. Data analysis; 3. Decision making; 4. Data representation; 5. Audits; 6. Design for X; 7. Problem solving; 8. Quality improvement methods
- OUTPUTS: 1. Quality reports; 2. Test and evaluation documents; 3. Change requests; 4. Project management plan updates; 5. Project documents updates

4.3 INTEGRATION — Direct and Manage Project Work
- INPUTS: 1. Project management plan; 2. Project documents; 3. Approved change requests; 4. Enterprise environmental factors; 5. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Project management information system; 3. Meetings
- OUTPUTS: 1. Deliverables; 2. Work performance data; 3. Issue log; 4. Change requests; 5. Project management plan updates; 6. Project documents updates; 7. Organizational process assets updates

4.4 INTEGRATION — Manage Project Knowledge
- INPUTS: 1. Project management plan; 2. Project documents; 3. Deliverables; 4. Enterprise environmental factors; 5. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Knowledge management; 3. Information management; 4. Interpersonal and team skills
- OUTPUTS: 1. Lessons learned register; 2. Project management plan updates; 3. Organizational process assets updates

13.3 STAKEHOLDER — Manage Stakeholder Engagement
- INPUTS: 1. Project management plan; 2. Project documents; 3. Enterprise environmental factors; 4. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Communication skills; 3. Interpersonal and team skills; 4. Ground rules; 5. Meetings
- OUTPUTS: 1. Change requests; 2. Project management plan updates; 3. Project documents updates

12.2 PROCUREMENT — Conduct Procurements
- INPUTS: 1. Project management plan; 2. Project documents; 3. Procurement documentation; 4. Seller proposals; 5. Enterprise environmental factors; 6. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Advertising; 3. Bidder conferences; 4. Data analysis; 5. Interpersonal and team skills
- OUTPUTS: 1. Selected sellers; 2. Agreements; 3. Change requests; 4. Project management plan updates; 5. Project documents updates; 6. Organizational process assets updates

11.6 RISK — Implement Risk Responses
- INPUTS: 1. Project management plan; 2. Project documents; 3. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Interpersonal and team skills; 3. Project management information system
- OUTPUTS: 1. Change requests; 2. Project documents updates

10.2 COMMUNICATIONS — Manage Communications
- INPUTS: 1. Project management plan; 2. Project documents; 3. Work performance reports; 4. Enterprise environmental factors; 5. Organizational process assets
- TOOLS & TECHNIQUES: 1. Communication technology; 2. Communication methods; 3. Communication skills; 4. Project management information system; 5. Project reporting; 6. Interpersonal and team skills; 7. Meetings
- OUTPUTS: 1. Project communications; 2. Project management plan updates; 3. Project documents updates; 4. Organizational process assets updates

CLOSING

4.7 INTEGRATION — Close Project or Phase
- INPUTS: 1. Project charter; 2. Project management plan; 3. Project documents; 4. Accepted deliverables; 5. Business documents; 6. Agreements; 7. Procurement documentation; 8. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Data analysis; 3. Meetings
- OUTPUTS: 1. Project documents updates; 2. Final product, service, or result transition; 3. Final report; 4. Organizational process assets updates

13.2 STAKEHOLDER — Plan Stakeholder Engagement
- INPUTS: 1. Project charter; 2. Project management plan; 3. Project documents; 4. Agreements; 5. Enterprise environmental factors; 6. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Data gathering; 3. Data analysis; 4. Decision making; 5. Data representation; 6. Meetings
- OUTPUTS: 1. Stakeholder engagement plan

12.1 PROCUREMENT — Plan Procurement Management
- INPUTS: 1. Project charter; 2. Business documents; 3. Project management plan; 4. Project documents; 5. Enterprise environmental factors; 6. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Data gathering; 3. Data analysis; 4. Source selection analysis; 5. Meetings
- OUTPUTS: 1. Procurement management plan; 2. Procurement strategy; 3. Bid documents; 4. Procurement statement of work; 5. Source selection criteria; 6. Make-or-buy decisions; 7. Independent cost estimates; 8. Change requests; 9. Project documents updates; 10. Organizational process assets updates

11.1 RISK — Plan Risk Management
- INPUTS: 1. Project charter; 2. Project management plan; 3. Project documents; 4. Enterprise environmental factors; 5. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Data analysis; 3. Meetings
- OUTPUTS: 1. Risk management plan

11.2 RISK — Identify Risks
- INPUTS: 1. Project management plan; 2. Project documents; 3. Agreements; 4. Procurement documentation; 5. Enterprise environmental factors; 6. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Data gathering; 3. Data analysis; 4. Interpersonal and team skills; 5. Prompt lists; 6. Meetings
- OUTPUTS: 1. Risk register; 2. Risk report; 3. Project documents updates

11.3 RISK — Perform Qualitative Risk Analysis
- INPUTS: 1. Project management plan; 2. Project documents; 3. Enterprise environmental factors; 4. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Data gathering; 3. Data analysis; 4. Interpersonal and team skills; 5. Risk categorization; 6. Data representation; 7. Meetings
- OUTPUTS: 1. Project documents updates

11.4 RISK — Perform Quantitative Risk Analysis
- INPUTS: 1. Project management plan; 2. Project documents; 3. Enterprise environmental factors; 4. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Data gathering; 3. Interpersonal and team skills; 4. Representations of uncertainty; 5. Data analysis
- OUTPUTS: 1. Project documents updates

11.5 RISK — Plan Risk Responses
- INPUTS: 1. Project management plan; 2. Project documents; 3. Enterprise environmental factors; 4. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Data gathering; 3. Interpersonal and team skills; 4. Strategies for threats; 5. Strategies for opportunities; 6. Contingent response strategies; 7. Strategies for overall project risk; 8. Data analysis; 9. Decision making
- OUTPUTS: 1. Change requests; 2. Project management plan updates; 3. Project documents updates

10.1 COMMUNICATIONS — Plan Communications Management
- INPUTS: 1. Project charter; 2. Project management plan; 3. Project documents; 4. Enterprise environmental factors; 5. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Communication requirements analysis; 3. Communication technology; 4. Communication models; 5. Communication methods; 6. Interpersonal and team skills; 7. Data representation; 8. Meetings
- OUTPUTS: 1. Communications management plan; 2. Project management plan updates; 3. Project documents update

MONITORING & CONTROLLING

5.5 SCOPE — Validate Scope
- INPUTS: 1. Project management plan; 2. Project documents; 3. Verified deliverables; 4. Work performance data
- TOOLS & TECHNIQUES: 1. Inspection; 2. Decision making
- OUTPUTS: 1. Accepted deliverables; 2. Work performance information; 3. Change requests; 4. Project documents updates

5.6 SCOPE — Control Scope
- INPUTS: 1. Project management plan; 2. Project documents; 3. Work performance data; 4. Organizational process assets
- TOOLS & TECHNIQUES: 1. Data analysis
- OUTPUTS: 1. Work performance information; 2. Change requests; 3. Project management plan updates; 4. Project documents updates

6.6 SCHEDULE — Control Schedule
- INPUTS: 1. Project management plan; 2. Project documents; 3. Work performance data; 4. Organizational process assets
- TOOLS & TECHNIQUES: 1. Data analysis; 2. Critical path method; 3. Project management information system; 4. Resource optimization; 5. Leads and lags; 6. Schedule compression
- OUTPUTS: 1. Work performance information; 2. Schedule forecasts; 3. Change requests; 4. Project management plan updates; 5. Project documents updates

7.4 COST — Control Costs
- INPUTS: 1. Project management plan; 2. Project documents; 3. Project funding requirements; 4. Work performance data; 5. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Data analysis; 3. To-complete performance index; 4. Project management information system
- OUTPUTS: 1. Work performance information; 2. Cost forecasts; 3. Change requests; 4. Project management plan updates; 5. Project documents updates

4.5 INTEGRATION — Monitor and Control Project Work
- INPUTS: 1. Project management plan; 2. Project documents; 3. Work performance information; 4. Agreements; 5. Enterprise environmental factors; 6. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Data analysis; 3. Decision making; 4. Meetings
- OUTPUTS: 1. Work performance reports; 2. Change requests; 3. Project management plan updates; 4. Project documents updates

4.6 INTEGRATION — Perform Integrated Change Control
- INPUTS: 1. Project management plan; 2. Project documents; 3. Work performance reports; 4. Change requests; 5. Enterprise environmental factors; 6. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Change control tools; 3. Data analysis; 4. Decision making; 5. Meetings
- OUTPUTS: 1. Approved change requests; 2. Project management plan updates; 3. Project documents updates

13.4 STAKEHOLDER — Monitor Stakeholder Engagement
- INPUTS: 1. Project management plan; 2. Project documents; 3. Work performance data; 4. Enterprise environmental factors; 5. Organizational process assets
- TOOLS & TECHNIQUES: 1. Data analysis; 2. Decision making; 3. Data representation; 4. Communication skills; 5. Interpersonal and team skills; 6. Meetings
- OUTPUTS: 1. Work performance information; 2. Change requests; 3. Project management plan updates; 4. Project documents updates

12.3 PROCUREMENT — Control Procurements
- INPUTS: 1. Project management plan; 2. Project documents; 3. Agreements; 4. Procurement documentation; 5. Approved change requests; 6. Work performance data; 7. Enterprise environmental factors; 8. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Claims administration; 3. Data analysis; 4. Inspection; 5. Audits
- OUTPUTS: 1. Closed procurements; 2. Work performance information; 3. Procurement documentation updates; 4. Change requests; 5. Project management plan updates; 6. Project documents updates; 7. Organizational process assets updates

11.7 RISK — Monitor Risks
- INPUTS: 1. Project management plan; 2. Project documents; 3. Work performance data; 4. Work performance reports
- TOOLS & TECHNIQUES: 1. Data analysis; 2. Audits; 3. Meetings
- OUTPUTS: 1. Work performance information; 2. Change requests; 3. Project management plan updates; 4. Project documents updates; 5. Organizational process assets updates

10.3 COMMUNICATIONS — Monitor Communications
- INPUTS: 1. Project management plan; 2. Project documents; 3. Work performance data; 4. Enterprise environmental factors; 5. Organizational process assets
- TOOLS & TECHNIQUES: 1. Expert judgment; 2. Project management information system; 3. Data representation; 4. Interpersonal and team skills; 5. Meetings
- OUTPUTS: 1. Work performance information; 2. Change requests; 3. Project management plan updates; 4. Project documents updates

9.6 RESOURCE — Control Resources
- INPUTS: 1. Project management plan; 2. Project documents; 3. Work performance data; 4. Agreements; 5. Organizational process assets
- TOOLS & TECHNIQUES: 1. Data analysis; 2. Problem solving; 3. Interpersonal and team skills; 4. Project management information system
- OUTPUTS: 1. Work performance information; 2. Change requests; 3. Project management plan updates; 4. Project documents updates

8.3 QUALITY — Control Quality
- INPUTS: 1. Project management plan; 2. Project documents; 3. Approved change requests; 4. Deliverables; 5. Work performance data; 6. Enterprise environmental factors; 7. Organizational process assets
- TOOLS & TECHNIQUES: 1. Data gathering; 2. Data analysis; 3. Inspection; 4. Testing/product evaluations; 5. Data representation; 6. Meetings
- OUTPUTS: 1. Quality control measurements; 2. Verified deliverables; 3. Work performance information; 4. Change requests; 5. Project management plan updates; 6. Project documents updates

PMBOK® GUIDE 6TH EDITION – 49 PROJECT MANAGEMENT PROCESSES

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Explanatory Note: This flow ***does not replace*** the need for reading the PMBOK® Guide. The PMBOK® Guide contains a deep explanation of all processes including Inputs, Tools & Techniques and Outputs that are listed in this flow.

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Download this processes flow at **http://rvarg.as/pmbok6en**

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Appendix D

Mail correspondence with mangers no.1

From: Laaouar, Nassiba
Sent: Thursday, March 31, 2022 5:31 PM
To: [redacted]
Subject: Masteroppgave - kvalitativ undersøkelse

Hei!

Dette semestret skriver jeg masteroppgave som noen av dere allerede vet, i forbindelse med det så trenger jeg intervjuobjekter med prosjektledelse erfaring til dybdeintervju. Oppgaven handler om hvordan prosjektledelse kan optimaliseres ved hjelp av kunstig intelligens innenfor ressurs- og kommunikasjon ledelse. Planen er å sende noen få spørsmål på mandag hvor hensikten er å stille spørsmål relatert til erfaring deres som prosjektledere.

Setter stor pris på om dere kan sette av litt tid til å svare. På forhånd takk 😊

Nassiba Laaouar

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-LAEmHhHzdJzBITWfa4Hgs7pbKI

From: Laaouar, Nassiba
Sent: Tuesday, April 5, 2022 10:12 AM
To: [redacted]
Cc: s.bakker@stud.uis.no <s.bakker@stud.uis.no>
Subject: Masteroppgave - kvalitativ undersøkelse

Hei!
Masteroppgaven er et casestudie som handler om grensesnittet mellom prosjektledelse og kunstig intelligens. Formålet er å analyse mulighetene kunstig intelligent kan bidra med for å optimalisere kommunikasjon og ressurs fordeling i plan processen av et prosjekt.
For å forstå mulighetene, og hvordan dette er i virkligheten. Så ønsker vi å stille følgene spørsmål på onsdag:

- Hva er de vanligste utfordringene du har som prosjektleder i et prosjekt?
- Hva er dine tanker om bruk av BIM, og har det påvirket hvordan du jobber?
- Tenker du at BIM har bidratt med å øke kommunikasjon og informasjonsflyten
- Synes du at teknologi kan hjelpe med kommunikasjon
- Har du opplevd at kravene for å være prosjektleder har endret seg på grunn av det den digitale utviklingen som har skjedd siden Covid?
- Hvilket utfordringer opplever du med ressurs allokering i planleggings processen, og hvordan har teknologi hjulpet eller bidratt?

Nassiba Laaouar

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Vurdering

Referansenummer

[redacted]

Prosjekttittel
How can AI systems influence the planning process to become more optimized

Behandlingsansvarlig institusjon
Universitetet i Stavanger / Det teknisk- naturvitenskapelige fakultet / Institutt for sikkerheit, økonomi og planlegging

Prosjektansvarlig
Sigbjørn Landezuri Tveteraas

Student
Nassiba Laaouar

Prosjektperiode
01.01.2022 - 15.06.2022

Meldeskjema

Dato
20.04.2022

Type
Standard

Kommentar
OM VURDERINGEN
Personverntjenester har en avtale med institusjonen du forsker eller studerer ved. Denne avtalen innebærer at vi skal gi deg råd slik at behandlingen av personopplysninger i prosjektet ditt er lovlig etter personvernregelverket.

Personverntjenester har nå vurdert den planlagte behandlingen av personopplysninger. Vår vurdering er at behandlingen er lovlig, men du må oppdatere informasjonsskrivet før du starter (se neste avsnitt).

INFORMASJONSSKRIV
Informasjonsskrivet ditt mangler noen punkter loven krever er med. Du må derfor legge til disse punktene i informasjonsskrivet før du gir dette til forskningsdeltakerne dine. Du trenger ikke å laste opp den oppdaterte versjonen i meldeskjemaet:

- Studiens formål og hva opplysningene skal brukes til
- Hvilken institusjon som er behandlingsansvarlig
- Hvilke opplysninger som innhentes og hvordan opplysningene innhentes
- At det er frivillig å delta og at man kan trekke seg så lenge studien pågår uten at man må oppgi grunn
- Når behandlingen av personopplysninger skal avsluttes og hva som skal skje med personopplysningene da: sletting, anonymisering eller videre lagring
- At du behandler opplysningene om dine forskningsdeltagere basert på deres samtykke
- At utvalget ditt har rett til innsyn, retting, sletting, begrensning og dataportabilitet (kopi)
- At utvalget ditt har rett til å klage til Datatilsynet
- Kontaktopplysninger til prosjektansvarlig (evt. student og veileder)
- Kontaktopplysninger til din institusjon sitt personvernombud

Ta gjerne en titt på våre nettsider for hjelp til formuleringer:
https://www.nsd.no/personverntjenester/fylle-ut-meldeskjema-for-personopplysninger/sjekkliste-for-informasjon-til-deltakerne/

DEL PROSJEKTET MED PROSJEKTANSVARLIG
For studenter er det obligatorisk å dele prosjektet med prosjektansvarlig (veileder). Del ved å trykke på knappen «Del prosjekt» i menylinjen øverst i meldeskjemaet. Prosjektansvarlig bes akseptere invitasjonen innen en uke. Om invitasjonen utløper, må prosjektansvarlig inviteres på nytt.

TYPE OPPLYSNINGER OG VARIGHET
Prosjektet vil behandle alminnelige kategorier av personopplysninger frem til den datoen som er oppgitt i meldeskjemaet.

LOVLIG GRUNNLAG
Prosjektet vil innhente samtykke fra de registrerte til behandlingen av personopplysninger. Vår vurdering er at prosjektet legger opp til

et samtykke i samsvar med kravene i art. 4 og 7, ved at det er en frivillig, spesifikk, informert og utvetydig bekreftelse som kan dokumenteres, og som den registrerte kan trekke tilbake.

Lovlig grunnlag for behandlingen vil dermed være den registrertes samtykke, jf. personvernforordningen art. 6 nr. 1 bokstav a.

PERSONVERNPRINSIPPER
Personverntjenester vurderer at den planlagte behandlingen av personopplysninger vil følge prinsippene i personvernforordningen om:
- lovlighet, rettferdighet og åpenhet (art. 5.1 a), ved at de registrerte får tilfredsstillende informasjon om og samtykker til behandlingen
- formålsbegrensning (art. 5.1 b), ved at personopplysninger samles inn for spesifikke, uttrykkelig angitte og berettigede formål, og ikke behandles til nye, uforenlige formål
- dataminimering (art. 5.1 c), ved at det kun behandles opplysninger som er adekvate, relevante og nødvendige for formålet med prosjektet
- lagringsbegrensning (art. 5.1 e), ved at personopplysningene ikke lagres lengre enn nødvendig for å oppfylle formålet

DE REGISTRERTES RETTIGHETER
Så lenge de registrerte kan identifiseres i datamaterialet vil de ha følgende rettigheter: innsyn (art. 15), retting (art. 16), sletting (art. 17), begrensning (art. 18), og dataportabilitet (art. 20).
Personverntjenester vurderer at informasjonen om behandlingen som de registrerte vil motta oppfyller lovens krav til form og innhold, jf. art. 12.1 og art. 13.

Vi minner om at hvis en registrert tar kontakt om sine rettigheter, har behandlingsansvarlig institusjon plikt til å svare innen en måned.

FØLG DIN INSTITUSJONS RETNINGSLINJER
Personverntjenester legger til grunn at behandlingen oppfyller kravene i personvernforordningen om riktighet (art. 5.1 d), integritet og konfidensialitet (art. 5.1. f) og sikkerhet (art. 32).

Ved bruk av databehandler (spørreskjemaleverandør, skylagring eller videosamtale) må behandlingen oppfylle kravene til bruk av databehandler, jf. art 28 og 29. Bruk leverandører som din institusjon har avtale med.

For å forsikre dere om at kravene oppfylles, må dere følge interne retningslinjer og/eller rådføre dere med behandlingsansvarlig institusjon.

MELD VESENTLIGE ENDRINGER
Dersom det skjer vesentlige endringer i behandlingen av personopplysninger, kan det være nødvendig å melde dette til oss ved å oppdatere meldeskjemaet. Før du melder inn en endring, oppfordrer vi deg til å lese om hvilken type endringer det er nødvendig å melde: https://www.nsd.no/personverntjenester/fylle-ut-meldeskjema-for-personopplysninger/melde-endringer-i-meldeskjema
Du må vente på svar fra oss før endringen gjennomføres.

OPPFØLGING AV PROSJEKTET
Personverntjenester vil følge opp ved planlagt avslutning for å avklare om behandlingen av personopplysningene er avsluttet.
Lykke til med prosjektet!