CHALMERS
UNIVERSITY OF TECHNOLOGY

Implementation of Digital Tools in Construction

Digital Maturity and Transformation

Master's thesis in the master's program
Design and Construction Project Management

LINNEA ARRHENIUS
MARTIN LINELL

DEPARTMENT OF ARCHITECTURE AND CIVIL ENGINEERING
CHALMERS UNIVERSITY OF TECHNOLOGY

Gothenburg, Sweden 2022 www.chalmers.se

Master's Thesis ACEX30

Implementation of Digital Tools in Construction
Digital Transformation and Maturity

LINNEA ARRHENIUS
MARTIN LINELL

Department of Architecture and Civil Engineering
Division of Construction Management
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2022

Implementing Digital Tools in Construction

Digital Transformation and Maturity

Master's Thesis in Design and Construction Project Management

LINNEA ARRHENIUS
MARTIN LINELL

Supervisor & Examiner: Mikael Johansson, Department of Construction Management

Department of Architecture and Civil Engineering
Division of Construction Management
Chalmers University of Technology
SE-412 96 Gothenburg
Sweden
Telephone: + 46 (0)31-772 1000

Implementing Digital Tools in Construction
Digital Transformation and Maturity
LINNEA ARRHENIUS, MARTIN LINELL
Department of Architecture and Civil Engineering
Division of Construction Management
Chalmers University of Technology

Abstract

Digitization in the construction industry has a predominant focus on the implementation of digital tools in the early stages. In order to increase the digital maturity over the entire life cycle of the building project, more focus and resources are therefore needed for the implementation of digital tools during the production phase. Dalux is a digital tool for this, and Dalux field is the software that has been adapted for the production phase.

The purpose of this thesis is how a digital tool can be implemented for the production phase in construction and to identify which prerequisites that are needed for the implementation. For the implementation, a digital transformation is executed in order to adapt the tool to the construction site, and both soft and hard parameters must be considered. The study's outcome will provide a better grasp of how a digital tool should be implemented for the production phase of a construction project. For academical contribution there are additional suggestions for how a wider perspective should be considered and that there are more research views than simply how it should be applied directly on-site.

A literature review served as the thesis's basis in order to obtain a deeper understanding of the subject and to develop a theoretical framework that encompassed the thesis's scope. The empirical chapter of the thesis accompanied the literature study with a qualitative abductive method in the construction industry, with semi-structured interviews providing as the thesis' backbone.

Initially, the thesis tried to identify the prerequisites for the implementation of a digital tool for the construction site. However, during the process, the digital transformation was even more crucial. And as a result, the most important prerequisites in the implementation of a digital tool were the transformation, which naturally lead to the understanding of the prerequisites for the digital implementation of the tool.

Several prerequisites were found to be necessary for the implementation of a digital tool for the production phase in this thesis. These were divided into three phases, aligned with the digital transformation, where the first was before the implementation, the second during the implementation and the third was after the implementation. Acceptance of the implementation, clear communication, a vision and goal, extensive analysis, and specialists were the first prerequisites before the implementation. Suitable technology, the will of individuals, generalists and specialists, proper training and support, and time committed to mastering the digital tool were all required during the actual implementation. Persistence, a clear consequence of simplification, additional decision-making, development, and knowledge transfer to the next project are all necessary after an implementation.

The conclusion shows that only a common digital maturity can be achieved if the digital transformation is followed step by step. Even during the implementation of a digital tool, the perspective of the users should also be prioritized as it is those who will use the tool in their daily work. Employees must be involved in the digital transformation; otherwise, resistance may occur, and digital maturity will be difficult to achieve just by implementing new technology without fostering a digital open culture in the company.

Key words: Digital Transformation, Digital maturity, Digital tool, Construction, Production Phase

Implementering av Digitala Verktyg i Byggbranschen
Digital Transformation och Mognad
LINNEA ARRHENIUS, MARTIN LINELL
Institution för Arkitektur och Samhällsbyggnadsteknik
Avdelning för Construction Management
Chalmers Tekniska Högskola

Sammanfattning

Digitaliseringen inom byggbranschen har ett övervägande fokus på implementering av digitala verktyg i tidiga skeden. För att öka den digitala mognaden över hela byggprojektets livscykel behövs därför mer fokus och resurser för implementering av digitala verktyg under produktionsfasen. Dalux är ett digitalt verktyg för detta och Dalux Field är mjukvaran som har anpassats för produktionsfasen.

Syftet med detta examensarbete är hur ett digitalt verktyg kan implementeras för produktionsfasen i ett byggprojekt och att identifiera vilka förutsättningar som behövs för implementeringen. För implementeringen genomförs en digital transformation för att anpassa verktyget till byggarbetsplatsen och både mjuka och hårda parametrar måste övervägas. Studiens resultat ska ge en bättre förståelse för hur ett digitalt verktyg ska implementeras för produktionsfasen av ett byggprojekt. Som ett akademiskt bidrag finns ytterligare förslag på hur ett bredare perspektiv bör tas i hänsyn och att det finns fler forskningssynpunkter än bara hur det ska tillämpas direkt på byggarbetsplatsen.

En litteraturgenomgång låg till grund för avhandlingen för att få en djupare förståelse av ämnet och för att utveckla ett teoretiskt ramverk som omfattade avhandlingens omfattning. Det empiriska kapitlet i avhandlingen kompletterade litteraturstudien med en kvalitativ abduktiv metod i byggbranschen, med semistrukturerade intervjuer som avhandlingens ryggrad.

Inledningsvis försökte examensarbetet identifiera förutsättningarna för implementering av ett digitalt verktyg för byggarbetsplatsen. Men under processen var den digitala transformationen ännu mer avgörande. Och som ett resultat av detta var den viktigaste förutsättningarna för implementeringen av ett digitalt verktyg, transformationen, vilket leder till förståelsen av förutsättningarna för den digitala implementeringen av verktyget.

Flera förutsättningar visade sig vara nödvändiga för implementeringen av ett digitalt verktyg för produktionsfasen i detta examensarbete. Dessa var uppdelade i tre faser, i linje med den digitala transformationen, där de första var före implementeringen, de andra under implementeringen och de tredje var efter implementeringen. Acceptans för implementeringen, tydlig kommunikation, en vision och mål, omfattande analys och specialister var de första förutsättningarna innan implementeringen. Lämplig teknik, vilja från individer, generalister och specialister, korrekt utbildning och stöd samt tid för att bemästra det digitala verktyget krävdes under själva implementeringen. Uthållighet, en tydlig konsekvens av förenkling, ytterligare beslutsfattande, utveckling och kunskapsöverföring till nästa projekt är alla nödvändiga efter en implementering.

Slutsatsen visar att endast en gemensam digital mognad kan uppnås om den digitala transformationen följs steg för steg. Även vid implementering av ett digitalt verktyg bör även användarnas perspektiv prioriteras då det är de som ska använda verktyget i sitt dagliga arbete. Medarbetarna måste involveras i den digitala transformationen, annars kan motstånd uppstå och digital mognad blir svår att uppnå bara genom att implementera ny teknik utan att främja en digital öppen kultur i företaget.

Nyckelord: Digital Transformation, Digital mognad, Digitalt verktyg, Konstruktion, Produktionsfas

Acknowledgement

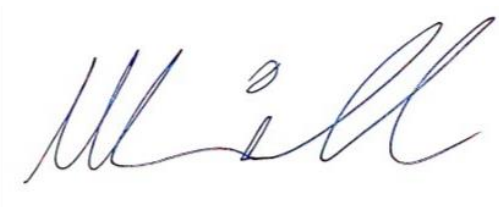
We would like to thank our supervisor at Chalmers University of Technology, Mikael Johansson that provided invaluable support, guidance, and overall knowledge in this field, which enabled us to accomplish our thesis. We would also want to express our gratitude to our supervisor Carl Olofsson at JM, for his knowledge, guidance and support within the company.

Special thanks to JM, the case company, for their assistance with support, interviews, and conversations needed to accomplish and complete our thesis. Others whom we like to thank are the interviewees from the other two companies taking the time to contribute with valuable opinions and expertise in the field.

We would also like to take this opportunity to thank Chalmers University of Technology, which has given us the opportunity to develop as individuals and engineers. We are convinced that the knowledge we have accumulated over the years at Chalmers will be very useful in our coming years in working life.

Finally, we would want to express our gratitude for each other's encouragement and motivation throughout the master's thesis.

Gothenburg, Sweden 2022



---------- ----------

Linnea Arrhenius Martin Linell

Table of Content

List of Figures

List of Tables

List of Abbreviations

2D – Two dimensional
3D – Three dimensional
AEC industry – Architecture, Engineering & Construction Industry
AR – Augmented Reality
BIM – Building Information Modeling/Management
HVAC – Heat, Ventilation & Air Conditioning
IFC-File – Industry Foundation Classes
IT – Information Technology
KM – Knowledge Management
VR – Virtual Reality
Total BIM – An approach where the BIM is the legally binding construction document and no traditional 2D drawings are used on the construction site

1. Introduction

Construction was one of humanity's first occupations, and it continues to affect people's daily lives to this present day. Generally, many other sectors, businesses, and people rely on the construction industry to build, deliver, and maintain houses, factories, infrastructures, and other facilities. As a result, the construction industry has a large impact on how people live and work, as well as a significant economic and environmental impact, affecting the entire society (Agenda, 2016). Many other sectors have seen significant changes in recent decades, resulting in simplified processes and product innovation, according to Agenda (2016), whereas the construction industry has not grown to the same degree with the adoption of new technological opportunities. In line with this, Hautala, Järvenpää and Pulkkinen (2017) claimed that the construction industry is falling behind in terms of digital technology adoption. Thus, many construction organizations, according to Koseoglu and Nurtan-Gunes (2018), rely on more traditional ways of working and do not take advantage of what technology advancements may provide.

According to Bråthen and Moum (2016), building deliverables are unique and complex since they are developed by temporary project organizations made up of a variety of actors and businesses. As a result, complex environments define the construction sector, according to Sundquist, Leto, Gustafsson, Johansson and Roupé (2020), who also drew parallels with temporary integrative project organizations that generate complex products. Accordingly, Hautala et al. (2017) anticipate that future initiatives will bring together participants from many organizations on a common shared platform. Digital technologies, which contribute to a more integrated and innovative industry, serve as the foundation for this. Agenda (2016) thinks that modern technologies provide several opportunities and that organizations must be at the forefront of digitally transforming the construction industry. Building Information Modeling (BIM) plays a key role, in enabling a wide range of technologies in the construction industry (Agenda, 2016). However, Sadeh, Mirachi and Pavan (2022) and Liu, Xie, Tivendal and Liu (2015) mentioned that the implementation of BIM is falling behind its potential and that BIM is not universally standardized yet.

Koseoglu and Nurtan-Gunes (2018) stresses the fact that the BIM implementation and its potential cannot be fully exploited, since the present implementation is predominantly focused on effective utilization for the design phase, even though BIM has the potential to increase the production efficiency, quality and benefits as cost and time savings will be obtained (Koseoglu & Nurtan-Gunes, 2018; Bråthen & Moum, 2016). Additionally, Disney, Johansson, Leto, Roupé, Sundquist and Gustafsson (2021) pointed out that, while the construction industry strives to utilize BIM to increase efficiency and quality, adoption in the actual production phase is restricted. Hautala et al. (2017), on the other hand, proposed therefore that it is advantageous to accelerate digitalization in the construction and production phases, which could be beneficial for the whole construction industry since a wider adoption of digitalization over several construction phases will be achieved.

Several aspects are essential for successful technology implementation. Individuals' attitudes toward the adoption of new technologies are influenced by the ambiguity of their usage and the perception of the outcome of their use, according to Liu et al. (2015). Hautala et al. (2017) believe that it is critical to developing a user-friendly interface in order to attract individuals and optimize the interface for them. Furthermore, Agenda (2016) stated that individuals must drive and support all changes and as a result, the construction sector must focus on attracting, developing, and retaining individuals in order to build an appealing organizational culture that encourages development and innovation.

1.1 Background

The case company of this thesis is JM, which is a Scandinavian company active in the development of residential and housing areas. JM is also unique in owning the entire value chain from land and property acquisition to the maintenance of the property. JM has recently announced internally that each new construction project will work digitally with the tool Dalux Field in 2022. At this present, Dalux is used in many of JM's projects but to varying degrees, some projects only use the free version while some projects have the paid version. Last year (2021), a questionnaire was sent out, by JM, to all people who were supposed to work in Dalux, both in Sweden and Norway. And based on this survey, the majority were understanding and positive about BIM. However, the results from the survey showed that the knowledge to work digitally was not sufficient. It also showed that prerequisites are needed and whether the person felt comfortable working on a model basis was not sufficient either. Thereto, it is obvious that the need for increased support and clearer instructions regarding a BIM approach is wanted.

1.2 Purpose & Aim

The purpose of this thesis is to both facilitate the implementation of Dalux Field more efficiently in the production phase for the case company and to come up with proposals to help them with that. The second focus is to help the construction industry more generally with how the implementation of a digital tool can be implemented for the production phase in a construction project. Therefore, the aim for this master thesis is to investigate the gap between the understanding and the attitudes towards a digital work approach with which the required prerequisites are needed to lead the digital transformation towards an enhanced digital maturity on the construction site. Initially, an investigation of the current utilization of digital technologies on the construction site within the case company will be identified and then compared to the provided vision, from the top management, regarding a model-based work approach at the case company. Additionally, the aim is to examine the softer parameter in general to see the differences between the vision and the actual use of Dalux Field on the construction site.

If the purpose and aim of this master thesis will be achieved, a contribution to both the construction industry and the academia will be made. Contribution to the construction industry will be proposal for prerequisites needed for implementing a new digital tool, while the contribution to the academia will be wider fields of investigation when implementing a new digital tool for the production phase. Here, the investigation fields for the implementation of digital tool will be a spectrum from the requirement of a clear vision and purpose to the right hardware and software used on the construction site by the construction workers.

1.3 Research Questions

To be able to reach the purpose and aim of this thesis, the following research question will be answered:

- What prerequisites is needed for the implementation of a digital tool in construction?
- How can digital transformation contribute to digital maturity?

The desired possible outcome from answering the abovementioned questions will help both the company as well the construction industry to facilitate the implementation of Dalux Field and digital tools in the production phase as well as the user's utilization and prerequisite towards a more digitally mature construction site. It will also contribute to the journey towards a higher level of digital maturity for the individual when using new digital tools and to a wider digital maturity generally for the construction industry since a deeper understanding of the importance of digital tools in the production phase will be developed.

1.4 Delimitations

The study was conducted in a partnership with the case company JM, with the goal of determining a more comprehensive and straightforward implementation of the digital tool Dalux for them. Other companies that use Dalux will be studied for comparison and thereto other perspectives on how Dalux can possibly be implemented will be discussed. Additionally, no other digital tool than Dalux will be investigated. This thesis will be delimited to Dalux Field, which is the Dalux tool that is suitable for the production phase, therefore the other tools from Dalux (I.e., Dalux Box, Dalux Viewer & Dalux FM) or other similar digital tools (e.g., StreamBIM etc.) will not be focused on. The thesis will also be delimited to the Scandinavian construction industry since JM is operative in this market, however, it could be thought to be somewhat more leaned towards the Swedish construction industry, especially in the western region. Moreover, the relevant segment in the construction industry for this thesis will focus on the production phase of housing and not the whole construction process even if it sometimes mentioned.

Further delimitations are that the collected information and data for this report will be limited to the literary framework and the conducted interviews, from which analyzes, and conclusions have been made. The idea with the information and the data gathering was to try to respond to the master thesis' purpose and aim, thus has this been collected during the spring of 2022 and may therefore differ from previous periods and regions.
The mentioned prerequisites for implementing a new digital tool for the construction site mean the relevant prerequisites for the construction workers for actually starting to use the digital tools on site e.g., time, education a clear vision, the right hardware and software. Although the prerequisites for the implementation are also relevant for other phases in the construction process, these stages will not be analyzed or explained.

1.5 Structure of the Report

The structure of this master thesis is as followed:

Chapter 1: Introduction	This chapter contains the introduction for this master thesis where the Background, Purpose & Aim, Research Question, and Delimitation will be presented.
Chapter 2: Theoretical Framework	This chapter contains the master thesis' literature framework were a description of BIM, Digital Transformation, Change Management, Production Readiness, and Knowledge Management will be explained.
Chapter 3: Method	This chapter contains the selected methodology for the performance of this master thesis.
Chapter 4: Empirical	This chapter contains the empirical material of this master thesis where the data gathering and information from the conducted interviews will be presented.
Chapter 5: Discussion & Analyzes	This chapter contains the analysis & discussion of this master thesis were a comparison between the literature chapter and the empirical chapter will be made. Here, similarities and differences will be analyzed and discussed.
Chapter 6: Recommendations	This chapter contains recommendation for future prerequisite and approaches for the case company and the construction industry in general.
Chapter 7: Conclusion	This chapter contains the conclusion of this master thesis were the final thoughts and summaries will be presented.

2. Theoretical Framework

In order to be able to answer the research questions of this paper, a theoretical framework must be created. For the upcoming chapter, relevant literature will be presented and aspects such as *BIM*, *Digital Transformation*, *ADKAR Change Model*, *Application of BIM hardware on the construction site* and *Knowledge Management* will be described. The framework will compare and contrast similarities and differences before evaluating them. Furthermore, this theoretical framework is provided in order to serve as a foundation for answering the research questions and achieving the thesis's purpose and goal.

2.1 BIM

BIM is an acronym for Building Information Modeling or Building Information Management and refers to the collaborative process of all engaged actors in the design and lifetime management of building components (Lorek, 2019). Furthermore, all the data gathered from concept to completion is not only saved but also used (Lorek, 2019). Liu, Lu, Nath, Wang, Tiong and Peh (2021) make a similar assertion, stating that the use of BIM extends throughout the lifespan of a project, embracing areas such as development, design, construction, and building operations. To that end, Liu et al. (2021) state that BIM has been acknowledged, by both the educational and industrial sectors separately, as a technologically advanced approach that facilitates efficiency and quality improvements. Indifferent to the preceding BIM explanation, BIM is described in resembling tones by Mahamadu, Manu, Mahdjoubi, Booth, Aigbavboa and Abanda (2019) and Gu and London (2010). BIM, according to Mahamadu et al. (2019), is the epitome of rules, procedures, and technologies that will enable the construction industry to create, manage and store project data in digital formats for long-term management. According to Gu and London (2010), BIM is an IT-enabled process that entails implementing and maintaining an integrated digital representation of all building information throughout the project's lifespan.

Furthermore, there are several definitions of BIM. According to Mahamadu et al. (2019), some people think of BIM as a software application, while others think of it as a 3D virtual model of a structure. BIM, on the other hand, is defined in Mahamadu et al. (2019) as "a coordinated set of processes, supported by technology, that add value by creating, managing and sharing the properties of an asset." Another definition by ISO 16757-1:2015 defines BIM as "*construction of a model that contains the information about a building from all phases of the building life cycle*" (ISO, 2015, in Sadeh et al., 2022). Succar (2009) defines BIM as a "set of interacting policies, processes and technologies generating a methodology to manage the essential building design and project data in a digital format throughout the building's lifecycle".

With the use of BIM throughout the lifecycle of a building project, Sundquist et al. (2020) also claimed that BIM can be used from the design phase to facility management. BIM is used throughout the tendering process, including design, planning, construction, and use and maintenance. The client, contractors, subcontractors, consultants, suppliers, and facility managers are all involved in this process according to Sundquist et al. (2020). All these actors apply BIM in accordance with their professions, which has resulted in various BIM levels and information sharing among the project participants mentioned by Sadeh et al. (2022). For this state, all project stakeholders are given a digital representation of the building's characterizations to help with this (Agenda, 2016). According to Liu et al. (2015), BIM is more than just a collection of 2D and 3D methodologies, it is a system for bringing the essential people and information together. As a result, providing stakeholders with defined processes, technology, and information. BIM is thus seen as a creative and collaborative way of working, as well as a digital workflow process for more efficient design, construction, and maintenance of the built environment (Mahamadu et al., 2019).

A BIM methodology, as characterized by Lorek (2019), is a highly collaborative approach that allows all project stakeholders and other construction industry professionals to plan, design, and construct a structure using a single 3D model. BIM can then extend to the operation and facilities management of a building utilizing data that the owner has access to. This information allows a property manager or someone in a comparable position to make informed decisions based on data from the BIM model. This information could be utilized to increase knowledge transfer among stakeholders, reduce modification orders, and provide insight into the existing structure for renovation purposes, among other things according to Lorek (2019). On the construction site, BIM can also be implemented. In a study, Bråthen and Moum (2016) stated that BIM systems on-site allow construction staff to use tablet devices to access diverse information. BIM is utilized to develop drawings, address specific tasks to different disciplines, and utilize the information that construction workers actually need (Bråthen & Moum, 2016).

Adopting a modeling work method means that in all phases, the actors utilize digital information from the model in their work, and all information is included in these models (Hautala et al., 2017). Even the initial data in a project is collected and stored in the initial information model which includes relevant and correct information regarding the project mentioned by Hautala et al. (2017). Succar (2009) classifies dimensions and information in BIM based on process, technology, people, policy, and laws. The activities connected to sharing or exchanging information are included in the process dimension. The technical dimension refers to the various hardware and software required to support the process, whereas the people dimension refers to the professionals involved in the delivery of BIM-compatible projects as well as people's attitude toward BIM adoption. The policy and legal dimensions are concerned with the statutory rules required to promote BIM adoption, as well as the laws that govern the consequences of sharing building information or working jointly (Succar, 2009).

There are many benefits to BIM, as stated by Zielinski and Wojtowicz (2019), BIM technology allows project participants to benefit from the data generated in the designed building models. Furthermore, according to Liu et al. (2015), BIM technology delivers a diversity of direct and indirect benefits and has streamlined and transparentized the entire design and building process in many ways. Additionally, an integrated design, greater quality at a lesser cost, and a shorter time frame are all achievable (Liu et al., 2021). The use of BIM allows the project team to virtually plan construction projects, which can improve knowledge and understanding of the project's requirements ahead to its actual construction, allowing for a more thorough examination of the project according to Liu et al. (2021).

2.1.1 BIM Maturity

According to Disney et al. (2021), the BIM environment is not mature enough in the Scandinavian construction industry, especially for total BIM. As a consequence, a variety of maturity models have been developed to analyze and evaluate the extent of BIM deployment inside organizations. The level of BIM maturity may be assessed using these maturity models by evaluating the simultaneous application and social aspects from a socio-technical perspective (Disney et al., 2021). Furthermore, Böes, Barros-Neto and Lima (2021) means that the concept of BIM maturity is used to define a set of process improvements that enables the accomplishment of certain outcomes, resulting in a better understanding of BIM's use and its potential for development and variety. Böes et al. (2021) assert that BIM capacity is defined as the capacity to provide deliverables and services, while BIM maturity is defined as the extent, depth, quality, predictability, and replicability of this ability while completing a task or providing a BIM service. Thus, BIM maturity refers to how far a company has progressed in using BIM (Böes et al., 2021). The BIM model is a choice, according to Zielinski and Wojtowicz (2019), that depends on the decisions of the project participants, which selects a certain level of detailed information in the project documentation. Hence, the level of maturity is the reflection of the documentation (Zielinski & Wojtowicz, 2019).

Many construction organizations, mentioned by Agenda (2016), have a conservative company culture and philosophy and are generally inhibited by organizational dullness. As a result, businesses must pursue organizational change that is carefully aligned with the company's culture and purpose. Liu et al. (2021) make a similar claim, stating that BIM provides increased process alternatives and that the organization's desire to adapt is a critical component. As a result, it's critical that the company offers training to help its employees grow their skills. Liu et al. (2015) claim that organizations must educate and train their employees to build and integrate BIM technology into their operations, either by employing new employees or educating and training existing employees. Organizations may prepare to meet the rising demand for BIM processes and methodologies by adding newly graduated with BIM in their curriculum, according to Liu et al. (2015) and Böes et al. (2021). Furthermore, in accordance with Böes et al. (2021), BIM teaching approaches should be planned and prioritized to progress through the stages of BIM maturity.

2.1.1.1 BIM Fields and BIM Maturity Stages

As aforementioned a few dimensions were mentioned by Succar (2009), which are included in Succar's (2009) BIM Maturity Matrix. For a higher level of maturity, an organization must be supported by three BIM fields. Each field has its own sets of stakeholders, requirements, and outputs. The first is the technology field, which is associated with the relation of software, hardware, equipment, and networking systems that are required to enable or support the design, construction, and operation stages of the construction industry. These services and support that contribute to efficiency, profitability, and productivity are provided by actors belonging to organizations with direct or indirect application to the different phases' development.

The process field, which is the interaction of actors who design, construct, produce, utilize, and manage buildings, is the second dimension. The owner of the building, engineers, contractors, consultants, facilities managers, and other roles engaged in the ownership, delivery, and operations of the structure are practitioners in this dimension.

The policy dimension is the third field. The goal is to bring together actors in the AEC industry who work to educate professionals, conduct research, distribute benefits, allocate risk, and reduce conflict in order to benefit and avoid conflict amongst stakeholders. The government, educational institutions, and insurance companies are the actors in this third field. And while none of these actors generate any building goods, they all play an important part in the planning, regulatory, and contracting phases of the project (Succar, 2009). Additionally, Succar (2009) mentioned that the three fields sometimes overlap as they share actors and deliverables.

Moreover, since Succar (2009) established BIM fields, the same author has proceeded to explain various stages that characterize the implementation of various maturity levels. According to Succar (2009), these BIM maturity stages identify the initial stage before the BIM adoption and then explain three BIM maturity levels that allow for unpredictable future developments in BIM technology. Succar (2009) defines BIM maturity as a sequence of stages that stakeholders must apply systematically and gradually inside organizations, projects, and industries. BIM stage 1 "object-based modeling," BIM stage 2 "model-based collaboration," and BIM stage 3 "network-based integration" are the phases discussed (Succar, 2009).

Before the description of the BIM maturity stages, BIM Data Flows and Project Lifecycle Phases need to be mentioned for further illumination regarding the stages. BIM Data Flows and Project Lifecycle Phases are variables where the BIM maturity stages are defined, according to Succar (2009). BIM data flow, to explain it briefly, is a set of smart objects that represent physical elements in a model and carry object-specific information. Furthermore, BIM data flow encompasses not only the sending and receiving of substantial data in objects but also the sending and receiving of document-based data. Data in document-based information transfers between stakeholders and can be either file-based or data-based. Project lifecycle phases in a construction project pass through three major lifecycle phases, (see figure 1), which are the design phase, the construction phase and lastly the operation phase (Succar, 2009).

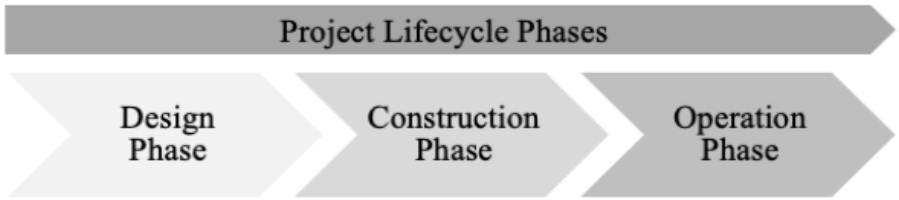


Figure 1: Project lifecycle phases

BIM Stage 1 mentioned by Succar (2009) is the deployment of an "object-based 3D parametric software tool," such as Revit, which initiates the BIM implementation. Users create single-disciplinary models in one of the Project Lifecycle Phases, such as design, construction, or operation, at stage one. The architectural design model is delivered initially, followed by the HVAC model, which is primarily utilized to automate the development and coordination of 2D documentation and 3D visualization. Basic data exports and easier 3D models with no adjustable parametric characteristics are among the other outputs. Because there are no significant interactions between disciplines in the BIM model, collaborative activities among stakeholders are not prioritized. However, data is only exchanged in one direction between project stakeholders, and communication is inconsistent and unsynchronized. Furthermore, when only small processes are changed, organizational behavior, contractual relationships, and risk distribution remain unchanged. Actors may recognize the possible benefits of engaging additional design and construction actors with similar modeling capabilities after maturity is established during stage 1 implementation, according to Succar (2009). As a result of these acknowledgments, actors and organizations will be able to progress to BIM stage 2 (Succar, 2009).

Succar (2009) goes on to explain BIM stage 2. Collaboration takes place in a variety of technological ways, depending on the actors' choice of BIM software tool and file formats. Thereto, actors participate actively with actors from different disciplines. Additionally, one or more project lifecycle stages may occur during BIM stage 2 (design, construction, and operation), and it is important that in order for different disciplines to collaborate digitally, only one collaboration model is required that contains the 3D geometric data. Some contract adjustments are required as interaction grows and begins to replace document-based processes. As the level of information in each life cycle phase grows with the degree of maturity in step 2, the modeling in each life cycle phase changes as well.
In BIM Stage 3, described by Succar (2009), comprehensive integrated models are produced, shared, and maintained collaboratively across the project lifecycle phases at this stage. The models evolve into multidisciplinary nD (2D, 3D, 4D, 5D,... nD....) models in this third maturity stage, allowing for complicated analysis throughout the early stages of virtual design and production. Furthermore, not only is object-specific information provided, but it also includes additional significant qualities. In terms of process, the coordinated interaction of model and document-based data causes project lifecycle phases to overlap significantly, resulting in a phase-less process. During stage 3, the networked-based interaction creates a concurred environment in which numerous project activities are integrated and all project lifecycle phases are planned concurrently by the project actors to optimize the project's performance. According to Succar (2009), the maturity development of technologies allows for a larger interaction among project participants. Therefore, the need to reassess the contractual connection between the actors will then arise because of the creation of a concurred environment and a higher degree of collaboration amongst the involved actors.

2.1.2 BIM Levels

In various research by Gu and London (2010), Lorek (2019), and Zielinski and Wojtowicz (2019) different BIM Levels are mentioned and described. These BIM levels correlate to BIM Maturity Stages that are mentioned by Succar (2009). Initially, it is stated by Disney et al. (2021) that moving up to another BIM Level is challenging for the involved actors. And furthermore, to ease the transformation, it is also common to mix 2D documents with the BIM model (Disney et al., 2021).

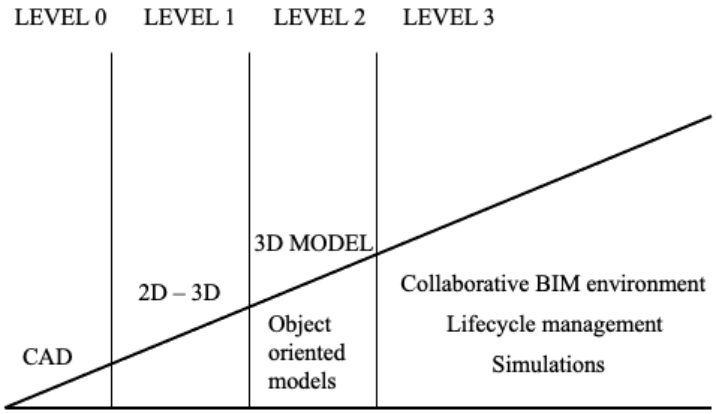


Figure 2: BIM Levels inspired by Zielinski and Wojtowicz, (2019).

Level 0: is the first stage of the "BIM ladder", during which players design, document, and create visualizations without embracing object-oriented modeling or data integration. Collaboration between project stakeholders is not taking place, and the probability of risk in a project is much higher. Furthermore, if an organization is at level 0, it is likely that it has received insufficient BIM training (Gu and London, 2010; Lorek, 2019; Zielinski and Wojtowicz, 2019).

Level 1: only utilizes a small proportion of the BIM technology's capabilities. It is mostly used to communicate with clients during the early conceptual stages, as well as for early construction evaluations. In level 1, 3D models are utilized for conceptual work and detailed 2D is used to generate product information and other documentation. Each discipline manages its own data, and the model is still in its early stages of development, therefore cross-disciplinary features are missing, resulting in a lack of collaboration between disciplines (Gu and London, 2010; Lorek, 2019; Zielinski and Wojtowicz, 2019).

Level 2: introduces a collaborative environment that allows two or more disciplines to collaborate on object-oriented models. Structural elements, installations, and other interior components are introduced at this level, allowing for improved 3D coordination and the development of 2D documentation from a 3D model. Even if the project team members do not use the same 3D model, information sharing between project team members occurs since information about the design of the built environment is exchanged through a common IFC-file. Furthermore, a more developed model contributes to a better understanding of multidisciplinary collaborations in the project (Gu and London, 2010; Lorek, 2019; Zielinski and Wojtowicz, 2019).

Level 3: contains a more collaborative environment, which implies that instead of working on their own model, project members collaborate in a single, shared project model. As a result, numerous multidisciplinary BIM models can be combined into a single model. This model is maintained in a central location and is accessible and modifiable by anyone. The level 3 detailed model also allows for more diverse simulations of the construction process. It also enables the creation of a facility management system (Gu and London, 2010; Lorek, 2019; Zielinski and Wojtowicz, 2019).

Lorek (2019) also addresses BIM level 4, 5, and 6, which refers to the addition of time, cost, and sustainability data to the BIM model.

BIM level 4 incorporates the time dimension into the model, which includes data on scheduling, time sequencing of various activities, and time allocation across stages.

BIM Level 5 includes the integration of cost estimation and budgeting in the BIM model. Users can determine and track the costs that will occur throughout the project at this level.

BIM level 6 information regards to the assessment of a building's energy consumption during earlier project phases, i.e., prior to the building's production (Lorek, 2019).

2.1.3 BIM at the Construction Site

Digitalization in the construction industry is typically synonymous with BIM implementation, according to Sundquist et al. (2020). Additionally, according to Liu et al. (2015), BIM brings major benefits to the AEC organizations that enables project actors to collaborate better through the project as well as improving the information sharing among them. Nonetheless, by adapting to a BIM methodology, like any new implementation, needs costs associated with education, administration, licensing, and the transition (Liu et al., 2015). It is also emphasized by Sundquist et al. (2020) that there are digitalization activities, on the construction site, that may be utilized in various BIM-tools, such as Dalux, but that do not necessitate the usage of BIM because these activities can be used in connection with 2D drawings. Furthermore, Sundquist et al. (2020) claim that by combining traditional 2D drawings with BIM in a project, a shift to a fully BIM approach can be initiated. However, by not providing the opportunity to the workers to use traditional drawings, Disney et al. (2021) claim that the construction site workers do not have the possibility to use any other drawings than from the BIM model, which may help the transition.

Furthermore, in a case study by Koseoglu and Nurtan-Gunes, (2018), a BIM model were used on an iPad together with BIM coordinated compatible 2D drawings. Thereto, the construction workers were able to conduct various activities on the construction site by using the mobile BIM application, which contributed to increased productivity, efficiency and quality with their work (Koseoglu & Nurtan-Gunes, 2018). In contrast to the traditional communication methods, Kim, Park, Lim and Kim (2013) stated that a mobile BIM application allows construction stakeholders to exchange project information regardless of time or location. Online task direction is an activity in the mobile BIM application that allows construction workers to allocate specific work assignments to other actors, according to Kim et al. (2013). Another way to describe how the BIM application can be used is that several users can be inside and work in the digital model at the same time, but from different separate mobile devices in real-time. Other utilization areas on the construction site using a mobile BIM application mentioned by Kim et al. (2013) is general construction management, safety management, defect management, and project-specific features developed in accordance with the project (Kim et al., 2013). Furthermore, according to Bråthen and Moum (2016), the BIM model's ability to visualize complex situations and display the entire building is beneficial, since it provides a clearer overall picture of the building with more details in various views. In comparison with a 2D drawing, the visualization in the BIM model in the mobile application also highlights the different tasks of the different disciplines, since it can show specific areas of responsibility for the different actors.

Bråthen and Moum (2016) also mentioned one of the benefits of mobile BIM technology is that it allows construction employees to take the BIM model with them to the certain unique work context. Koseoglu and Nurtan-Gunes (2018) makes a similar argument, claiming that the process of going to the office to look for the newest version of a document is avoided thanks to the mobile BIM application. Aside from the convenience of not having to go to the office, new design changes or new information are delivered to the site in a reasonable timeframe. As a result, new information or design may be applied correctly without delay, resulting in fewer problems on-site. As a result, according to Koseoglu and Nurtan-Gunes (2018), project quality improves, unnecessary rework is eliminated, and cost and time savings are obtained, all as a result of improved information workflow technology.

Both Disney et al. (2021) and Koseoglu and Nurtan-Gunes (2018) underlines the necessity for equipment and support at the construction site for this to be achievable. Wi-Fi is required to facilitate the internet connection. In addition, iPads, tablets, and mobile devices with the appropriate software are required to support the BIM model. Furthermore, according to Koseoglu and Nurtan-Gunes (2018), certain setups and restrictions may be effective in allowing construction workers to focus solely on work-related activities while using the essential hardware.

2.1.4 Dalux

Dalux is a Danish company that develops digital tools and BIM technology for the construction industry in order to make the construction industry smarter and more efficient. According to the Dalux website, the building sector is one of the most polluting in the world, and developing products that support improved construction processes, helps to decrease and limit emissions as well as wasted and lost time and resources (Dalux, 2021).

Dalux Viewer, Dalux BOX, Dalux Field, and Dalux FM are the products available for mobile devices and computers. The first one is free software that integrates the BIM model with collaboration and case management. From design to facility management, Dalux BIM Viewer combines 2D drawings and 3D models and can be utilized throughout the building process using Revit and IFC files. Dalux BOX is the second product, which was created for the design process. This product serves as a cloud-based document organizer and storage system for all the documents that the actor works with during the design phase. The third product is Dalux Field, which will be discussed further below. Dalux FM, a facility management system, is the fourth option. The building's operation and maintenance can be performed here, as well as storage of all the building's documents (Dalux BIM Viewer, n.d.: Dalux Box, n.d.: Dalux FM, n.d.).

According to Dalux Field (n.d.), construction projects become more complex as time goes on, requiring a higher level of collaboration and coordination. BIM has been shown to be a verification of this, and according to Dalux Field (n.d.), BIM is for everyone and should work hand in hand with the staff on the construction site. Dalux Fields is a software application created by Dalux that is developed for construction sites. The application's focus is on activities including workflow between on-site actors, checklists to control and collaborate, safety and work environment, and tracking all activity on-site directly from mobile devices (Dalux Field, n.d.). According to Dalux Field (n.d.), construction site risk is reduced while time is saved. The activities in the Dalux field are described in table 1 below.

Table 1: Dalux Fields and area of use (Dalux Field, n.d.)

Drawings and Models	Quality Control	Safety and Work Environment	Checklists	TwinBIM - AR
All models from the project disciplines are uploaded in the same BIM model, hence one model for all disciplines. Access from various devices and filter features.	In the mobile device, access to information, documents, the model and drawings are given and in real time.	Site inspections can be conducted in the mobile device in a correct and time efficient way.	Easy access to the checklist and have all the checklist in the mobile devices and document the work activities continuously.	With AR, mix the real and the digital world with the mobile devices. Merge, integrate and anchor the BIM-model with the physical surroundings.
Compatible with different file formats.	Work both in online and offline mode. If offline, download what is needed and then synchronize later when online.	Own unique templates can be created for various inspections.	Add pictures with the mobile devices and add it to the checklist.	TwinBIM is a quality checker to see what is built matches the BIM-model.
Model integration in the mobile device and easy interaction with the model, were measurement, cuts and visualization can be done.	Allocate and send information to other actors that includes pictures, description, location and timeframe.	Report observation immediately and create reports directly from the mobile device and send it to the correct source for it to be fixed.	Create checklists for an organization, or specific checklist for the project. Tailer the checklist by yourself.	Easier and cheaper to share what you see digitally from the mobile device compared to VR
Access to all the drawings in the mobile device.	Progress on the construction site can be followed directly from the mobile device, which gives a complete overview of the project.		Link BIM-objects to the checklist and navigates in the 3D model and adds pictures.	

2.2 Digital Transformation

Many organizations are currently undergoing digital transformations, and the faster the rate of change is externally in the industry, the faster the rate of change needs to be internally if the company wants to succeed with digital transformation (Heaton, Parlikad, Owens and Pawsey, 2019). Furthermore, BIM is a catalyst for digital transformation, although the successful digital transformation is more about people and transforming the organization to take advantage of new technology's opportunities than it is about the technology. Therefore, successful digital transformation requires more than just installing new technology; it also involves organizational changes to fully benefit from the digital transformation (Heaton et al., 2019; Jansson, Andervin & Klose, 2016). Matt, Hess and Benlian (2015) define digital transformation as a “strategy that is a blueprint to support companies in governing the transformation arise owing to the integration of digital technologies, as well as in their operations after a transformation”.

Since organizations can't stop digitalization, it is critical to recognize their strengths and weaknesses in the area (Jansson et al., 2016). Moreover, "*You can't stop the waves, but you can learn to surf*", said Jansson et al. (2016), implying that you can learn how to surf the right waves, although it is not enough to just catch a wave, the proper one must be chosen. There are also some mistakes to avoid for successful implementation and transformation (Jansson et al., 2016). If the organization does not have a consensus on digitization and digital transformation, it must acknowledge that it affects all parts of the organization, not only IT and communication projects (Jansson et al., 2016). Furthermore, a sense of urgency must be established since the deadliest opponent to change is complacency or self-satisfaction. Employees also need a clear vision to move in the same direction, and it is necessary

to communicate it repeatedly in various venues and contexts because individuals absorb information in different ways (Jansson et al., 2016). Moreover, a common miscalculation is to hire exclusively digital specialists rather than a mix of digital specialists and generalists. Specialists aren't as adept at seeing the broad picture as generalists are, e.g., the generalist often understands the implications of digitalization in the organization and where they might focus, as well as the relationship between technology and people.

2.2.1 The Digital Maturity Matrix

It is essential for a firm and an organization to understand how digital development affects the business (Jansson et al., 2016). Furthermore, a unified understanding of what digital transformation is and why it is important should be the starting point. Companies typically go through three phases in their digital journey, hence the digital maturity matrix established by Jansson et al. (2016) (see figure 3). It is essential to consider that the time required varies depending on the company, nonetheless, the most important aspect for the management is to obtain control without controlling with this matrix (Jansson et al., 2016).

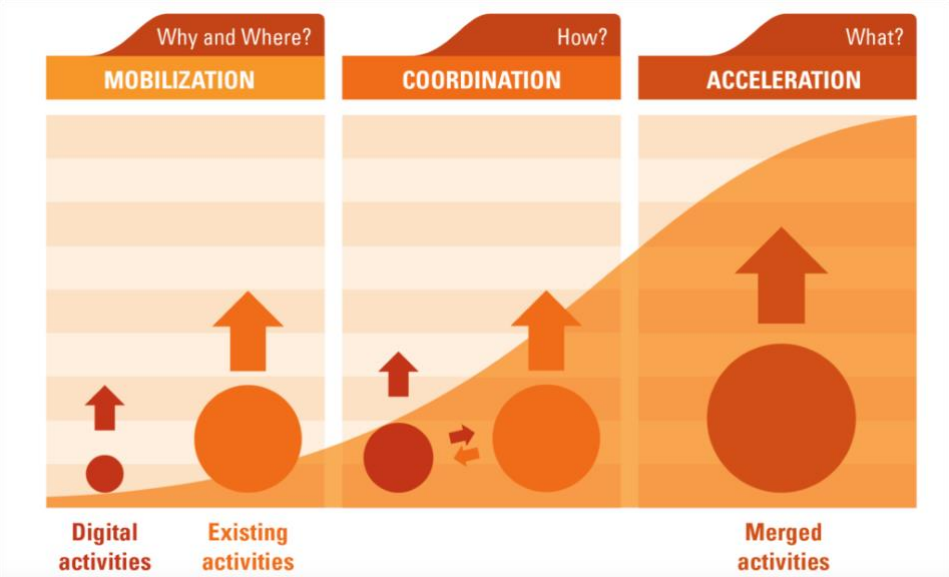


Figure 3: The Digital Maturity Matrix by Jansson et al. (2016), Illustrated by Cecilia Petterson at Pica Pica (Digital Maturity Matrix, n.d.)

The first step is the mobilization phase, which separate the digital and existing activities in the company (Jansson et al., 2016). Furthermore, the focus should be on mobilizing and developing interest and acceptance for the transformational necessity rather than on the specifics. The company should be able to communicate *why* it is important (Jansson et al., 2016). Although the purpose and focus of this phase are to create a *sense of urgency* throughout the company, it usually involves fewer people in the company driving the issue, who are sometimes limited or completely independent from the existing activities (Jansson et al., 2016).

The digital activities begin to develop in the next coordination phase, and the attention shifts to *how* the company should implement the digital technology (Jansson et al., 2016). Hence, more resources are allocated, and a specialized division is typically established to manage the new digital activities. Interaction between existing and digital activities begins, hence conflicts between these activities are common and must be resolved before the desired effect can be achieved (Jansson et al., 2016). Additionally, all the lessons learned during the mobilization phase are being applied, and long-term initiatives are being developed to urge people to change their complacent habits with a convincing goal and vision. This may be the most difficult phase in terms of maturity, hence competent leaders are required because the interaction between departments must be coordinated efficiently (Jansson et al., 2016).

Lastly, the acceleration phase occurs when existing and digital activities are no longer separated (Jansson et al., 2016). Furthermore, the strategy and vision pervade the entire company, giving the investment in the implementation a stronger foundation and allowing change to come more effortlessly. This usually means that the organization may detect digital changes outside of their own company and can adapt to them more easily. The company now has a better understanding of the comprehensiveness of digital transformation, as well as a higher level of digital maturity (Jansson et al., 2016).

Furthermore, Innovation, change management, and digital maturity are the three essential parts for successful transitions between the phases in the digital maturity matrix (Jansson et al., 2016). As a result of society's technological advancements, new solutions have been discovered that were previously unimaginable, therefore companies need to challenge themselves to embrace innovation. Rogers (2003) developed Diffusion of Innovation, one of the earliest social science theories, which describes how people in a social system adapt to new ideas, behaviors, or services. There are five recognized categories that differentiate people in terms of how they adapt to innovations (see table 2), and this knowledge is vital for businesses to help them with innovation or to not inhibit innovation so that the correct encouragement and prerequisites are in place for different adopters (Rogers, 2003).

Table 2: Diffusion of Innovation by Rogers (2003)

	Innovators	**Early Adopters**	**Early Majority**	**Late Majority**	**Laggards/ Skepticals**
Characteristics	Curiosity for new ideas, optimism for innovation, and willingness to consider risks.	Leadership responsibilities, seizes opportunities, and recognizes the need for change.	Usually not leaders, accept new ideas before the average person	Skeptical of change, the majority must try the innovation first.	Tradition-bound, conservative, and skeptical.
Prerequisites	Almost nothing or even anything must be done.	Persuasion isn't required, but how-to guides and implementation information sheets are enticing.	Success stories and evidence of the effectiveness of the innovation are required.	Success stories and data on how many others have implemented the innovation.	Statistics, fear appeals, and pressure from other adopter groups.

Furthermore, Ertan (2018) gathered information through a survey, including 61 responses from 21 different organizations in Sweden. The report investigated the company's digital readiness using Rogers' Diffusion of Innovation methodology. Three of the companies were classified as skeptics, with two of them being construction firms. According to Ertan (2018), this could be related to the fact that the construction industry has relatively high entry barriers and limited rivalry, which are the primary sources of innovation. Furthermore, Barlow (2019) believes there is a lack of competition, but then also believes that there is a lack of success stories, a well-defined plan, and a fundamental fear of change, all of which are contributing factors to the high rate of skeptics in the construction industry.

The second of the three essential parts for successful transitions between the phases in the digital maturity matrix is change management. Furthermore, a built-in structure, behavior, and a long-shaped culture can easily become an obstacle to transformation, hence change management is required to get employees to take the necessary steps (Jansson et al., 2016). Dr. Kotter describes an 8-Step Process of Creating a Major Change that aims to assist leaders in organizations in implementing change through a culture shift and how inspire employees to contribute to quality improvement (Jansson et al., 2016). It is one of the most globally recognized change management models and can be summarized as follows (Britcher, 2017):

1. Establishing a sense of urgency
2. Creating the guiding coalition
3. Develop a vision and strategy
4. Communicating the change vision
5. Empowering broad-based change
6. Generating short-term wins
7. Consolidating gains and producing more change
8. Anchoring new approaches in the culture

The first three steps of the process are all about creating the ideal environment for change, with the first step, "create a feeling of urgency," being the most essential (Joseph Galli, 2018). As a result, by presenting facts and communicating change to employees, leaders must sell the value of the future state while simultaneously informing employees that the current state is an uncertain and even dangerous place to stay in. Moreover, steps four to six connect the change to the organization by building support, engaging in dialogue with all employees, and motivating through short-term goals. The final steps are focused on after the changes have been implemented, where the organization must continue to seek improvements and have regular progress conversations to help consolidate the change and newly established culture (Joseph Galli, 2018).

The final component for a successful transition between the phases of the digital maturity matrix is digital maturity (Jansson et al., 2016). Furthermore, the degree of innovation as well as the ability to manage change influence digital maturity, which is the core of the working methodology. The digital degree of maturity represents how far a company has progressed in comparison to its surroundings, i.e., if a company stops exploring for improved digital opportunities, its digital maturity will stagnate (Jansson et al., 2016). Although, to develop an individual's degree, Jansson et al. (2016) describe a five-step model that demonstrates how an individual receives digital information until it becomes a natural part of daily life. The first step is knowledge, the individual must first gain knowledge of the innovation and the problem it can solve. In the second step, the individual must be convinced of the value of the innovation, as well as comprehend why and how its use will benefit them. In the next step, the individual takes a decision if it or should use the innovation and in the fourth step, they start to use the innovation. Although, after implementing the innovation in combination with previous ways, it is not until the last stage that the individual has entirely replaced the previous ways with the new invention (Jansson et al., 2016).

2.3 ADKAR Change Model

JM has used the ADKAR model in their research for BIM implementation methodologies and analyses (see Chapter 4), since it is an action-oriented framework for managing or analyzing the change in a company (Wong, Lacombe, Keller, Joyce, & O'Malley, 2019). Furthermore, ADKAR is an acronym for five steps that an individual or a group must do to successfully change (See figure 4). This evidence-based change management strategy, according to Wong et al. (2019) is well adapted to satisfy the needs of complete implementation and additionally adequate for understanding the multifaceted needs to succeed.

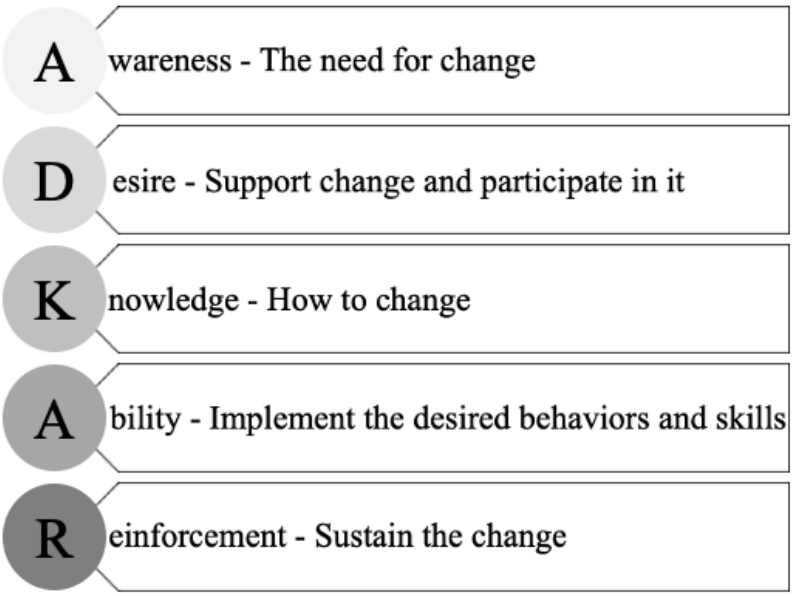


Figure 4: The ADKAR Model inspired by Creasey's (2020)

Before initiating training and improving employees' knowledge, Creasey (2020), a worldwide known leader in change management, states that the first two steps, awareness and desire, must be addressed and completed to not create resistance and make implementation more difficult. Hence, awareness provides the necessary understanding of the need to change, and therefore targeted communication is crucial to answering questions such as "why is it necessary?" and "what will happen if we don't implement the change?". Wong et al. (2019) explain that desire is a personal decision to support the change and that a full understanding of why the change is needed must be established with awareness. Furthermore, knowledge about the change can be addressed through e.g., coaching, mentoring, and different training tools (Boca, 2013). It is important to give the employees a solid understanding and knowledge of how to perform once the change is implemented (Creasey, 2020) Additionally, new abilities are developed through hands-on instruction and more in-depth coaching by experienced and skilled persons in the fourth level. Hence, improving two-way communication, learning by doing, and sharing knowledge resources throughout time is essential for embracing ability. Finally, efforts must be made through reinforcement to maintain the change and avoid reverting to old patterns (Wong et al., 2019). Furthermore, when resources and support are immediately transferred to new projects after the implementation, change is more likely to fail. In addition, Creasey (2020) emphasizes the necessity of celebrating successes, highlighting the impact of change, and the individual aspects of receiving positive feedback and recognition. Finally, while using the ADKAR model, avoid skipping steps because individuals are less likely to adapt to change effectively. Instead, invest knowledge and skills in those who are ready and encourage others by focusing on awareness and desire (Creasey, 2020).

2.4 Application of BIM hardware on the construction site

According to Son, Park, Kim and Chou (2012), mobile devices have emerged as important instruments for improving construction productivity, management effectiveness, and information accessibility. The development of mobile devices, according to Chen and Kamara (2011), has the potential to expand the boundaries of information systems from site offices to individual workplaces on-site, with real-time data between the various locations on site. As a result, the construction sector has begun to use mobile devices to collect and process data on construction sites. However, despite the increased interest and usage of mobile devices in the construction sector, there is still skepticism due to a lack of supporting evidence and understanding of mobile devices (Son et al., 2012).

Chen and Kamara (2011) presented the benefits of utilizing mobile devices (e.g., smartphones & tablets) on the construction site, claiming that the potential of mobile devices for the construction site has not been completely realized and that it is not widely adopted by the construction industry. Chen and Kamara (2011) identified benefits such as decreased lead time, more effective resource usage, and improved work quality by deploying mobile devices on the construction site. According to Bowden, Dorr, Thorpe and Anumba (2006), further benefits of using mobile devices on the building site were decreased construction time and cost, lower operation, and maintenance costs, increased productivity and consistency, and a reduction in defects, accidents, and waste. Saidi, Haas and Balli (2002), on the other hand, highlighted certain challenges to mobile device adoption. The limitation of mobile devices and how they handle information, as well as their screen size and visibility, were noted as challenges. Furthermore, another challenge was the physical environment of the building site, such as the temperature, rain, and dirt. The construction industry's fragmentation and risk tolerance were also mentioned as a challenge by Saidi et al. (2002).

A theoretical model was developed by Chen and Kamara (2011) with the prerequisites for the application of mobile devices on the construction site. In this model, three dependent factors were identified as well as three independent factors. These factors were mobile devices, wireless networks and mobile applications respectively the user (see figure 5), construction information, and the construction site, where the independent factors are fundaments to the dependent factors to work within. Firstly, the mobile device is something that the workers on site have to interact with to perform their tasks. For this, it is required that the construction workers can process the information on the construction site efficiently and effectively. Secondly, the wireless network concerns the construction site coverage of the wireless network as the construction workers move, hence the essence of a wide range of the wireless network. Thirdly, it is crucial that the construction workers can perform efficiently with the mobile application when they conduct their tasks (Chen & Kamara, 2011).

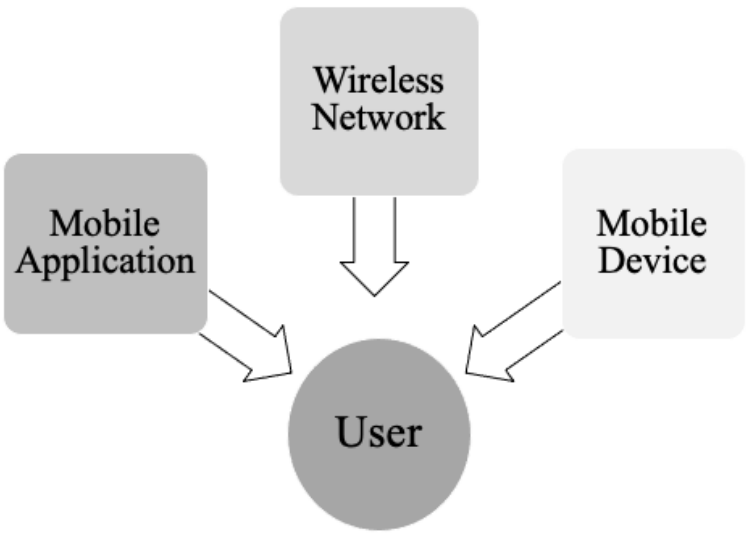


Figure 5: Description of Chen and Kamara's (2011) prerequisites for the adoption of digital tools

According to Son et al. (2012), a lot of information is created, processed, and stored throughout the implementation of a construction project, thus the information presented to construction employees should be in a way that allows them to make decisions based on the most up-to-date information. It is also stated that the success of information technology (IT), such as mobile devices, depends on the employees' commitment to using it when conducting their work. Understanding the conditions under which the construction workers would accept information technology and realizing its advantages with it, is essential to achieving a better level of information technology utilization and realizing its benefits. Furthermore, acceptance of IT by construction employees has been identified as a critical component in influencing the effectiveness of IT deployment (Son et al., 2012).

To understand the acceptance of utilizing mobile devices by construction workers, Son et al. (2012) developed a model based on a technology acceptance model (TAM) made by Davis (1989). The purpose of Davis' TAM was to discover external influences on the users' intentions to use technology and their actual use of it. From this model Son et al. (2012) got the foundation and developed eleven assumptions related to their own model. The eleven assumptions were:

Assumption 1: The user's satisfaction influenced perceived performance, and hence a positive IT performance is connected to a high level of satisfaction.

Assumption 2: User satisfaction is affected by the perceived usefulness of the IT, and if the site workers perceive the IT beneficial, it is then easier to be satisfied with it.

Assumption 3: The construction workers need to believe that the use of mobile devices should be effortless, which also contributes to the satisfaction.

Assumption 4: The IT is useful if it is easy to use.

Assumption 5: Social effects have an impact on the construction workers decision to adopt technology, and they have a stronger impact when using technology is required. In addition, the user considers it more significant if others think new technology is beneficial.

Assumption 6: If the construction workers believes that the new technology is relevant to their job, it then facilitates the perceived usefulness of the IT.

Assumption 7: It is more truly to accept new technology if the consequences of using it are positive.

Assumption 8: A key factor in the acceptance of new technology is support from the management organization.

Assumption 9: he importance of technical support in the successful implementation of new technologies cannot be understated. A positive attitude toward new technologies among construction employees is encouraged by strong technical support.

Assumption 10: IT and new technology will be more accepted if appropriate training is provided, resulting in a greater understanding, a positive attitude, and consistent use.

Assumption 11: The complexity of the new technology has an impact of the use of it.

2.5 Knowledge Management

Knowledge is a key resource for an organization, according to Yusof, Bakar and Tufail (2012), since it embodies best practices, routines, lessons learned, problem-solving approaches, and creative processes. Furthermore, the quality of knowledge, of which technology is a component of, is linked to a construction company's success. To remain competitive and be properly up to date with performance methodologies, it is critical to manage and organize information within an organization. Thus, to manage knowledge, knowledge management (KM) facilitates the systematic and effective management of knowledge (Yusof et al., 2012). Additionally, Xue (2017) stresses organizations urge to implement processes to manage the organizations' knowledge, so it does not languish away. Furthermore, Bigliardi, Galati and Petroni (2014) emphasize the need of knowledge acquisition, storage, transfer, distribution, and support to properly implement the KM process.

Initially, knowledge, according to Xue (2017), is defined as information stored in an individual's mind, as well as skills and experiences. It also offers ready-to-use information that may be utilized to make decisions and choices. Hence, knowledge is therefore believed to consist of information, skills, and expertise. Furthermore, the goal of sharing information is to make it visible and encourage individuals to participate and contribute to the creation of a knowledge-sharing environment (Xue, 2017).

Knowledge, as mentioned by Xue (2017), can be categorized in a variety of ways, but the most common are explicit and tacit knowledge. Explicit knowledge, according to Alexander (2019), is the most basic sort of information because it is easiest to distribute because it is written down and accessible. Data that has been processed, organized, structured, and understood is referred to as explicit knowledge. Xue (2017) also defined explicit knowledge as knowledge that has been systematically coded and can be easily obtained, gathered, and shared. Tacit knowledge, on the other hand, is the knowledge that individuals have gathered via personal experience and context, according to Alexander (2019), and is intangible. Xue (2017) identified tacit knowledge as values, beliefs, and assumptions that can only be stored in a human being.

KM on the other hand, has a variety of definitions. In the research by Yusof et al. (2012) several definitions of KM are given, and the first one from Webb (1998) in Yusof et al. (2012) defines KM as the "*identification, optimization and active management of intellectual assets to create value, increase productivity and gain and sustain competitive advantage*". Another definition by Yang (2011) in Yusof et al. (2012) defines KM as "*the process of identifying/creating, assimilating, and applying organizational knowledge to exploit new opportunities and enhance organizational performance*". Furthermore, Gold et al. (2001) in Yusof et al. (2012) definition of KM "*as a structured coordination for managing knowledge effectively*". Another definition by Xue (2017) mentions KM as "*a systematic process for gathering, organizing and communicating both tacit and explicit knowledge for employees*". Apart from the various definitions of KM, Xue (2017) states that KM allows an organization to explore tacit and explicit knowledge from individuals, groups, and organizations to turn knowledge into assets for decision-making. On the other hand, Yap, Lim and Skitmore (2022) said that KM includes ongoing activities such as knowledge generation, sharing, storage, and application. Xue (2017) emphasizes the importance of KM, believing that a proper KM provides a competitive advantage and improves organizational processes by allowing employees to exchange best practices and expertise.

In KM there are four main elements and processes according to Kayworth & Leidner (2003), Zaim (2006), Fong & Choi (2009), and Turner et al. (2012) in Xue (2017). These are knowledge acquisition, knowledge storage, knowledge transfer, and knowledge application:

Knowledge acquisition refers to the process of implementing new information or replacing existing explicit and tacit knowledge inside an organization. New information might emerge from outside or inside the organization, and it could be connected to a significant impact on performance (Kayworth & Leidner, 2003; Zaim, 2006; Fong & Choi, 2009; Turner et al., 2012, in Xue, 2017).

Knowledge storage is the process of storing explicit and tacit knowledge that employees have received inside the organization. Knowledge may improve efficiency if it is integrated into the organization, therefore the knowledge storage should be accessible (Kayworth & Leidner, 2003; Zaim, 2006; Fong & Choi, 2009; Turner et al., 2012, in Xue, 2017).

Knowledge transfer involves the sharing and exchanging of knowledge between the employees within an organization. To avoid the tacit knowledge from being lost, the organization must ensure that knowledge is converted from tacit to explicit knowledge (Kayworth & Leidner, 2003; Zaim, 2006; Fong & Choi, 2009; Turner et al., 2012, in Xue, 2017).

Knowledge application is the application of obtained knowledge to solve problems, make decisions, increase efficiency, and cut costs. Hence, individuals can employ knowledge, possessed from other employees (Kayworth & Leidner, 2003; Zaim, 2006; Fong & Choi, 2009; Turner et al., 2012, in Xue, 2017).

In addition to the above-mentioned processes, Bigliardi et al. (2014) described new properties of the various phases. Organizations are said to accept new information from both internal and external sources for knowledge acquisition, which might include job rotation inside the organization or outsourcing. According to Bigliardi et al. (2014), databases are used to store knowledge. Thereto, mentoring, expert advice, everyday engagement, and documentation all contribute to knowledge transfer. And finally, the application should represent the accumulation of the preceding project's expertise and experience.

3. Method

This thesis is based on the survey conducted by the case company JM. In order to identify the problem to the gap, the most suitable method was therefore a qualitative abductive method. The approach to this thesis is illustrated below in figure 6. In this chapter, all relevant parts and methods that have been used will be described and justified.

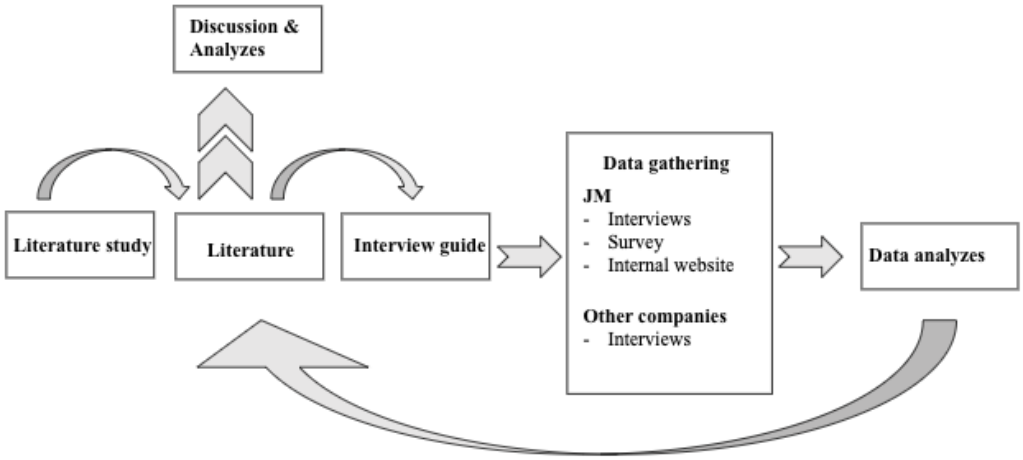


Figure 6: The method approach for this thesis

3. 1 Research Approach

The methodology of this thesis was an abductive strategy with a qualitative approach. The approach of data collecting was based on interpretations of the data that were considered to be most suitable for the study, both from literature and interviews. To generate theory, an abductive approach is employed to make logical conclusions (Bell, Harley and Bryman, 2022). Furthermore, Bell et al. (2022) claim that there are some phenomena that theories cannot explain. To provide with an answer to the phenomena, an abductive method is used, which is based on a back-and-forth approach between theory and empiricism, see figure 6. Therefore, for this thesis, literature was read and then interviews were conducted. If new perspective that was not thought of before was identified, new literature was then gathered, hence an iterative process of data gathering was performed.

Initially, a qualitative approach was conducted through in-depth interviews. A qualitative research approach, according to Bell et al. (2022) and Javadi and Zarea (2016), is a strategy that stresses language and relative information, and hence generates the knowledge. In order to begin the study, the authors of this thesis must portray philosophical ideas and assumptions, from the interviews, using a qualitative technique. According to Vaismoradi, Turunen and Bondas (2013), research is created based on the data collected, and the aim is to get a better knowledge of a phenomenon from the perspective of those who have experienced it.

3.2. Literature Review

There were various stages for the reading and the collecting of knowledge from literature. It was first done to establish a knowledge basis for the subject based on a review of exploratory scientific literature. This foundation helped in developing a better grasp of the chosen topic and filtering through the several subcategories to discover the one that best suited the thesis' purpose. A literature search, according to Saunders, Lewis and Thornhill (2009), is done as an early activity to improve subject knowledge and establish a foundation for the research. Furthermore, the primary purpose of the literature review is to facilitate the formation of a thorough grasp and comprehension of the research (Saunders et al., 2009). To ensure that scientific perspectives and data were acquired, this method and gathering of information were mainly done through Google Scholars and Chalmers Library. Furthermore, if something needed to be explained, searches via gray literature, such as internal websites, were conducted to clarify particular scientific findings.

Figure 6, which was utilized during the literature overview for this thesis, shows how the first gathering of information and knowledge established the groundwork for guidelines and details. Thereto, new material was read to match the issue more specifically, depending on the interviews and the forthcoming interviews. This was done several times until the writers were pleased with the literature and interview information. Finally, one of the cornerstones on which the analysis and debate were developed was the literature foundation. The literature is also recommended by Saunders et al. (2009) to be made continuously throughout the writing of the thesis to be culminating in the final version.

3.3 Data Collection

In addition to a literature study, other data collections were also made, such as interviews and knowledge acquisition through internal communication at the case company's office. As previously mentioned, the case company conducted a survey that revealed a gap in attitudes and understanding of the lack of knowledge regarding working more digitally. This paper is based on a survey conducted by the case company. This survey was analyzed in further depth and compared to both the literature and what was stated during the interviews to acquire a better understanding of what was causing the divergence. Several interviews were conducted, transcribed, thematized, and analyzed in order to investigate the survey and to fulfill the purpose and aim of this thesis.

3.3.1 Interviews

For this thesis, a total of 11 interviews were conducted. Throughout the thesis, participants were chosen for interviews on a continuous basis. These selections were made by recommendations of people who were interviewed in a so-called snowball effect (Bell et al., 2022) and by selected people who were already relevant to an interview early in the preparations.

The first was the person who assisted in the creation of the survey, which was done to aid in a better understanding of why it was done and what it was for. Following that, persons who were specialists in working digitally in the construction sector and people who played key roles in the case company's implementation of the digital tool were interviewed. BIM-Leader, Production Manager, Change Management Consultants, and Project Manager was among the positions held by these individuals. The final segment of individuals interviewed were those who worked in production and would utilize the digital tool on a regular basis. The interview preparations were planned and structured in accordance with how the implementation was carried out in the organization, i.e., from the top down to the production site.

When an interview was scheduled, the material and questions for the interview was prepared. The interview questions were altered based on the person's position and when the interview was performed the questions served as guidelines for the interview. The interview was then semi-structured, meaning that the interviewee may freely answer the questions that were asked and that additional follow-up questions might also be asked. Semi-structured interviews, as mentioned by Saunders et al. (2009), enable more developed responses by allowing the interviewee to elaborate on their answers. It may also lead to dialogue in areas that were not previously explored but are still significant for the research. The interviews were also performed in two ways: digitally through teams or zoom, and in person, either in an office or in a construction site office. Furthermore, everyone interviewed expressed enthusiasm for being questioned, and everyone thought the topic was relevant and significant to the construction industry.

3.3.2 Analyzing the Interview Results

To ensure that a fair analysis could be made of what the interviewees had said, each interview was transcribed verbatim afterward. Based on these transcripts, different themes could be highlighted. This is known as thematic analysis, according to King & Brooks (2018), which is a qualitative data analysis that focuses on detecting, interpreting, and organizing various themes in the text that has been created, which in this case was the transcriptions. The different themes that were identified were to see patterns and similarities between what the different interviewers said. According to King & Brooks (2018), thematic analysis is the most common approach for identifying and analyzing patterns in qualitative data. They also think that qualitative methodologies generate large amounts of detailed data and that it is critical to be able to separate crucial information from this and transmit it to readers through the research's own language.

3.4 Critical Evaluation of the Method

To establish trustworthiness, the findings from the case company were compared using a triangulation of sources (Andersson, Bachman, Perkins, and Choen, 1991). Hence, two other construction companies were interviewed to see if the case company shared other construction companies' perspectives. Although, the results are primarily applicable to the Swedish construction sector due to the geographic range of the interviews and the majority of the literature emerging from Swedish researchers. The thesis can be perceived as generalizing toward one company, although Flyvberg (2006) believes that a case study is an important type of research for the development of social science and can therefore contribute knowledge to the field to later be compared with other case studies. Furthermore, because the survey focused on the issues of change management in the implementation of BIM rather than being specific to Dalux, Heale, and Twycross (2015) believe it is invalid. Therefore, it has only served as a framework for the thesis and not as a valid result.

3.5 Research Ethics

The thesis is partly based on interviews. According to Mero-Jaffe (2011) 1) *"An interview by its very nature is based on a power relationship and where there is power, there lies a potential for the infraction of human rights".* As a result, each interviewee was informed before the interview that the conversation would be recorded and transcribed for the thesis. The writers would not share the collected information and to protect people's ethical commitments, the interviewees' roles would only be mentioned in the thesis. Thus, according to Mero-Jaffe (2011), the core elements of human dignity are privacy, anonymity, and confidentiality. Furthermore, the interviewees were always informed of the thesis's aim and purpose, and the recording would not begin unless the interviewee gave their approval. Moreover, the interviewee could inform the interviewer that they divulged something in confidence that could not be included in the thesis during the interview. It was voluntary to participate in the study.

3.6 Sustainability

The study provides a deeper understanding of how to implement digital tools in the construction phase and wider usage of digital tools in the construction sector will create more sustainable work processes by simplifying communication and work methods. In addition, knowledge is given about change management for the implementation of a digital tool, and it identifies the effects on employees in the construction phase and the prerequisites and strategies needed for a more socially sustainable transformation to digitalization.

Furthermore, if everything is combined in one digital tool, unnecessary processes and time-consuming activities can be decreased. As a result, the implementation of a digital tool could enable the construction industry to become more efficient, resulting in more economic sustainability.

4. Empirical Findings

This chapter will describe and compile the qualitative data from the conducted interviews. To begin with, the case company JM's view of what a model-based approach looks like is explained, followed by how Dalux is integrated into this. Thereafter, a description on which people that was interviews and what role they had is described. This is done to strengthen the argumentations that were said and to prove the relevance of the selected people who were interviewed. At the end of this chapter, various themes have been identified, such as the vision for implementation, the digital transformation, the implementation of the digital tool for the construction site, training and support, prerequisites and lastly, digital maturity.

4.1 JM context of study

The studied company for the report is JM AB who is one of the leading developers of residential and housing areas in Sweden, Norway, and Finland. Their focus is on the new production of homes in attractive locations such as expanding metropolitan areas and university towns (JM AB, 2021). According to JM's annual report 2021, the annual sales are approximately SEK 15 billion and the company has around 2,500 employees. In 2018 the company took a decision to certify all residential units with Swan Ecolabels and is therefore the first construction company to certify all their projects in the Nordic markets (JM AB, 2021). Moreover, they manage the entire value chain from land and property acquisition to maintenance (see figure 7).

The implementation of Dalux is part of JM's model-based approach, and JM explains that working in a model-based approach entails using digital 3D models rather than traditional drawings. JM also considers that the models assist in a better understanding of a project's overall scope and details. JM creates a digital presentation early in the project by building and designing the construction project virtually before it takes place on the actual construction site. According to JM, all projects begun after December 2017 will be regulated by a model-based approach, which has the advantage of reducing the time between planning and completion due to streamlined processes. Another benefit of a model-based approach is that quality assurance is simplified since errors may be detected early in the process, and project communication is improved when models are utilized as a common foundation. Additionally, the model-based approach is applied by JM in design, project management, sales, project procurement, and production as well as taking out quantities, reviews, and quality assurance (Internal website JM, 2022).

Furthermore, Dalux for JM is a new digital tool that helps the company to invest in digital production technology. JM characterizes Dalux as a digital platform that allows production to interact with models in real-time for the first time, while simultaneously facilitating collaboration between design and production.

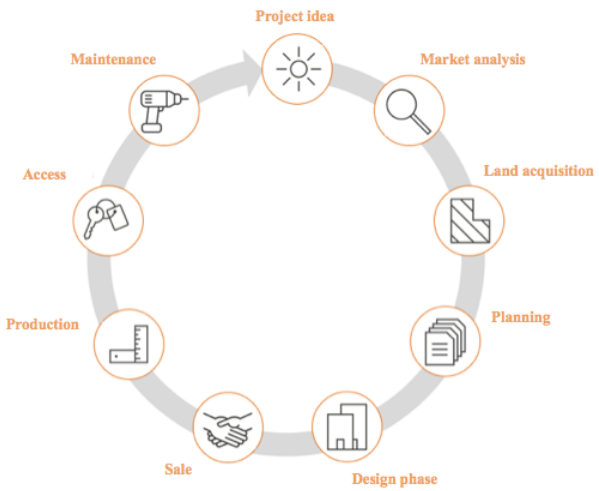


Figure 7: JM's projects lifecycle (Translated figure from JM)

4.2 JM’s Approach Methods for BIM

This paragraph will explain JM's approach on how they should transform their organization more digitally as well as their attitude towards working more model based.

An interview was held on 14-02-2022 with the responsible consultant (A) hired to handle the company JM's BIM implementation methods. The person's overall responsibilities include dealing with concerns of change management and how an individual absorbs knowledge and information about this change. According to the consultant, the most important thing is to have a clear goal to encourage and argue for it, and BIM implementation will not be completed in a single step, hence it will be a multi-step process. This will result in a new way of working that will necessitate a significant shift in employee behavior. Furthermore, the obstacles will almost certainly not be technological; rather, the readjustment that everyone must undertake.

Three alternative approaches have been used to examine the change management challenges in the implementation of BIM. A survey is used as the foundation; it evaluates patterns to see if they are on the right track if additional efforts are required, and what the employees of the company consider. In addition, in-depth interviews are conducted with a variety of employees to further understand the real repercussions of the survey pattern, and those interviewed are usually chosen at random to get a broad perspective of the situation. Lastly, there is a production-based reference group that serves as an expert group for BIM-related difficulties and concerns. They are fully aware that the group cannot provide a fair picture of the current state of the BIM maturity in production, although it is an important part of their alternative approaches to have a connection with production employees to fully understand the challenges in BIMs further implementation.

4.2.1 Survey

The survey was conducted by JM to examine the current situation when it came to the attitude to work model-based and was sent to all employees in Norway and Sweden in late 2021 via e-mail, with a total reach of 888 employees and a response rate of 21% in Sweden. However, JM made a mistake by sending this through a survey instrument that the responder didn't recognize, and it was therefore misinterpreted by some for spam or a virus. As a result, in 2022, the survey will be addressed before it is sent out, and the email will have a different outlook to attract a larger range of responses. Furthermore, the survey will be sent out every year with essentially the same questions to examine patterns, although due to upcoming changes in the organization, more specific BIM implementation questions will be added in 2022.

To arrive to a conclusion to analyze, JM created various themes and posed questions in two separate ways before combining the responses. The surveys demonstrate what they're aiming towards and where the various gaps are in the organization. The ADKAR model (Figure 4), a classic change management tool, was used to recognize that people must go through a change journey before being able to fully absorb and integrate a change into their everyday routines (See section 2.3). It was obvious that the respondents had an awareness and desire for BIM implementation in the organization, although lacked the necessary knowledge, ability, and reinforcement. All the criteria must be met in the model to completely adapt and incorporate changes into daily routines.

To further clarify on the result from the survey, figure 8, “A” in this stand for awareness, “D” for desire, “K” for knowledge, “A” for ability” and, “R” for reinforcement. In the survey people who answer it had the possibility to answer the ADKAR from a scale 1 to 4, where 4 is the highest and 1 is the lowest. As shown below in figure 8, the awareness and desire for changes is high compared to the knowledge, ability and reinforcement for the change. Thus, this is the gap which has been talked about during chapter 1, the introduction chapter, which this thesis is based on.

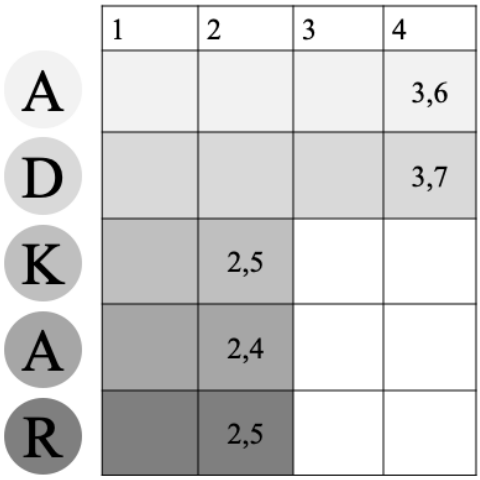


Figure 8: The result from the ADKAR survey (Inspired by the original from JM)

As a result of the analysis, JM realized that they needed to offer educational assistance and resources to increase the level of knowledge about BIM. They created the "Befattningsmatris," a matrix that defines which activities everyone should be able to use in BIM that is based on their work role. The goal was to make it clearer what to do, although they are fully aware that there are no correct solutions, therefore the model took a long time to design and is open for interpretation. JM educated the work managers on how to read the matrix and what their team should be able to accomplish using BIM. They focused on the managers since the consulting group didn't believe they knew what the current situation was and required their help in conveying it appropriately. Although, they noticed a definite pattern of reduced commitment among the work manager and they are fully aware that this was a pilot initiative, and if it fails, they simply need to reassess and develop a new strategy for informing the employees of the necessary skills they should posit.

4.3 Results from the Interviews

The results of the interviews will be presented in this chapter, beginning with a presentation of the 11 respondents from three different Swedish construction companies. Five key themes emerged from the interviews: Vision for BIM and Dalux, digital transformation, implementation of Dalux in construction, education and training, prerequisites, and digital maturity. This theme will be utilized to examine data gathered from observations made at the office, case study, JM's internal website, although most of the data will originate from interviews.

4.3.1 Presentation of the Interviewees

The interviewees' connection to Dalux, as well as whether they work for JM or the other two construction companies, will be presented in this section. All these interviewees were chosen based on their knowledge, expertise, or position.

Site Manager A

Site Manager A works for JM at the studied construction site. The interviewee was the one who requested that Dalux be implemented at the current construction site. It was implemented in the middle of the construction and has been mainly used for inspections. The interviewee was a representative of a Dalux development group, which can explain the knowledge and enthusiasm for the new tool Dalux.

Site Manager B

Site Manager B works for Sweden's leading partnering contractor at a construction site in Gothenburg. This is the interviewee's second Dalux project, however, it has now been used in a greater range thanks to the support of the Project Engineering assistance. They use Dalux for e.g., deviations, inspections, and safety inspections.

Supervisor A

Supervisor A works for JM at the studied construction site. The interviewee is responsible for the Dalux inspection and has never used the tool before. Consultant B has been extremely helpful to the interviewee with support and knowledge.

Supervisor B

Supervisor B works for JM at the studied construction site. Although the assigned task and responsibility are not yet suitable for Dalux, the interviewee works at a construction site where Dalux is used. The interviewee had used it to a limited degree on the construction site, both on the computer and on the mobile phone.

Consultant A

Consultant A is responsible of handle the company JM's BIM implementation methods. The interviewee's overall responsibilities include dealing with concerns of change management and how an individual absorbs knowledge and information about this change. Consultant A oversees the three approaches to examining the change management challenges in BIM implementation, one being the survey.

Consultant B

Consultant B is a management consultant hired by JM for three years. The interviewee is the project leader for the strategic investment "Must win battles" focused on the Dalux implementation. They decided that Dalux was the most suitable tool for a digital way of working and created a training package for the fundamentals of Dalux. During the implementation of Dalux at the studied construction site, the interviewee additionally provides support and expertise to Supervisor A.

Consultant C

Consultant C is a change management consultant at JM and has been filling in for another consultant due to the BIM implementation project's extension. The difficulties are primarily in production when it comes to change management and learning how to work digitally because they haven't performed it before, even though Consult C is now primarily focused on project planning the interviewee is a support for the entire firm e.g., education and telephone support.

Production Manager

The Production Manager works for JM and has the responsibility for the CEO group's choices, hence, making the company digitally leading. The Production Manager, in collaboration with Consultant B, has decided that Dalux is the best tool for increasing the digital process. The Production Manager plays a significant role in deciding which projects are ready for implementation.

BIM-Leader

The BIM-Leader works for JM and is responsible for developing the process for Dalux for production. However, regardless of whether it is the digital tool Dalux or Solibri, the role is to get people to work with BIM. Even if it is not the interviewee's primary role, education and training is provided if necessary.

VDC-Specialist

The VDC-Specialist works for one of Sweden´s largest companies in construction and project development. Since the beginning of the company's implementation of the tool Dalux 5 years ago, the interviewee has been responsible with assistance from the BIM coordinator. The interviewee is assisting one of the company's largest projects with Dalux-related concerns and education.

Project Engineer

The Project Engineer works for Sweden's leading partnering contractor at a construction site in Gothenburg. The interviewee is responsible for overall quality and environmental processes, as well as providing support to Site Manager B with Dalux. The tool is utilized in everyday activities, e.g., quality control, where self-inspections must be checked in Dalux.

4.3.2 Vision for BIM and Dalux

According to JM's internal website, JM uses BIM because they aim to work smarter, communicate more easily, and resolve faults early in the project process. JM also believes that it is a working methodology that makes it easier to access and understand drawings and models and therefore BIM is the project management method for all projects that started after December 2017. The vision is that BIM will make the projects more streamlined, flaws will be identified early in the process, real data will be used instead of key numbers, project communication will improve, the time between planning and completion will be decreased and it will be more cost-efficient. In the interview, the Production Manager stated that the company aims to be a digital leader and that many aspects of that vision have already started to be implemented.

The three consultants are part of a JM strategic initiative called "Must win battles," which aims to reduce production costs and lead times, since it has become increasingly expensive to build. Furthermore, Consultant B stated that during a digital project collaboration in the company, they determined that the tool Dalux was the best investment for developing the BIM approach. The tool was chosen based on several criteria and requirements, and an agreement with Dalux was signed in 2021, as the new tool being used for some pilot projects during the spring of 2022. Dalux will assist the company with BIM development and will eventually replace DOX and Bluebeam, as well as other file-sharing platforms and digital tools. Additionally, the Production Manager believed that Dalux is the new information platform, and all the other digital models and tools are therefore unnecessary. According to the company's internal website, Dalux is being examined for a coordinated control plan, question and answer function, inspections, working environmental application, project purchasing, and deviations for the logistic purposes for production. Consultant B explained that the investment has a variety of aims and values, both soft and hard parameters. Direct costs were highlighted since the company could eventually remove other licenses for other tools. Additionally, allowing those in production to spend more time on value-creating activities by eliminating administrative tasks like ineffective paperwork, Excel structures, and long email conversations. In addition to implementing Dalux for JM, Consultant B explained that the production director has requested a strategy for enhanced digital maturity because the industry is evolving digitally, and more modifications are necessary. According to the company, there are numerous opportunities to develop BIM, and Dalux has enabled them to move in the right direction.

4.3.3 Digital Transformation

In the interviews, the three consultants described that they were recruited because of their change management expertise. Although, most of them have never worked with construction-related issues or even the tool Dalux before. Consultant C went on to explain that production has a better understanding and respect for each other than if a consultant would notify them what to do. Consultants can guide and build up processes for the tool, but they need to interact with production for the appropriate implementation structure. Therefore, Consultant A uses a variety of research approaches to evaluate BIM implementations, one of which is a production-based reference group that Site Manager A has participated in. Although, Site Manager A expresses unhappiness with the extended implementation period and doesn't understand why JM has not just implemented it already. Additionally, both Supervisors A and Supervisor B stated that when it comes to new difficulties and digital programs, they believed in *"learning by doing"*. Although, Consultant A described that it is important that everyone see the big picture of the changes and it is therefore important to communicate the goal and purpose first to understand why you should devote time to the new change. Consultant A further addressed the issue that JM is a relatively digital immature organization that needs to develop to avoid falling behind.

Site Manager A and B, likewise, Supervisor A and B expressed that they easily adapt to new ideas and implementation of new tools. Furthermore, Supervisor A is new to the position and has not utilized any other tools that the interviewee believes could have interfered with the learning process for a new digital tool. For workers being more skeptical the VDC-Specialist believed that the organization needs to show the benefits and further advises JM to control, or at least to some extent control the process so that everyone uses the tool in the same way. Consultant C hoped that by

utilizing the super-users' talents and advice, JM will be able to raise awareness among the skeptical, as the consultants are only responsible for the BIM project and implementation, not how to improve digital maturity and how to assist the company with doubtful individuals. Consultant B also argued that they most likely have not been able to involve everyone, rather those who are enthusiastic about the Dalux implementation. Site Manager B believed that those who are skeptical to use Dalux require assistance, as skepticism is often based on uncertainty, and Supervisor B believed that this assistance should most likely not be optional. Employees in the regional head office have expressed concern over the implementation of new ideas in the company, highlighting recent implementations that were not always well-thought-out, causing annoyance and unnecessary additional work for the employees.

4.3.4 Implementation of Dalux in Construction

A theme from the interviews was the implementation and the use of Dalux for the production phase. This theme focuses on the process for the implementation of Dalux, the usage of Dalux on-site, the choices of not using Dalux, and which other tools are being used instead of Dalux. Initially, before Dalux is implemented at the construction site, various decisions and processes are being conducted. Thus, from both the VDC-Specialist and Consultant B, it was stressed that for an actual usage of Dalux on site, it was easier and better to implement Dalux in the early phases of the construction project. Hence, the recommendation of Dalux BOX is to be able to handle early project documentation and facilitate the transition to Dalux Field. The VDC-Specialist meant thereto that more can be gained by using the same software products since they are connected. Moreover, Consultant B said that it is more natural to use Dalux Fields if Dalux Box has been used in the earlier phases of the construction project. Another interviewed individual was a Project Engineer from another company than the case company. This Project Engineer said that during the procurement, the company states to their clients that they wanted to use Dalux. This results in Dalux being implemented early in the project, which also indicates that Dalux will be used during the construction phase.

Furthermore, Consultant B described an implementation process of Dalux, for the production phase, which begins with a start-up meeting. Thereafter, various basic education is given to the teams in the design phases as well as for the production team. It is stressed by Consultant B, that the education and training for the production team are structured in a way where the participants sit together and do activities and elements, with the purpose to give the individuals training within Dalux. The next step described by Consultant B, for the production phase, is where the production representatives sit together with the design phase team to adjust some settings and to create a project adjusted foundation of Dalux specific for that project. When this is done, help and support will be provided and available. Consultant B continued to describe that for further training and information to external project actors and subcontractors, it is up to the project itself to be responsible to do this with the educational material provided by the central organization. Additionally, Consultant B mentioned that lead times in the construction industry are long, which results in a non-directly application of Dalux. Consultant B continued to explain that coordination of everything regarding the implementation with different application plans is needed as well to have a dialogue with managers on which projects that are most suitable within a time aspect and which projects that are mature enough and which projects that are interested in Dalux. In addition, Consultant B said that it is more desirable to implement Dalux on a project that has a genuine interest, and therefrom that the word can spread to the less-interested project on how well the project performance was with Dalux.

Similarities are also said by Consultant A, that mentioned that there is a reference group in the production that is well versed with a model-based work approach as well in their respective work role on the construction site. These individuals are good to discuss the matter of various approaches. So, when it comes to which activities and elements should be applied in Dalux there was the Production Manager that was part of the reference group mentioned by Consultant A. The Production Manager said during an interview that some activities, such as inspection, have been used in Dalux in some projects that have been recommended by the Production Manager. The Production manager continued to explain that new activities that should be implemented are now being discussed and with time, more and more activities will be added. In accordance with this, Consultant B also stated that the first step of the implementation of Dalux is the use of inspections on the construction site.

What correlates to the implementation of Dalux is how it was used and implemented on a construction project. An early adopter, Site Manager A, wanted and pushed for the use of Dalux on its specific construction project. Site Manager A described that there was no clear and absolute decision regarding Dalux, since the case company was in the middle of the process of the implementation. As a consequence, Dalux was implemented in the middle of the construction project. Site Manager A thought that during the implementation process of Dalux, the program could be used on Site Manager A's construction project as a pilot project. And from this, one could give feedback on what works well and other solutions for improvement. Site Manager A also thought that it is better to release a program and to let people learn and use it, so they can get familiar with it. For this project, only inspection is being used in Dalux as a governing activity according to Supervisors A and B. Another tool in Dalux that is used mentioned by Site Manager A and Supervisor A is the ability to look at drawings directly on a mobile device and all other documentation if needed. To be able to do this is advantageous according to Site Manager A since everything is contained in the mobile devices and individuals do not need to look for other documentation in other places. In addition to the governing activity in Dalux, Site Manager A wished for more activities that should be governing. Safety rounds are one of those that are perceived to be easy to use according to Site Manager A, where an individual can take pictures, if a problem is found, and send it directly to the correct disciplines for it to be fixed. Site Manager A continued to describe the advantages even for the facility management of the finished building. Thereto, if a problem occurs, one can go back to the inspection and safety rounds to see if there is a history on that particular point.

The VDC-Specialist description of the usage of Dalux is also aligned with what is said by the interviewees from JM. With Dalux, the VDC-Specialist can ensure that individuals on the construction sites are looking at the latest and most up-to-date drawings. Governing activities for the VDC-Specialist's company are "self-inspections" and "proactive job planning" for their employees and for the subcontractor, "self-inspection" and "deviations management and reports" are required to do be conducted in Dalux, which is described in the procurement documents between the actors. Furthermore, the construction company where the Site Manager B and the Project Engineer work for are using activities such as safety rounds, moist protocols, inspections, self-inspections, deviations reports, proactive job planning, internal environment rounds, and looking at drawings. The Project Engineer said that due to Dalux, lesser individuals are asking for traditional drawings and that the individuals are diligent when it comes to the use of Dalux.

When Dalux is not used, Site Manager B and the Project Engineer meant that it depends on a lack of knowledge on how to use it and if a smaller subcontractor only has small elements and activities on the construction project. Aligned to this is mentioned by Supervisor A, who described that it is not necessary to learn or use Dalux if activities on the construction site are small, then more time will be allocated to the process of learning Dalux rather than just finishing the activity directly. Another opportunity to not choose to use Dalux is when the activities in Dalux are not a governing activity according to Consultant B. In this case, individuals can choose not to use Dalux since it is not mandatory. Consultant B continued and said that to counteract this, more governing activities should be required, and then, individuals do not have any other choices for certain activities.

Other tools than Dalux that are being used are especially Bluebeam and Solibri, which are mentioned by the Project Engineer, Site Manager B, Supervisor B, and the VDC-Specialist. Some different views regarding Dalux and other tools were shown. Site Manager B thought that Solibri and Bluebeam are good and smooth tools to use and that it is not necessary to use everything in Dalux. Site Manager B continued to explain that there is no reason to have everything in one program that results in a slightly deteriorating quality, only to have every function in one program. The VDC-Specialist had another view and explained that in the initial stages of the VDC-Specialist's construction project, Dalux was relatively new and developed enough. However, with time almost everything has been transferred to Dalux from Solibri. But on the other hand, the VDC-Specialist said that Bluebeam will probably not disappear since individuals like it better when it comes to some functions, such as measuring. Supervisor B said the same thing, that Bluebeam is used to take measurements.

4.3.5 Education and Training

Another theme that emerged for the implementation of Dalux or other technological help tools is proper education and training for the program. From the conducted interviews, all Consultants, the BIM-Leader, Site Manager B, and Supervisor B, preferred to have the education at the beginning of the production. However, by conducting the Dalux education early in the project, Consultant A, Consultant B, Consultant C, and the BIM-Leader all stressed that not all project participants are involved or even procured. Thus, more education is needed when more project participants are involved. Aligned with this, Site Manager B said that new employees, that missed the first education opportunity, are gathered afterward to conduct some courses and to get an overview of how Site Manager B's company works with Dalux. It is also mentioned by Consultant C that individuals who come in later will go through the same educational process as the previous individuals have done and sometimes individual meetings occur for people who are behind with Dalux. A contradicted thought regarding education early in the project is from the Project Engineer, who mentioned that not all project participants are procured and that it is better to conduct the education gradually.

Furthermore, the Production Manager mentioned that for every project for JM, there should be a person who will have a pre-education in Dalux, and this person can be a site manager, supervisor, or a person who is more familiar with Dalux. In accordance with this, the Project Engineer described that training packages are sent out to all site managers for the Project Engineer's company and that it is up to the site managers to determine the level of knowledge for the project and then base the training on that. Site Manager B mentioned that education and training for subcontractors are done by themselves on the construction site. Another similar statement is made by Supervisor A who mentioned that him/herself shows subcontractors around on how to navigate in Dalux and similar elements. Supervisor A also mentioned that they do it even though they do not feel that there is enough time.

The training that the construction workers attend is relatively easy according to Consultant C and based only on what is needed and used for the construction site. Consultant C mentioned that the training is based on how different steps are performed in Dalux, such as how comments are made, what all parts mean and contain, how to make cuts in the model, how tasks are allocated and how to navigate between a drawing and the 3D model. In addition to this, the individuals can test for themselves how certain elements are done under supervision and that these individuals feel that it does not go too fast, while those who hold the training can answer questions at the same time as the individuals do the tasks in Dalux. Similar is it in the company which the VDC-Specialist works for. There, the VDC-Special holds the training for all new employees to the construction site and shows how Dalux works in general, how to filter, and other functions used at the construction site. The VDC-Specialist also adds that the nearest colleague on-site can also answer questions related to Dalux if any should arise for the new employees. Thereto, the Project Engineer also said, for the Project Engineer's company, that depending on which elements that will be used by the individuals who attend the training, the content will be adapted so that the individuals only learn what they will use. Furthermore, navigating by yourself and" learning by doing" is something that Consultant A, the Project Engineer, and the VDC-Specialist stressed as something that facilitates the learning curve

of an individual. A newly develop a helpful tool for the learning and educational process, at JM, is a positional matrix mentioned by Consultant A. In this matrix, the description of various activities is described for different roles within JM that should be mastered. However, Consultant A stressed that the present at JM has not fully adopted this. And with the interviews with Supervisor A and B, none of them have heard about the positional matrix. But Site Manager A believed that the positional matrix was something that had been gone through for Site Manager A.

4.3.5.1 Help and Support

A theme from the conducted interviews were that help and support was needed to maintain the newly developed skills. The Project Engineer said that help and support to individuals on the construction site are distributed by the Project Engineer itself. The Project Engineer further described that the individuals could call anytime and then help was given. Site Manager B mentioned that without the competence of the Project Engineer in their organization, some activities or elements would not be conducted in Dalux. When asked what support resources Supervisor A utilized at JM, Supervisor A stated that Consultant B has been quite helpful with Dalux. Supervisor A states that whenever an issue or a thought arises, a call is made to Consultant B. Supervisor A also emphasizes the convenience of receiving support nearly instantly rather than viewing help videos on JM's intranet. Supervisor A also mentioned that, while open meetings are available at JM if you need assistance with Dalux, Supervisor A considers that the time is insufficient to attend these sessions. The ability to receive support immediately is the key to Supervisor A's performance in Dalux.

Another type of support is a central Dalux group for the Project Engineer and the VDC-Specialist's companies, but also for JM. According to Consultant B, the goal of such a group is to oversee the Dalux implementation. The Project Engineer also stated that a Dalux group would be developed for its company in order to make it obvious who is responsible and whom to contact when it comes to Dalux for the Project Engineer's company. It is the same for the VDC-Specialist's firm. There is a central Dalux group here whose job is to implement Dalux and manage which activities in the program are to be carried out on the construction site. The VDC-Specialist also mentioned an agreement with the company Dalux, where employees from that organization come to the VDC-Specialist's company, to provide support and guidance.

For additional support within Dalux to the individuals on the construction site, there is a specific role called "super-user". The purpose of this role, according to the Production Manager, is to be a close contact within an area. The BIM-Leader also stressed that a super-user is necessary to prevent someone on the building site from stepping outside their area of duty to answer too many concerns regarding Dalux simply since they are knowledgeable. Then the BIM-Leader said that the individuals on site should then turn to the super-user when it comes to questions or concerns regarding Dalux. This also contributes to the same response and working methods for all projects in the region, since the answer will come from the same person. When Supervisor B was told that this role would come to JM, the reaction was positive. Supervisor B believes that once they get to the location, it would be simple and straightforward to ask this individual questions. Despite this information, Supervisor A was not as convinced. Supervisor A said that when questions arise, Supervisor A wants answers immediately and does not want to write down thoughts and then bring them up with the super-user a few days later when they may or may not be as relevant or necessary. Site Manager A also thought it was a good idea to have a super-user on the construction site. Site Manager A believed that, while site managers are often responsible for competency on their construction sites, it is beneficial to have a super-user to come in to hold education, and when new employees arrive, the super-user should teach how Dalux functions. Production experience for the role of the super-user is not required, but it can be beneficial, according to Site Manager A. Then it will be easier to teach in terms and expressions that individuals at the construction site more easily understand. The super-user, according to Site Manager A, should also be aware that different individuals will learn Dalux in different ways. The person most suited to be a super-user, according to the Production Manager and Site Manager A, should be a person who has a great interest in Dalux and digitalizing the construction industry. Another role that helps and supports construction projects is the role of the BIM-Leader and VDC-Specialist. The VDC-Specialist said that early on, there was not the same need to have a

person who supports building projects with digital tools. While now there is a need and the VDC-Specialist said that individuals at the construction site as well as subcontractors often come forward and ask questions related to Dalux.

The support and help desired by Supervisor A is the direct contact. Supervisor A would like a review of Dalux to be done when a person has just entered a construction project and then that there is a direct contact when questions arise. Furthermore, Supervisor A thinks that individual meetings are fruitful, where you can go through different steps together, instead of meetings in groups. Supervisor B would also like to have someone on site who one can ask or a direct number to the right person.

4.3.6 Prerequisites

Although there is a vision, an implementation process, education, training, and support as well as other processes for Dalux to be used on-site, the right prerequisite is required according to the interviewees. One of the prerequisites mentioned during the interviews with Consultant A, Site Manager A and Supervisor B was that individuals received the right education and that they will work with Dalux continuously, otherwise the "old methods" can be chosen instead.

Except for the right education and training, Site Manager A added that it is crucial for people to get familiar with Dalux and that they will get the proper support when the individuals use it. The BIM-Leader stressed another support to facilitate the use of Dalux. The BIM-Leader mentioned that by having a super-user or a BIM-Leader arriving at the construction site, individuals feel safe to use Dalux because support is available directly at the construction site. Despite the fact that individuals get the same education and support, prerequisites nonetheless can differ. The BIM-Leader and Site Manager A said that individuals process information differently which contributes to an uneven distribution of competence. As a result, different individuals need different education methods. Consultant B mentioned that it is up to the project manager to give the right prerequisite for the individuals on the construction site. Age and background are one of these aspects that lays the foundation for the different prerequisites for the individuals on the construction site. The Project Engineer mentioned that the younger generation is grown up with technology which facilitates the adoption of new digital information and technology help tools compared to the older generation. The Project Engineer sees however this as not a problem. The learning curve might be longer, but usually, individuals always tend to learn a new program and all that is needed is time, and when time is given, the threshold will not be as high. Time is also something that is mentioned by Supervisor B. Supervisor B said that as long as there is time to learn new things, the degree of difficulty will not be an obstacle for new technologies. Learning new technologies and programs can also work as an incentive for the younger generation since the working life is in the initial stage compared to the older generation. The older generation, according to the Project Engineer, might not feel that they need to learn new things since they do not have too many construction projects left before retirement.

Consultant C mentioned that despite various prerequisites, the most important things are that the individual wants to learn and have a positive attitude towards changes. In addition, Consultant C said that several factors must be aligned for it to be good. An individual should feel ready and want to learn new things. For this, the organization must give this individual the right amount of time for this as well as correct and relevant education. Then during the use, the organization must also give the individual the right support to facilitate the use. If this works, the utilization of new technologies and tools will be good according to Consult C. Another approach, which the VDC-Specialist said, is also a basis for the use of Dalux to actually work, is that individuals out on the construction site help each other.

There is also an important prerequisite for Dalux to work on site. This condition, according to the VDC-Specialist, is that the construction site and the hardware used are compatible with the use of Dalux. An Internet connection can sometimes be a concern at the construction site. In order for people not to become skeptical and prefer old methods with paper drawings, it is important that there is good internet in place. Then the VDC-Specialist also said that it should be easy to use a tablet on the construction site and that all information should always be updated and easily accessible.

4.3.7 Digital Maturity

Consultant B claimed that the younger generation is more interested in digital processes, and Project Engineer assumes that this interest is since it will benefit them more in the future, whereas the older generation does not have the same level of interest in the future, because they do not have as many years left in the construction industry. It's critical to improve everyone's digital maturity and not just the eager young people, although Consultant B is unsure how to achieve that. Moreover, individuals that have managerial positions are normally positive, although Consultant B described that they are often careful and that they do not want to test on their projects before success is shown first. Consultant C, on the other hand, believed that digital maturity is determined by your role and interest in digital processes and that is not age-specific.

To improve the digital maturity and common competence in the organization, the VDC-Specialist believed that you must dare to make decisions higher up in the organization that the digital tool is the only option and then you need to adapt. Hence, if two options are provided, most people will choose the one they are most acquainted with. For example, if the Project Engineer does not notify the subcontractors about the processes that should be done in Dalux, the subcontractor will then perform the tasks in the old manner. Moreover, Supervisor B has been assigned to conduct the inspection in Dalux, whereas the other coworkers have the option of using it, and it is obvious that the others do not utilize the tool.

Consult C believed it is critical to spend time on-site to provide support, hence both Site Manager B and Supervisor B agree that on-site mandatory courses are preferable to online courses since it is easy to get distracted and lose attention on online courses. Moreover, those who work on the construction site in question believe that educational opportunities should provide concrete and specific examples, and the BIM-Leader agrees, stating that the examples should be pertinent to the current project. JM will send out surveys and question employees about the best approach to learn, as well as confirm that the use of Dalux is followed up after the implementation to ensure a higher level of digital maturity, according to Consultant C. Although nothing has been decided, the management organization will most likely be held accountable in the future for this approach to ensure digital maturity.

5. Discussion and Analyzes

In this upcoming section, a discussion and analysis based on the literature chapter as well as the empirical findings chapter will be made. Three main components will lay as the foundation during the chapter, and it will be influenced by Janssons et al. (2016) Digital Maturity Matrix. Thereto, the three components will first be the mobilization phase, secondly, will the coordination phase be discussed, and thirdly the acceleration phase. In addition to the three phases, relevant parts from the previous chapter will be added. The layout of this chapter will be structured in this way due to the digital transformation, see figure 9, that runs throughout the implementation process. It has been possible to apply the previously mentioned text sections in the digital maturity matrix to explain the prerequisites required for the digital transformation of the implementation of a new digital tool.

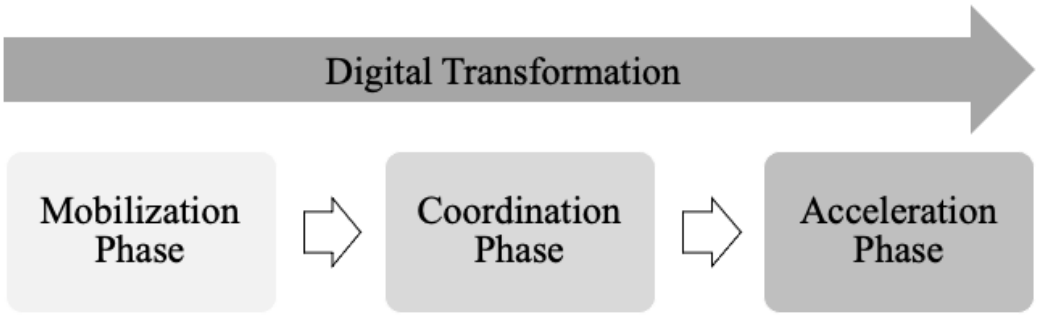


Figure 9: The layout of the Discussion and Analyzes chapter.

5.1 Mobilization Phase

The focus before implementation of a new digital tool in construction should be on mobilizing and developing interest and acceptance for the digital transformation (Jansson et al., 2016). According to Mahamadu et al. (2019) and Heaton et al. (2019), BIM and digital transformation are more about the process, people, and cultural change supported by technology than it is about the technology itself. Furthermore, Consultant B supports the claim by emphasizing the need to initially communicate the goal and purpose to encourage people to devote time to the new change. Although, in a conservative industry such as the construction sector (Agenda, 2016), knowing why is vital and what a digital transformation is could be difficult to interconnect and communicate.

The most important elements to achieve are establishing a sense of urgency and answering the question of why the change is vital for the company, group, and individual. Furthermore, Jansson et al.´s (2016) digital maturity matrix clearly demonstrates that existing activities in the organization in the early mobilization phase are separate from digital activities, making it difficult to find a social system for communication. Therefore, it could be beneficial to communicate using both tacit and explicit knowledge information channels in order to reach various individuals (Alexander, 2019; Xue, 2017). Moreover, Jansson et al.'s (2016) five-step model explain how an individual absorbs digital information until it becomes a part of their everyday life usage, hence if an individual is not entirely convinced of the benefits of digital tools, he or she is more likely to return to the traditional approaches. In addition, an internal website has been utilized to describe the vision to JM's employees, however, it appears to be more focused on business success than individual employees' success. Consequently, when the digital and existing actives are separated, it would be advantageous to use the internal website to communicate personal gains and success stories to the employees. Nonetheless, it is important to set strategic goals for the organization, while the social systems should be prioritized for the diffusion of innovation in the early stage of implementation. Hence, according to Jansson et al. (2016), the most dangerous opponent when implementing new digital technology is complacency or self-satisfaction among the employees.

According to Disney et al. (2021), the construction industry is not digital mature enough, thus Consultant A has investigated the perceptions of a wider adoption of BIM for JM. Three different methods were used and one of them, the ADKAR change management model, reveals that the first two steps, awareness and desire are nearly achieved at the company. According to Creasey (2020), if these are satisfied, implementation will be simpler because the need for change and willingness to support is already present. On the other hand, the survey that served as the foundation for the ADKAR model received a low response rate in Sweden, and the respondents worked across the whole organization and not merely in construction. Digitalization is more natural in the design phase, according to Koseoglu and Nurtan-Gunes (2018), thus the design phase is more theoretical, and the construction phase is generally more practical. As a result, the majority of those who responded to the survey work in the early phases or possess the characteristics of "innovators" or "early adopters" which show an incorrect analysis of the present situation in construction. Additionally, Consultant A stated that the organization realized it needed to express the purpose more clearly after the investigation in 2021. As a result, when sending out the survey again it would be preferable to separate the responders in the earlier phases from the construction workers in order to obtain a more accurate current analysis of the situation. Therefore, it would be unwise to skip steps and not be certain that the appropriate environment for change has been created before implementing the digital tool Dalux in construction. However, if the company is confident that some construction sites, such as the one where Site Manager A, Supervisor A, and B work at, are ready for implementation, an investment in skills and further knowledge can be made to not restrain their enthusiasm. However, if the difference between the construction projects becomes too large, it may result in a splintered organization and a confused work methodology.

If the company can't explain why the change with the new digital tool is necessary, or if creating an appropriate environment for change is challenging, it could be because the organization has a long-shaped culture that needs to evolve to avoid being an obstacle to digital transformation (Jansson et al., 2016). Hence, JM started to implement a BIM methodology already in 2017 and Dalux is simply the next step in the development of a more digital way of working. As a result, the company's culture is unlikely to be a threat, although the focus area had primarily been the design phase and no significant changes made to construction sites have been done except for adding the possibility to work in Solibri. Therefore, the implementation of Dalux will be a substantial change for the construction, and the managerial position in the organization will bear a large amount of responsibility for the new digital transformation (Jansson et al., 2016). Hence, using the 3 first steps in Kotters 8-step process to assist leaders in the organizations in inspiring employees to participate in digital transformation would be beneficial. Once again, it is to first establish a sense of urgency, then create a guiding coalition, and after that develop a strong vision and strategy.

Furthermore, the implementation of Dalux and its vision has been worked out from top to bottom, from the organization to production. Although much has been decided, Supervisor A and Supervisor B stated that they are unaware of the vision of the implementation of Dalux. As a result, processing the vision from the bottom-up may be helpful as a complement since the digital transformation has not been immediately communicated to the construction site, even though many beneficial elements have been initiated.

The digital activity group, which is distinct from the current activity, is composed of a carefully selected group of consultants as well as relevant company personnel. The three consultants were hired for their change management expertise, but due to their lack of construction experience, they had a difficult time reaching out to those who work on the construction site who does not posit the characteristics of "innovator" or "early adapters". There is no doubt that the head of the company has made a major investment and is committed to the implementation of Dalux, however they may have overlooked the first step of conveying and communicating the individual benefits to construction employees to encourage them to invest time, willingness and a desire for the digital transformation ahead.

5.2 Coordination Phase

The second component of the discussion chapter is based on sections from the literature chapter and the empirical findings chapter. Based on what Jansson et al. (2016) said, the digital activities begin in the coordination phase and the focus is more on how the implementation of digital help tools will be conducted. It is also mentioned that more resources are allocated to this phase and interaction between the existing processes and the new digital approaches occurs. Therefore, well-planned coordination is needed between the implementation and work methodology.

5.2.1 Specialist and Generalist

To coordinate the transformation from an old approach to the development of a new one, Jansson et al. (2016) stress the importance to have a direction and a vision for the employees to strive for, hence, the employees need to have a willingness for it. Therefore, various individuals with different skills are needed, both generalists and specialists will lead the way forward for the implementation. Generalists according to Jansson et al. (2016) could visualize view and understand the implication to digitalize. A specialist on the other hand according to Jansson et al. (2016) are specialist in their field and holds the digital competence and the ability to develop a strategy for implementation. Hence, the company JM has succeeded to obtain both generalists and specialists. The specialists are hired consultants that helped to structure and build up the process and strategies for the new digital tool Dalux in construction. Moreover, the generalist is typically the individuals on the construction sites, such as Site Manager A, Supervisor A, and Supervisor B, enthusiastic and first with the implementation. Hence, Site Manager A has the characteristics of an "innovator", and the Supervisors could be perceived somewhere between "Early Adopters" and "Early Majority" because of their initiative for being the first to implement Dalux and their own perception of them being individuals adapting fast to new ideas.

To further support and coordinate the development, a reference group with production-related knowledge was applied and according to Consultant A, this reference group is good to discuss various approaches suitable for the construction site. Similar is it for the other mentioned companies in this research. Both companies have also applied special Dalux groups to support and facilitate digital work. Once again are the specialists mentioned by Jansson et al. (2016) a part of the development. Another specialist who has been appointed to assist the generalist is a "super-user", who will help and support the individuals on-site with more technical concerns, but also provide education. The most suitable person for this role must be a person with a genuine interest to digitalize the construction industry and new digital help tools, therefore could this person also be perceived as an "Innovator". In JM's case, a previous site manager with great interest in Dalux has been appointed to be the super-user in this region.

Despite the categorization of individuals to be suitable for the development of a new digital approach for the construction site, the desire to learn and to understand the benefits of the new adjustment is an important factor. As a result, a company, which individuals work for must provide the necessary prerequisites. And, if the correct conditions are met, everything is possible. This is something Son et al. (2012) also mentioned as important. They stated that a successful implementation depends on the individual's commitment to adapt to new digital help tools. To this, it is also required that the individuals realize the advantages with it of wider utilization.

5.2.2 Prerequisites for the Implementation

One of the most important factors for the implementation and the utilization of new digital help tools are thus that the right prerequisites are given. Chen and Kamara (2011) mentioned mobile devices, wireless networks, and mobile applications as concrete prerequisites for the use of digital help tools on the construction site. Added to these prerequisites are the individuals, the information, and the physical construction site. Similarities were mentioned by both Disney et al. (2021) and Koseoglu and Nurtan-Gunes (2018), who mentioned the need for the right hardware and software. Saidi et al. (2002) statement aligned with Chen and Kamara's (2011) prerequisites, which was the importance of providing the right information within the digital help tool to the construction site. In accordance with the mentioned prerequisites, Son et al. (2012) developed eleven assumptions for a smoother

adaptation to new digital approaches. The assumptions that correlate to the prerequisites found in this research were that the individuals need to see the benefits of the new digital help tool and that it will help the individuals with their daily work and that it is relevant. Dalux, in this research, should be easy to use and thus are easier accepted if proper education and training are provided. Furthermore, support is another assumption that is an important prerequisite. Thereto, the support needs to be both technical and managerial.

The interviewees stated similar prerequisites aligned to the literature on what they thought and found important for the actual use of Dalux and its implementation. According to the survey conducted by JM, the majority has a positive attitude towards new digital approaches, however, to bridge the gap between the lack of knowledge and the right prerequisites needed, both supervisors mentioned that time is crucial to succeeding with new approaches. However, it was noticeable that time was insufficient for the adaption to Dalux. Additionally, it was stated that with enough time, it did not matter what age or background an individual had, as long as sufficient time was provided during the learning process of a new digital tool. In other word, learning Dalux is dependent on the personnel's willingness to adapt to changes and that enough time is given to the individuals. Since, time was insufficient for the individuals on the construction site, the organization should release the required time when implementing a new digital tool. Therefore, it is critical for the organization to allocate time for individuals and to prioritize the learning process. However, the difficulty here is for an organization to know how much time that is needed to allocate and this could be a reason why some thought that there was not enough time for the adoption of new digital tools.

A foundation for the implementation of Dalux was to streamline the user's time at the construction site. Can an organization understand that if time is invested despite a tight time schedule, a time profit can be made later. Once the program has been mastered, the individual, using the program, can save time by carrying out activities through the program, and in the long run, this saved time will be much more than the time that the individual needed to learn Dalux from the beginning.
In addition to the above-mentioned prerequisites both from the literature and the empirical, it is required that the physical construction site is also compatible with the new digital working approaches. Aligned to what Chen and Kamara (2011), Disney et al. (2021), and Koseoglu and Nurtan-Gunes (2018) described, the VDC-Specialist stressed the prerequisites for the construction site must be compatible with the use of Dalux. One factor was the wireless network, and if it is not working enough, people tend to fall back to the old methods, even if Dalux can be synchronized afterward when a better connection is found. However, the need for a wireless network can be crucial for the communication between the actors on site. Tablets and other hardware were also mentioned as important for the usage of Dalux. Therefore, when implementing a new digital approach or a tool, its implementation and use must be well worked out. Otherwise, it can lead to difficulties for the individuals at the construction site. It was obvious from the interviews that for new tools to be used, it should work smoother than the previous approaches has been. Therefore, new implementations should not contribute to making people doubt their use. User-friendliness, as well as ease of use, is something that Son et al. (2012) also emphasize as important in their assumptions.

Initially, to enhance a thorough implementation of Dalux for the construction site, Dalux Box should be used during the design phase. This will help to facilitate the transition from the earlier phases to the production phase since everything is in the same software. However, in this present case, JM does not use Dalux BOX during its design phase. To make Dalux more suitable for the individuals on the construction site and for a particular project, the layout and foundation of Dalux Field should be organized by people who have a connection to the production phase.

5.2.3 Provided Education and Training

When the right individuals and the right prerequisites are in place to start using a new digital help tool, such as Dalux, the implementation of it can then be initiated. This requires the actual implementation and then that education and training within the program are given.

When the setup is made, it is time to educate the individuals who will use the program. According to Liu et al. (2015), education is needed for the adaption of new digital approaches and Son et al. (2012) mentioned that new digital help tools will be more accepted if proper training is provided. Thus, there is no discrepancy regarding the essentials of education and training when it comes to the implementation. However, what proper education and training is can be hard to identify, since proper in this matter is relative from individual to individual. Nonetheless, statements about when the education will be conducted and who will hold it are not consistent with each other. Whereas some believe it should be held at the start of the project, others believe it should be held gradually throughout the project. However, the beginning of the project can be perceived differently regarding which role individuals possess or when an individual arrives at a project. It was further mentioned how an individual or discipline-adapted education can contribute to the wider and increased use of Dalux. Based on the statements about when the education should be held, a more thorough education can be carried out early in a project with people with more responsibility. Thereafter, the super-user or a BIM-Leader or VDC-Specialist can hold an individualized training where the only relevant material is taught to individuals in certain disciplines.

Something noticeable was the variety of statements regarding which activities and to what degree digital help tools should be implemented. However, Sundquist et al. (2020) stated that a combination of the traditional way and BIM can help the transition towards using BIM. Another perceived statement from Disney et al. (2021) was that if construction workers are allowed to use the traditional working methods, they will easily fall back on them. Instead, implementation will be more effective if the individuals on site do not have the possibility to work in another way than digitally. Aligned with what Sundquist et al. (2020) stated, Consultant B said that since the lead time in the construction industry is long, a non-directly application on Dalux is not possible, therefore, a combination of the traditional way of working and the new digital way is combined. In this matter, Site Manager A believed it is better to just implement Dalux and then evolve the digital knowledge during the process since Dalux is user-friendly. The Project Engineer, on the other hand, said that it is up to the project to decide what to include and that it is based on which activities are relevant. Because of statements about how intensive and rigorous the implementation of a digital tool should be, there may not be a straight answer to what is best. Thus, all construction projects are unique and project-based, therefore conducting a project may be different and therefore opinions on how the implementation should be are different.

5.2.4 Provided Help and Support

Afterward, when the education has been given, support is necessary to maintain the digital work methods. Due to the environment on the construction site, direct support was preferable. If no support is given directly, there is a chance that other approaches will be chosen instead. With direct support, it is meant one phone call away or personal interaction on the construction site with a specialist or generalist. Another support that was mentioned was that individuals met separately with a specialist, where specific topics can be highlighted and discussed instead of having to sit in larger meetings and having to go through the points from all the meeting participants. In addition, it was mentioned that other individuals on the construction site can be a support as well. This is something that Son et al. (2012) mentioned as an assumption for a wider acceptance and the use of a digital help tool. Thus, the social effect and impact were noticeable if several individuals used the same program.

Furthermore, as previously mentioned, the right support is essential for individuals on-site to utilize digital help tools. Therefore, the most obvious support feature that JM will provide will be a “super-user”. This person will act as a local contact in the region who will be able to answer questions when they arise and provide support and training. This role was decided to be filled since a need for technical support had been identified. Additionally, support from JM and from a “super-user”

are provided which aligns with organizational and technical support that Son et al. (2012) mentioned as an assumption for a wider adaption. Support might be even more important for individuals who are skeptical of new digital approaches. Therefore, the organization needs to highlight the benefits, and if that is not enough, JM can thus make sure that working digitally will be the new standardized way of working. Then everyone will work in the same way, despite skepticism. Governing activities contribute to a standardized way of working. If it is decided that certain activities must be done in Dalux, it does not matter what attitude different individuals have toward this. Therefore, governing activities should be prioritized and implemented to increase the digital way of working.

5.2.5 Utilization of Digital Help Tools

When the moment comes for the actual use of Dalux or other digital tools on the construction site, it can be used to various degree and activities. Initially, Bråthen and Moum (2016) said that by using a digital help tool, the individuals on the construction site can get access to a lot of project information that is needed for every unique work context. This is also mentioned by Site Manager A who stressed the advantages of having all the information with you to the construction site instead of having it at the construction site office. In accordance too this, Koseoglu and Nurtan-Gunes (2018) claimed that the process of going to the site office to look for drawings or other information will be eliminated since everything is on the mobile device. Another advantage of having the mobile device with you on the construction site is that the model and the information will almost always be up to date. The present degree of usage in Dalux chosen by JM is only one governing activity, and additionally, smaller mundane activities are used such as looking at the drawing. By adding new and more governing activities in Dalux, wider usage of it will be used. Therefore, more governing activities can be implemented, and this is something Disney et al. (2021) mentioned as a push toward to a faster and wider implementation of a digital work approach.

It is not always clear how well the construction site's various actors use Dalux. The construction industry has been working for many years before digital work approaches and therefore it is not decisive for those particular activities to be conducted in Dalux. It is mentioned from the interviews that Dalux and the digital work approach can sometimes make more harm than good, especially if the activities are small. Then more time and resources will be allocated for that activity since the activity is governed through Dalux. In addition, it could also be that some activities are not prioritized to be conducted through Dalux since it is not governing. Then individuals can choose to conduct the activity through the traditional methods. It is also stressed that there is no reason to put everything in Dalux, only to have everything in the same program. An activity that are easier to perform through another application noticed from the interviews is to measure in Bluebeam, and therefore there is arguable to say that if individuals on site think it is easier to perform some activity in Bluebeam, they should still have the possibility to do so. But for the wider adaption of Dalux it is important to choose by yourself to prioritize Dalux, even if there is an opportunity for the old or other methods. Sundquist et al. (2020) mean that by combining the new digital approaches with the more traditional way of working, the transition towards the new digital approaches will be easier for the individuals, hence the individuals take the steps of the development by themselves.

5.3 Acceleration Phase

The time it takes to adopt a digital tool in construction varies and is difficult to predict in advance (Jansson et al., 2016). However, it is critical not to divert resources and support after the physical implementation because change is more likely to fail if perseverance is overlooked (Wong et al., 2019). As shown in the Digital maturity matrix, the intention after implementing the digital tool is that the existing and digital activities are no longer divided, and thus the digital transformation can accelerate (Jansson et al., 2016). However, to succeed, the strategy and vision must pervade the entire company, and the necessary reinforcement must be in place. Furthermore, the consultants are hired to develop the strategy and oversee the implementation of the digital tool Dalux for JM, whereas Consultant C assumes that the company's management organization is most likely to be responsible for the future, to ensure digital maturity and perseverance.

Additionally, Consultant B is unsure about how to improve everyone's digital maturity and not just the enthusiastic younger employees. Therefore, it would be ideal and beneficial to collect tacit knowledge that has developed among the employees in the construction and transform it into explicit knowledge so that it is accessible to all. The company would then be able to establish necessary prerequisites to inspire tradition-bound and skeptical employees through success stories, evidence of effectiveness, and best practices. Moreover, analyzing how construction employees react to innovation could be useful in determining which requirements are needed to further improve the company's digital maturity and common competence, as well as for future innovations and digital transformations.

Moreover, both the VDC-Specialist and the Project Engineer from the two other companies agree that if two work methods are constantly presented, most people will choose the one which they are most familiar with. Furthermore, Disney et al. (2021) believed that all other tools should be extracted for a simpler transaction, resulting in the implementation of the digital tool as a requirement. File-sharing programs and digital tools will eventually be replaced when Dalux is implemented, according to the JM internal website. Although construction employees and the VDC-Specialists do not perceive the necessity to extract the digital tool Bluebeam. Sundquist et al. (2020) argued that combining new digital processes with old ways of working can enhance the transition and at the same time make the individuals feel empowered to make their own decisions. Although Roger (2003) believes that fear appeals, and pressure are the last required prerequisites for persuading the skeptical about the digital transformation. To avoid hindering the transition, all the decisions must be carefully made at the managerial level, recognizing the construction perspective of the decision. The Production Manager further stated that new Dalux processes and activities are being developed over time and tested in different projects. As a result, abstracting all the other tools before Dalux is ready could be unwise and create resistance in the construction.

To further develop the digital tools for construction, BIM maturity needs to systematically and gradually develop. Hence, Succar (2009) describe when model-based collaboration takes place in BIM stage 2, the level of information in the model increase, and document-based information decrease. As a result, all the actors operate in the same model at the same time, and less information is lost in other internal documents and processes. However, JM import separated IFC-files from various actors to build the 3D-model used for Dalux, and a cloud-based alternative would allow them to advance in BIM phases and BIM maturity. Hence, taking necessary steps and decisions in the early stages can have a significant impact for the construction.

Furthermore, the company must continue to seek improvement and anchor the new approaches in order to help consolidate the newly formed culture (Jansson et al., 2016). Hence, if the desire to improve digitalization diminishes, digital maturity can stagnate. Therefore, management needs to obtain control without controlling while continuing to communicate the value of digital transformation. Construction project tends to become more complex and complicated and with collaboration and coordination, digital transformation will become necessary to be a competitive company. Finally, the acceleration phase is present if the company has succeeded in bringing together the best of technology and the greatest of humanity.

5.4 Implementation vs Transformation

Throughout the development of this thesis, the word prerequisite has been mentioned, and this paragraph is to clarify and simplify the meaning of these prerequisites. Initially, to achieve the purpose and aim of this thesis, the prerequisites for the implementation of a digital tool for the construction site were intended to be identified. However, as the study progressed, the focus switched and the importance of the prerequisites for the digital transformation needed to be answered. Therefore, the three phases of Jansson et al (2016)'s Digital Maturity Matrix have played an important role in the development of the thesis.

The progression from prerequisites for digital implementation to prerequisites for digital transformation was necessary because the study revealed that the most important prerequisite in the implementation of a digital tool was the transformation, which naturally lead to an understanding of prerequisites for digital implementation.

6. Recommendations

In this section, strategies and prerequisites for the implementation of a digital tool in the construction are presented. The recommendations will assist construction managers in comprehending the required digital transformation. If the requirements are fulfilled, the company has ensured the appropriate culture for change and achieved digital maturity. The recommendations are divided into different intervals since the first requirements must be accomplished before the next stage can be initiated. Although, it is essential that the digital tool is implemented in the design phase before it can be implemented at the construction site.

Before implementation

Acceptance	Establish a sense of urgency and interest for the new digital tool. Emphasize why construction site employees should use the tool and what the individual can gain and achieve by doing so. As a result, employees want to devote time to the change.
Communication	Use different communication channels to establish the sense of urgency and acceptance for the digital tool. Use construction site employees who are enthusiastic to spread the message.
Strategy and Vision	Develop a strategy for the implementation and set the vision for the digital tool for the company. Everyone in the company should be able to comprehend and access it.
Analysis	Models like ADKAR can be utilized to comprehend the employees' perspective, attitude and viewpoint when introducing a digital tool.
Specialists	A carefully chosen group of people with managerial and change management abilities who will establish the implementation strategy and procedures.

The implementation

Technology	Secure installation and license of the digital tool, such as Dalux. Ensure that the construction site's employees have appropriate hardware such as mobile devices, computers and wireless network.
Willingness	The majority of the employees now has to see the benefits with the new digital tool. Start the implementation at construction sites with employees who are innovators and early adopters.
Generalist and specialist	Combine specialists and generalists and produce a reference group that can provide feedback. Choose one or more candidates for the role of "Super-user," who have construction experience and will work as a supportive link between the specialist and the construction.
Education	A project-specific education in the early stages of construction and personalized training depending on demands during the production phase.
Support	Direct support that is available at all times. There should be phone support or personal engagement from a specialist, “Super-user” or co-worker on site.
Time	It is crucial for an organization to allocate time for the construction workers and prioritize the learning process of a new digital tool.

After the implementation

Perseverance	Don’t divert resources and support directly after the implementation. The strategy and vision need to pervade the entire company.
Evidence of effectiveness	Use a platform to communicate and inspire employees with best practices and success stories.
Decision-making	Extract alternative work methods or digital tools that are similar to the new tool once it is fully implemented. Determine if the tool should be a construction governing activity.
Develop	To provide an impact on the construction, strive to develop in BIM phases and BIM maturity in the early phases. Don't stop the desire for digitization and anchor the digital culture.
Knowledge management	Knowledge transfer and applications from a finished project to a new project.

7. Conclusion

The thesis examined the implementation of a digital tool in construction, which has been criticized for having a low propensity to change. However, it has been observed that it is not the industry's unwillingness to change, but rather that the responsibility of the organization to provide the necessary prerequisites for the employees is insufficient, which hampers the transformation for an enhanced digital maturity. Therefore, the affected individuals need a higher level of attention rather than the process and strategies for the new technologies prioritizes. Therefore, the right prerequisites for digital transformation are essential for the implementation of digital tools.

As a result, before implementation the organization must focus on communication methods as well as cultural transformation and acceptability. The vision for the digital tool needs to be developed and analyzed by the organization so that the vision aligns and is adapted to the users' perspective. Nonetheless, the study revealed that the organization has not optimized the potential of the change management consultants. They are responsible for developing processes and strategies for a digital tool without having any construction experience. The consultants would be better suited to achieving cultural change for digital tools, whereas BIM professionals should be the specialists that simultaneously develop processes and strategies for the digital tool for construction.

Additionally, the case company possesses the most important prerequisites for a successful implementation of digital tools in construction to assure digital maturity. JM is one of the few construction companies that oversee the whole value chain. As a result, JM has the possibility to shape BIM manuals in the design phase that are suited for the transition to the construction phase, as well as take advantage of the knowledge gained through knowledge transfer between the phases and projects.

Although, to implement a digital tool in construction the focus should be on the individual's perspective rather than the technological processes of the digital tool. A fully achieved digital transformation generates digital maturity and implementation of digital tools in the construction is only successful if everyone participates in the digital transformation.

7.1 Future Research

After the performance of this thesis, interesting new perspective have emerged that may be worth to further research in.

- How can a clear vision and purpose influence a more efficient implementation of a digital tool in construction?
- How much better will it be if Dalux Box is utilized in the design phase during the implementation of Dalux Field?
- What have the soft parameters for impact for the implementation of a digital tool in construction?
- How can a bottom-up strategy influence the implementing a new digital tool?

References

Agenda, I. (2016). Shaping the future of construction a breakthrough in mindset and technology. WEF, Geneva.

Alexander, R. (2019, June 17). Tacit, Explicit, and Implicit Knowledge: Definitions and Examples. Bloomfire. https://bloomfire.com/blog/implicit-tacit-explicit-knowledge/

Anderson, N. J., Bachman, L., Perkins, K., & Cohen, A. (1991). An exploratory study into the construct validity of a reading comprehension test: Triangulation of data sources. Language Testing, 8(1), 41-66.

Barlow, J. (1999). From craft production to mass customisation. Innovation requirements for the UK housebuilding industry. Housing studies, 14(1), 23-42.

Bell, E., Harley, B., & Bryman, A. (2022). Business research methods. Oxford university press.

Bigliardi, B., Galati, F., & Petroni, A. (2014). How to effectively manage knowledge in the construction industry. Measuring Business Excellence.

Boca, G. D. (2013, March). Adkar model VS. quality management change. In International Conference Risk in Contemporary Economy; Faculty of Economics and Business Administration, Dunarea de Jos University of Galati: Galati, Romania.

Bowden, S., Dorr, A., Thorpe, T., & Anumba, C. (2006). Mobile ICT support for construction process improvement. Automation in construction, 15(5), 664-676

Britcher, J. (2017). *Leading Change by John Kotter*. Transformation Management. https://transformationmanagement.com/management-resources/leading-change/

Bråthen, K., & Moum, A. (2016). Bridging the gap: bringing BIM to construction workers. Engineering, Construction and Architectural Management.

Böes, J. S., Barros Neto, J. D. P., & Lima, M. M. X. D. (2021). BIM maturity model for higher education institutions. Ambiente Construído, 21, 131-150.

Chen, Y., & Kamara, J. M. (2011). A framework for using mobile computing for information management on construction sites. Automation in construction, 20(7), 776-788.

Creasey, T. (2020). *ADKAR: Core to the People Side of Change*. Prosci. https://blog.prosci.com/adkar-core-to-the-people-side-of-change

Dalux BIM Viewer. (n.d.). Dalux. Retrieved April 4, 2022, from https://www.dalux.com/sv/bim-viewer-plus/

Dalux Box | Common Data Environment (CDE) med integrerad BIM Viewer. (n.d.). Dalux. Retrieved April 4, 2022, from https://www.dalux.com/sv/dalux-box/

Dalux Field | Konstruktions app för snagging, RFI, Checklistor och HSE. (n.d.). Dalux. https://www.dalux.com/sv/dalux-field/

Dalux FM. (n.d.). Dalux. Retrieved April 4, 2022, from https://www.dalux.com/sv/fm-overview/

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS quarterly, 319-340.

Digital Maturity Matrix – a methodology that puts you in command Leading digital transformation. (n.d.). Digitaltransformation.net. Retrieved May 22, 2022, from https://digitaltransformation.net/en/digital-maturity-matrix-a-methodology-that-puts-you-in-command/

Disney, O., Johansson, M., Leto, A. D., Roupé, M., Sundquist, V., & Gustafsson, M. TOTAL BIM PROJECT: THE FUTURE OF A DIGITAL CONSTRUCTION PROCESS. Industry 4.0 Applications for Full Lifecycle Integration of Buildings, 21.

Ertan, J. (2018). Digital Readiness of Swedish Organizations.

Flyvbjerg, B. (2006). Five Misunderstandings About Case-Study Research. Qualitative Inquiry, 12(2), 219–245. https://doi.org/10.1177/1077800405284363

Gu, N., & London, K. (2010). Understanding and facilitating BIM adoption in the AEC industry. Automation in construction, 19(8), 988-999.

Hautala, K., Järvenpää, M. E., & Pulkkinen, P. (2017). Digitalization transforms the construction sector throughout asset's life-cycle from design to operation and maintenance. Stahlbau, 86(4), 340-345.

Heale, R., & Twycross, A. (2015). Validity and reliability in quantitative studies. Evidence-based nursing, 18(3), 66-67.

Heaton, J., Parlikad, A. K., Owens, D., & Pawsey, N. (2019). BIM as an Enabler for Digital Transformation. In International Conference on Smart Infrastructure and Construction 2019 (ICSIC) Driving data-informed decision-making (pp. 49-54). ICE Publishing.

Jansson, J., Andervin, M., & Klose, N. (2016). *Att leda digital transformation*. Hoi Förlag.

Javadi, M., & Zarea, K. (2016). Understanding thematic analysis and its pitfall. Demo, 1(1), 33-39.

JM AB. (2021). JM Annual Report 2021. https://www.jm.se/externalfiles/cision/B1365BBF17AA4D06/wkr0006.pdf

Joseph Galli, B. (2018). Change Management Models: A Comparative Analysis and Concerns. *IEEE Engineering Management Review*, *46*(3), 124–132. https://doi.org/10.1109/emr.2018.2866860

Kim, C., Park, T., Lim, H., & Kim, H. (2013). On-site construction management using mobile computing technology. Automation in construction, 35, 415-423.

Koseoglu, O., & Nurtan-Gunes, E. T. (2018). Mobile BIM implementation and lean interaction on construction site: A case study of a complex airport project. Engineering, Construction and Architectural Management.

Liu, Z., Lu, Y., Nath, T., Wang, Q., Tiong, R. L. K., & Peh, L. L. C. (2021). Critical success factors for BIM adoption during construction phase: a Singapore case study. Engineering, Construction and Architectural Management.

Liu, S., Xie, B., Tivendal, L., & Liu, C. (2015). Critical barriers to BIM implementation in the AEC industry. International Journal of Marketing Studies, 7(6), 162.

Lorek, S. (2019, March 12). What is BIM (Building Information Modeling). Trimble.com; What is BIM (Building Information Modeling). https://constructible.trimble.com/construction-industry/what-is-bim-building-information-modeling

Mahamadu, A. M., Manu, P., Mahdjoubi, L., Booth, C., Aigbavboa, C., & Abanda, F. H. (2019). The importance of BIM capability assessment: An evaluation of post-selection performance of organisations on construction projects. Engineering, Construction and Architectural Management.

Matt, C., Hess, T., & Benlian, A. (2015). Digital transformation strategies. Business & information systems engineering, 57(5), 339-343.

Mero-Jaffe, I. (2011). 'Is that what I Said?' Interview Transcript Approval by Participants: An Aspect of Ethics in Qualitative Research. *International Journal of Qualitative Methods, 10*(3), 231–247. https://doi.org/10.1177/160940691101000304

Rogers, E. M. (2010). Diffusion of innovations. Simon and Schuster.

Sadeh, H., Mirarchi, C., & Pavan, A. (2022). CLASSIFICATION OF CONSTRUCTION FIRMS BASED ON BIM ROLES AND BIM LEVELS USING MACHINE LEARNING TECHNIQUES. The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, 46, 205-210.

K.S. Saidi, C.T. Haas, N.A. Balli, The value of handheld computers in construction, 19th International Symposium on Automation and Robotics in Construction (ISARC), Gaithersburg, Maryland, 2002.)

Saunders, M., Lewis, P., & Thornhill, A. (2009). Research methods for business students. Pearson education.

Son, H., Park, Y., Kim, C., & Chou, J. S. (2012). Toward an understanding of construction professionals' acceptance of mobile computing devices in South Korea: An extension of the technology acceptance model. Automation in construction, 28, 82-90.

Succar, B. (2009). Building information modelling framework: A research and delivery foundation for industry stakeholders. Automation in construction, 18(3), 357-375.

Sundquist, V., Leto, A. D., Gustafsson, M., Johansson, M., & Roupé, M. (2020). Bim in construction production: Gains and hinders for firms, projects and industry. In Proceedings of the 36th Annual ARCOM Conference (ARCOM 2020) (Vol. 505, p. 514).

Vaismoradi, M., Turunen, H., & Bondas, T. (2013). Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study. Nursing & health sciences, 15(3), 398-405.

Wong, Q., Lacombe, M., Keller, R., Joyce, T., & O'Malley, K. (2019). Leading change with ADKAR. Nursing management, 50(4), 28-35.

Xue, C. T. S. (2017). A literature review on knowledge management in organizations. Research in Business and Management, 4(1), 30-41.

Yap, J. B. H., Lim, B. L., & Skitmore, M. (2022). Capitalising knowledge management (KM) for improving project delivery in construction. Ain Shams Engineering Journal, 13(6), 101790.

Yusof, M. N., Bakar, A. H. A., & Tufail, M. A. (2012). Knowledge Management and Growth Performance: Construction industry perspective. In Joint Conference APSEC-ICCER 2012, October 2 (Vol. 4, pp. 316-320).

Zieliński, R., & Wójtowicz, M. (2019, March). Different BIM levels during the design and construction stages on the example of public utility facilities. In AIP Conference Proceedings (Vol. 2078, No. 1, p. 020075). AIP Publishing LLC.

DEPARTMENT OF ARCHITECTURE AND CIVIL ENGINEERING
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2022

CHALMERS
UNIVERSITY OF TECHNOLOGY