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Building Information Modelling in the Production Process: A Holistic Case Study of Routine Changes in the Norwegian Construction Industry


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# Abstract

In response to the lack of research on, and the calls to advance researchers' understanding of, the application of Building Information Modelling (BIM) at the construction site, this thesis aims to identify how the implementation of BIM in the production process has changed the routines in construction projects. The research question is explored through a holistic case study of two construction projects at Veidekke, Norway's largest construction and contractor company, which applied the BIM software to different degrees at the construction site. The theoretical basis for this study is organizational change, routine change, and sociomateriality. The findings indicate several routine changes and improved efficiency on-site as a consequence of the implementation of BIM in the production process. Further, the study identified the emergence of change agents in the organization, who plays a vital role in implementing and promoting the BIM software. The implementation of BIM enables change agents to educate the workers in applying the software and to develop new solutions which create a shift in the routines. Further, this thesis proposes on-site BIM as a boundary object that works as a platform for discussion, also enabling actors to apply their common interpretation of the data presented and thereby changing their routines. Summarized, this thesis discusses the consequences of implementing BIM software in the production process at the construction site. The practical and theoretical implications are discussed.

# 1.0 Introduction

This thesis examines how the implementation of Building Information Modelling (BIM) in the production process has changed the routines in construction projects. The software has been practically implemented in the Architectural, Engineering, and Construction industry (AEC) since the mid-2000s (Azhar et al., 2015), and from a technical standpoint, it functions as a 3D model (Kymmell, 2008) or a digital representation of physical and functional characteristics of a facility (NBIMS, 2010). Traditionally, it is perceived as a planning tool typically used in the design process of a project (Bråthen & Moum, 2015), however, the software increasingly represents an important factor during the production process (Hewage & Ruwanpura, 2006; Ruwanpura et al., 2012; Davies & Harty, 2013; Alarcon et al., 2013; Mäki & Kerosuo, 2013; Harstad et al., 2015; Bråthen & Moum, 2015; Van Berlo & Natrop, 2015; Vestermo et al., 2016; Murvold, et al., 2016; Svalestuen, 2017).

With rising complexity in construction projects, bringing BIM to the construction site is the most effective way for workers to acquire new information (Chen & Kamara, 2008). BIM has the possibility to solve several challenges on-site, such as improving efficiency, number of errors, and worker satisfaction (Ruwanpura, 2012; Mäki & Kerosuo, 2013; Bråthen & Moum, 2015), as well as reducing costs (Davies & Harty, 2013), improving stability, reducing inventories, improving workflow, and enhancing collaboration and teamwork (Alcaron et al., 2013). However, applying the BIM software at the construction site is still understudied (Bråthen & Moum, 2015). For example, Mäki & Kerosuo (2013) calls for further research on the possible changes in collaboration, while Vestermo & Murvold (2016) and Bråthen & Moum (2015) highlights the need to study both on-site BIM in multiple situations, what the use of on-site BIM implies for the workers, as well as considering different BIM tools used in combination.

With this thesis, we aim to extend existing literature, as well as respond to the calls to advance researchers' understanding of the application of BIM at the construction site (Mäki & Kerosuo, 2013; Bråthen & Moum, 2015; Harstad et al., 2015; Vestermo & Murvold, 2016). It aims to address the lack of research on the implications the implementation of the software has for the workers, how it causes changes in collaboration on-site, while considering several BIM tools used in combination. More specifically, this thesis applies theories from literature within organizational change, routine change, and sociomateriality.

Construction projects often consist of specialists from different firms and trades, working together for a brief period of time, completing specific tasks. Thus, the implementation of BIM at the construction site could be seen as an ongoing and continuous process, considering the unique characteristics of the construction industry (Bråthen & Moum, 2015). Consequently, this thesis emphasizes the continuous change literature, which defines change as evolving, ongoing, and cumulative (Weick, 1999). It entails searching for new ways of carrying out specific activities (Greenwood, 2012), as well as altering and strengthening existing knowledge and skills (Sitkin et al., 1998). Continuous change may also be viewed as situated improvisation, where actors attempt to handle novel difficulties and achieve specific tasks (Tsoukas & Chia, 2002).

To address the implications the implementation of BIM at the construction site has for the workers, and how it changes collaboration on-site, this thesis will discuss an additional part of the change literature, namely changes in routines. Routines are defined as *"repetitive, recognizable patterns of interdependent actions, involving multiple actors",* where this thesis focus on the performative aspect, viewing routines as actual performances by specific people at specific times, in specific places (Feldman & Pentland, 2003). Routines are a central part of organizations (Cyert & March, 1963), and may be perceived as situated ongoing accomplishments, which keep changing, dependent on the dynamic between ideas, action, and outcomes (Feldman, 2000). The role of agency is also central to the routine literature, where researchers can gain a better perspective of routines when they are not separated from the people applying them (Feldman, 2000).

As the BIM software will be central to this study, we will further account for the role of human-made artifacts, which also plays an essential part in routine change (Glaser, 2017). Organizations or its managers often create artifacts in order to guide future routine performances (Feldman & Pentland, 2003), where routines are changed in order to improve efficiency (Bresman, 2013), implement new technology (Edmondsen et al., 2001), or adjust to changes in the environment (Kaplan, 2015). As this thesis look at the impact artifacts has on routines, the theory of sociomateriality proves beneficial (Feldman et al., 2016). The sociomaterial approach looks at artifacts and actors as inextricably related, where neither exist without one another (Orlikowski, 2007; Orlikowski & Scott 2008, 2014; Orlikowski & Beane 2015). It argues that technology may provide a language where the actors create a common interpretation (Iveroth, 2011), that allows different groups to work together without consensus (Star, 2010).

To sum up, this thesis extends existing literature, as well as respond the calls for advancing research on BIM at the construction site (Mäki & Kerosuo, 2013; Bråthen & Moum, 2015; Harstad et al., 2015; Vestermo & Murvold, 2016). It does this by applying literature from organizational change, routine change, and sociomateriality. This leads us to the following research question:

*How has the implementation of Building Information Modelling in the production process changed the routines in construction projects?*

Considering the state of the research question, we have chosen a holistic case study design, of explanatory nature. This approach was selected as the thesis analyses the implementation of on-site BIM at two projects within an organization, looking at the overall picture and not comparing the cases. The empirical context in the study is two construction projects conducted by Veidekke ASA, with one being ongoing and the other completed. We will look at the combination of different on-site BIM tools, more specifically BIM-kiosks and mobile devices such as tablets and smartphones. Both projects provide a broad range of characteristics, which helps us gain a more holistic conclusion to the research question. We are integrating qualitative research methods, using secondary data and semi-structured interviews to best capture the individual descriptions and perceptions of the actors' relationships and experiences.

The thesis is organized as follows: we will first provide a theoretical background, highlighting relevant literature to gain deeper insight into the construction industry, Building Information Modelling, and the mentioned theoretical perspectives. This is followed by a detailed presentation of the methodology, including the choice of design, case selection, how we collected and analyzed the data, as well as the validity and reliability of the research. We continue by presenting and analyzing the empirical findings, before discussing the results. Finally, we discuss theoretical and practical implications, and address limitations.

# 2.0 Theoretical Background

In the pursuit to understand more about how the implementation of Building Information Modelling in the production process has changed the routines in construction projects, we turn to organizational research to explore what is already known about BIM, the use of BIM at the construction site, how routine change happens in organizations, and the relationships between the material and human aspect. By providing a firm grounding in related literature, we will be better able to deliver comprehensive empirical research (Eisenhardt & Graebner, 2007). The review has provided us with new knowledge and has consequently helped us uncover what needs to be researched further. As a result, we present three propositions that will guide the research along with the research question. To avoid uncertainty regarding certain ideas, this section will also contain definitions of fundamental concepts and notions, as some are prone to interpretation.

## *2.1 The Norwegian Architectural, Engineering, and Construction Industry and Building Information Modelling*

To gain a deeper understanding of the setting of the research, we elaborate on the structure of the Norwegian Architectural, Engineering, and Construction industry (AEC). By doing so, we provide an understanding regarding which part of the building process BIM could be used as a tool. To describe the Norwegian AEC industry, we are relying on the work of Eikeland (2001) and Espelien & Reve (2007). We further elaborate on Building Information Modelling in order to gain more information about the software essential to this study and how it is used in construction projects.

### *2.1.1 The Norwegian Architectural, Engineering, and Construction Industry*

It is no simple task to create an unambiguous and general definition of an industry, and the same goes for the AEC. It inhibits a complex value chain, caused by the large range and number of services in demand (Espelien & Reve, 2007). Eikeland (2001) states that: *"The building process encompasses all processes that lead up to the planned construction"*, which points to the existence of several sub-phases. Espelien & Reve (2007) identified three distinct phases in the building process: development, execution, and management. The development phase entails identifying the goal of the project, as well as gaining the official approval from the relevant authorities. The execution phase, or construction phase, is the realization of the approved plans – the actual construction of the building. Finally, the management phase includes the operation, and possible rehabilitation, of the construction.

Eikeland (2001) dives deeper into the construction phase, and suggest three core processes. First, we encounter the process of programming, which is defined as *"the project owners view of which requirements the finalized construction should satisfy".* This process is the foundation of the construction phase (Eikeland et al., 2000). Next, we encounter the design process, which involves the development of the physical properties of the constructions, in the form of drawings, models, and descriptions. These solutions are based on the requirements and assumptions formulated by the project owner.

The programming process and design process lay the foundation for the last stage, the production process. Here we find the actual construction of the building, its physical performance, focusing on continuous improvement of the construction. This clarifies the scope of the research, where we will be focusing on the use and implementation of BIM in the production process of the construction phase. However, it is worth mentioning that although the processes are generally seen as having a certain order, in practice there is often an overlap in time between the core processes (Eikeland, 2001).

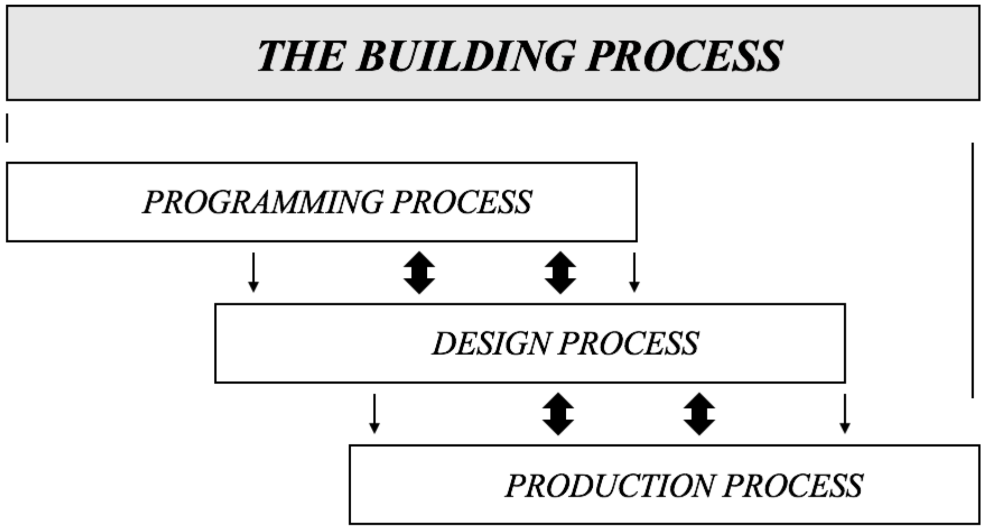


*Figure 1: Core Processes of the Building Process (Eikeland, 2001)*

*2.1.2 Building Information Modelling*

Building Information Modelling has for a significant period of time been frequently used in construction projects; however, the usage and design of the software has developed throughout the years. It was, and are by many still, seen as a revolutionary software which transformed the way constructions are envisioned, designed, constructed, and operated (Hardin, 2009).

Among the many definitions of BIM, most of them highlight the same core aspects of the software. One of the more comprehensive definitions is from the National Building Information Modelling Standards (NBIMS) which states that: *"BIM is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility, forming a reliable basis for decisions during its life cycle; defined as existing from earliest conception to demolition"* (NBIMS, 2010).

The Associated General Contractors of America adds to this definition, saying that data from *BIM "can be extracted and analyzed to generate information that can be used to make decisions and improve the process of delivering the facility"* (AGC, 2005). Chuck Eastman et al. (2008) further added that BIM was not just a modelling software, but could also be defined as *"associated set of processes to produce, communicate, and analyze building models"*. This is supported by the Construction Industry Council, which defines BIM as *"a collaborative way of* *working, that is underpinned by digital technologies which support more efficient methods of designing, creating, and maintaining the built environment"* (CIC, 2013).

What becomes clear from these definitions, is that BIM is not just a type of software, it is also about making changes in the workflow and project processes (Hardin, 2009). The fact that BIM is a process, as well as a shared knowledge resource for information, is what separates BIM from regular 3D models. The roots of BIM go back to the 1960s, wherein 1962 Engelbart presented his vision of the future architect (Abanda et al., 2015). It is further related to the parametric modelling research in both Europe and the United States in the 1970s and 1980s (Azhar et al., 2015), where the first BIM software available, named ArchiCAD, was released in 1984 (Bergin, 2012). The AEC industry practically started to implement BIM into projects from the mid-2000s (Azhar et al., 2015), with the term today being widely accepted and adopted by all of the key vendors of 3D software (Watson, 2010).

Traditionally, BIM is perceived as a planning tool used in the design process of a project (Bråthen & Moum, 2015). Looking at BIM from a technical standpoint, it functions as a 3D model, or a simulation, of all the modules in a project (Kymmell, 2008). Simultaneously, it connects these modules with all available information related to the building, including its physical and functional characteristics, to produce a fully coordinated production (Azhar et al., 2015). The models and representations are all generated from a unified archive, making the BIM software dependent on the integrity of the underlying database (Watson, 2010).

From a process perspective, BIM act as a tool which combines all aspects of a facility within a virtual model, creating an environment that favors more efficient collaboration than traditional processes (Azhar et al.,2015). This environment can be seen as a network of autonomous actors, cooperating to develop a model of the planned constructions (Taylor & Bernstein, 2009). The improved collaboration is expected to lead to better productivity, reduced costs, and increased efficiency in the design process (Bråthen & Moum, 2015). The BIM model also facilitates making changes at an early stage of the process (BIM Pro, 2018).

Kensek (2014) separate BIM into different dimensions, which is reproduced in Vestermo & Murvold's (2016) paper. In the two cases we investigate in this study, the BIM model contains the third-, fourth-, and fifth-dimension mentioned by Kensek (2014). In the following sections, we will elaborate on these dimensions:

*BIM 2D*. BIM 2D refers to two-dimensional printed drawings, the more traditional blueprints. These drawings are in many situations better suited than a 3D model, especially for small details where in-depth information has no use. This information would drastically increase the size of the model and would require an unnecessary amount of time modelling. This makes 2D drawings still applicable.

*BIM 3D.* The three-dimensional BIM model provides visualization, as well as possibilities for prefabrication and avoidance of collision. The visualization part of the 3D model is often what we refer to when discussing BIM, which makes it possible to visualize a building and its components in three dimensions, as explained above. The amount of information in the model also allows for the prefabrication of parts, which increase the overall productivity and reduce costs. In addition, the 3D model makes it easier to discover collisions in the design process, which reduce the number of errors.

*BIM 4D.* The fourth-dimension is here defined as time. By adding time to the model, it is possible to simulate changing of the seasons, how it is to move around in the building, etc. It also makes it possible to include information on lead time, the time needed to become operational, how long it takes to construct, and dependencies on other parts of the project (McPartland, 2017). Further, the time-dimension makes it possible to add progress, providing the opportunity to compare the current status of the project with the original plans. This dimension makes it possible to ensure that the work is conducted logically, safely, and efficiently (McPartland, 2017).

*BIM 5D, 6D, and 7D.* With the BIM model, it is much simpler to calculate lengths and volumes, which means that the total cost of the construction can be calculated at a much earlier stage in the design process. This leads to more detailed cost estimates, and more accurate measurements, which is the fifth BIM dimension. The sixth dimension is described by Kensek (2014) as information about the life cycle of the project, while 7D contains information about the management of the building, its operation, and maintenance.

## *2.2 Building Information Modelling in the Production Process*

Even though BIM is traditionally used in the design process of a project, the software could also be an important factor during the production process (Murvold, et al., 2016). BIM in the production process or at the construction site is referred to as *"on-site BIM"* in this study. The application of the software is somewhat similar as in the design process, involving visualization and planning (Eastman et al., 2011). Van Berlo & Natrop (2015) define three categories: computer terminals on-site (BIM-kiosk), mobile devices, and specialized environments. The BIM-kiosk developed by Veidekke can be described as a movable *"box"*. When opening this box, you find a large TV-screen connected to a computer, where the BIM software is installed. The kiosk is designed to be easy to move and to fit through doors, making it applicable both inside buildings and at the site (See illustration 1 and 2). Mobile devices entail tablets and smartphones, where the BIM software is installed. The workers may carry these devices with them when they are at the construction site. Specialized environments, such as BIM-caves, contains several screens and projectors installed in one room, and is designed to create a virtual reality inside the *"cave"* (Murvold, et al., 2016).


*Illustration 1.*

*Illustration 2*

The use of BIM on-site is a relatively unexplored area; however, a few studies have addressed the phenomena (Hewage & Ruwanpura, 2006; Ruwanpura et al., 2012; Davies & Harty, 2013; Alarcon et al., 2013; Mäki & Kerosuo, 2013; Harstad et al., 2015; Bråthen & Moum, 2015; Van Berlo & Natrop, 2015; Vestermo et al., 2016; Murvold, et al., 2016; Svalestuen, 2017). Bringing BIM to the construction site would make information accessible where the physical work is carried out, and workers will have it available whenever necessary. According to Chen & Kamara (2008), this is the most effective way for workers to acquire information. Van Berlo & Natrop (2015) claims that even though the BIM model provides more in-depth information, it *"stays hidden for construction workers on-site",* implying that the benefits of BIM in the production process have been limited. The production process is still dominated by 2D paper drawings (Bråthen & Moum, 2015), which could prove to be inefficient.

Van Berlo & Natrop (2015) states that *"with a raising complexity and fragmentation of experts on a construction site, most drawings don't seem to provide enough information, and are not specific enough for specialized tasks"*, making the argument for on-site BIM. Lofgren (2007) describes a situation where different administrative activities at the construction site must be carried out twice, both at the site and at the office computers, making the workers run back and forth between the two locations. This leads to inefficiency, solvable by using on-site BIM.

Further studies on BIM in the production process have seen optimistic effects, such as positive results in efficiency, number of errors, and worker satisfaction (Ruwanpura, 2012; Mäki & Kerosuo, 2013; Bråthen & Moum, 2015), as well as reduced costs (Davies & Harty, 2013), improved stability, reduced inventories, improved workflow, and enhanced teamwork (Alcaron et al., 2013). On-site BIM allows the workers to investigate complex issues and to access detailed information, almost impossible to see on paper drawings. Van Berlo & Natrop (2015) argue that bringing BIM to the production process would create a useful communication tool between the site workers and the site management, as well as improving communication on-site. As a consequence, it facilitates a greater level of collaboration between site workers, as on-site BIM leads to more meetings both planned and randomly near the BIM-kiosk (Bråthen & Moum, 2015). In their study of on-site BIM and the use of tablets in construction projects, Davies & Harty (2013) showed that technical skills were developed through personal relationships, rather than formal processes.

Looking more closely at learning, Harstad (2015) emphasized the importance of guidance and training in the implementation of on-site BIM, although it will incur costs. The study, therefore, concluded that it is crucial to have ambassadors promoting success stories to show the benefits of on-site BIM. Alcaron et al. (2013) also identify some of the barriers in implementing BIM in the production process, namely software and hardware issues, cultural barriers, legal aspects, lack of commitment, lack of client requests, and lack of training. Further, Mäki & Kerosuo (2013) found that on-site BIM made improvements on-site management, although inaccurate information in the models and insufficient knowledge among the workers proved to be a challenge when using the software.

The section above highlights the limited amount of research concerning on-site BIM, and several authors have called for further investigation. Mäki & Kerosuo (2013) call for further research on the use of on-site BIM and the possible changes in collaboration. Bråthen & Moum (2015) call for more research on what the implementation of on-site BIM implies for the workers, as well as projects where several tools, e.g., BIM-kiosks and mobile devices, are used in combination. Vestermo & Murvold (2016) states that even though some research has been conducted regarding on-site BIM, it is necessary to conduct similar explanatory studies of different construction projects to gain further insight. Concerning theoretical perspectives, previous literature on BIM at the construction site mainly focus on lean principles, implementation of new technology, hidden information, or general observations of the software.

To answer the research question, we believe identifying how the implementation of on-site BIM affects the efficiency of at the construction site, will help us. We believe changes in efficiency is directly related to changes in routines, and by identifying changes in efficiency, we will be able to connect them to and recognize, routine changes. This study applies three performance metrics; time, cost, and number of errors. The existing research believes implementation of on-site BIM will have a positive effect on efficiency at the construction site (Chen & Kamara, 2008; Van Berlo & Natrop, 2015; Lofgren, 2007). The first proposition is therefore as follows:

Proposition 1: *The implementation of on-site Building Information Modelling increases the efficiency in the production process.*

## *2.3 Change in Organizations and Routines*

*"The unstable environmental conditions in which modern organizations operate means that the ability to successfully manage change has become a key competitive asset"* (Macredie & Sandom, 1999). While written almost 20 years ago, this statement is as relevant as ever. Different types of change permeate all parts of the organizational space, with digitization being a significant driver.

Even though change is a widely known and recognized concept, there is little consensus around the definitions of what change really is, and it largely depends on the scope of the research and level of analysis. From a more general perspective, Ford & Ford (1994) define change as: *"a phenomenon of time. It is the way people talk about the event in which something appears to become, or turn into, something else, where the "something else" is seen as a result or outcome".* Huber et al. (1993) looked at change from an organizational view, specifically changes *"in how an organization functions, who its members and leaders are, what form it takes, or how it allocates its resources".*

As a means to understand the routine changes imposed by the introduction of BIM at the construction site, we feel it necessary to dive into the routine change literature. Scholars have discussed the *"routine"* term for decades, and as a consequence, we are presented with several definitions. At the most basic level, organizational routines allow different groups of people to work together to achieve shared goals and objectives (Howard-Grenville & Rerup, 2016). However, we have chosen to focus on Feldman & Pentland's (2003) definition of routines as *"repetitive, recognizable patterns of interdependent actions, involving multiple actors".* This definition is referring to organizational routines, characterized by multiple actors and interdependent actions (Feldman & Pentland, 2005). Cohen & Bacdayan (1994) argue that also individual features, such as skills and habits, contribute to organizational routines. However, this study will focus on organizational routines.

To truly understand routines, Feldman & Pentland (2005) stresses the distinction between the ostensive aspect and the performative aspect. The ostensive aspect characterizes routines as abstract patterns that participants use to *"guide, account for, and refer to specific performances of a routine"* (Feldman & Pentland, 2003). The performative aspect characterizes routines as actual performances by *"specific people at specific times, in specific places"* (Feldman & Pentland, 2003). Considering the nature of this research, we find the performative aspect to be the most appropriate. The ostensive aspect is something that exists in principle, and it is created through the process of objectification (Sevon, 1996). This aspect is seemingly deprived of active thinking, which is contrasting to organizational routines which involves a range of actions, behaviors, thinking, and feeling

(Feldman, 2000). Consequently, as we are looking at routines through Feldman & Pentland's (2003) definition, the performative aspect is more suitable.

It is also useful to make a distinction between routines and practices, in order to specify the focus of the research. According to Schatzki (2001), practices can be explained *as "clusters of recurrent human activity informed by shared institutional meanings"*. Central to the practice theory is the focus on the everyday activities and the view that social life is an ongoing production, and thus surfaces through the repetitive actions of individuals (Feldman & Orlikowski, 2011). When comparing the definitions of routines and practices, it becomes evident that the two perspectives share several similarities. However, when viewing routines as practices, you emphasize the consequentiality of the actions that individuals take while they are enacting routines (Feldman & Orlikowski, 2011). This will not be the focus of this study.

Routines are perceived as a central part of organizations, as many of the tasks completed in organizations are performed through routines (Cyert & March, 1963). They provide an understanding of appropriate behavior (Cohen & Bacdayn, 1994), and they help coordinate motivational goals and performance targets (Nelson & Winter, 1982). However, how organizational routines are perceived depends on how you choose to look at them (Feldman & Pentland, 2005). Weick (1999) separate between change that is *"episodic, discontinuous, and intermittent"* (macro perspective) and change that is *"continuous, evolving, and incremental"* (micro perspective).

This thesis will put more emphasis on the continuous change literature. Construction projects often consist of specialists from different firms and trades, working together for a brief period of time, completing specific tasks. Thus, the implementation of BIM at the construction site should be seen as an ongoing and continuous process, considering the unique characteristics of the construction industry (Bråthen & Moum, 2015). However, we will not neglect the contrasting views, as we find several elements useful.

*2.3.1 Continuous Change*

The change literature often makes a distinction between the macro and the micro levels of analysis. By applying a macro level of analysis, observers look at the organization from a distance, often addressing planned or episodic changes (Weick, 1999). On the other hand, the micro view brings us closer and suggests ongoing adaptations and adjustments. Advocates of the micro level of analysis often argue that collectives are incapable of action; meaning only individuals, which these social structures consist of, are able to act (Pfeffer, 1982). Ford & Ford (1995) state that macro changes are generated through the emergence of several micro-conversations, giving weight to the statement that even though changes are micro, it does not mean they are trivial (Staw, 1991).

The ongoing micro processes are often referred to as *"continuous change"*, a term which is used to cover organizational changes that "*tends to be evolving, ongoing, and cumulative"* (Weick, 1999). Where the planned or episodic change is the realization of intended alterations, continuous or emergent change is the realization of new structures which cannot be anticipated, in the absence of explicit a priori intentions (Mintzberg & Waters, 1985). Hutchins (1991) backs this claim, stating that many changes in an organization arrive from local adaptations, and not from managerial planning or reflection.

According to Vaughan (1996), continuous change could be seen as a sequence of fast mini-episodes of change, while Orlikowski (1996) defines it as the idea that minor alterations, created concurrently across units, can lead to significant change. She further notes that when changes in everyday activities *"are repeated, shared, amplified, and sustained, they can, over time, produce perceptible and striking organizational changes".* Sitkin et al. (1998) add to the idea of continuous change, claiming that it is not necessarily about altering or substituting a specific action but may also include the alteration and strengthening of existing knowledge and skills.

The following excerpt from Orlikowski's (1996) article acts as a thorough explanation of the concept of continuous change: *"Each variation of a given form is not an abrupt or discrete event, neither is it, by itself discontinuous. Rather, through a series of ongoing and situated accommodations, adaptations, and alterations (that draw on previous variations and mediate future ones), sufficient modifications may be enacted over time that fundamental changes are achieved. There is no deliberate orchestration of change here, no technological inevitability, no dramatic discontinuity, just recurrent and reciprocal variations in practice over time. Each shift in practice created the conditions for further breakdowns, unanticipated outcomes, and innovations, which in turn are met with more variations. Such variations are ongoing; there is no beginning or end point in this change process".*

Further, Orlikowski (1996) focus on the situated nature of continuous change, by defining it as situated micro level changes and ongoing improvisations by organizational actors, in order to *"make sense and act in the world coherently".* Others share this view of continuous change as situated improvisation, with Tsoukas & Chia (2002) defining it as localized attempts to handle novel difficulties and achieve specific tasks. It involves searching for new ways of carrying out specific activities (Greenwood, 2012). Battilana (2009) goes on saying that organizational actors' situated improvisation may unintentionally break with the dominant logic in their field, generating changes that are *"accidental"* (Plowman et al., 2007). Dorado (2005) supports this observation, although pointing out that even though change that develops from situated improvising is not strategic, it is not entirely unintentional or random either. Several studies have shown that situated improvisation has positive effects on restructuring (Orlikowski, 1996), cost savings and design effectiveness (Moorman & Miner, 1998), and other similar organizational activities (Weick, 1999).

Viewing routines from this perspective, several authors did early state their importance concerning flexibility and change (Cyert & March, 1963; Nelson & Winter, 1982). Routines may be perceived as emerging dynamic systems (Cohen, 1996) and situated ongoing accomplishments, which keep changing, dependent on the dynamic between ideas, action, and outcomes (Feldman, 2000). Feldman (2003) in her study of the enactment of routines, describe how they are recursively reproduced and yet adapt each time they are invoked (Langley, 2007). This view correlates with the micro level of analysis model, where organizations improvise, innovate, and adjust their routines over time (Orlikowski, 1996).

A question that needs to be addressed when discussing the literature of continuous change is why this level of analysis is worth pursuing. Most research focusing on change at an organizational level has emphasized the fact that change happens as a result of planned managerial actions (Tsoukas & Chia, 2002). In their paper, Tsoukas & Chia (2002) presents enlightening and compelling arguments for the relevance of continuous change. They argue that if researchers continue to view change as episodic or rare events in an organization's life, we underestimate how pervasive change is. By looking at change from the outside, we ignore some of the more important traits that change features; open-endedness, fluidity, and indivisibility. James (1890) share this view, stating that *"the stages into which you analyze change are "states"; the change itself goes on between them. It lies along their intervals, inhabits what your definition fails to gather up, and thus eludes conceptual explanation altogether".* Greenwood and Hinings (1996) continue by claiming that in order to understand change, we must accept that change has implications beyond those initially planned.

Several authors have shown the limitations of change programs, namely the fact that they rarely produce the change intended (Taylor, 1993). This does not imply that planned change strategies fail to create change as a whole. Planned change works as a trigger, and provides resources for further change. However, we do not know exactly what will happen, as these programs are often locally adapted, improvised, and elaborated by local agents (Tsoukas & Chia, 2002).

That change is an ongoing process in an organization, does not, however, imply that the firm changes constantly. Several of the local improvisations and alterations go unrecognized, and many of the local initiatives may never be implemented. Nevertheless, to only focus on the changes that are institutionalized we risk missing the micro alterations, which may lead to significant changes in an organization (Tsoukas & Chia, 2002).

We believe the research we are conducting offers a combination of two views, namely planned change and continuous change. As previously mentioned, the implementation of BIM at the construction site should be seen as an ongoing and continuous process because of the nature of construction projects (Bråthen & Moum, 2015). However, the choice of implementing BIM did not happen organically but happened as an initiative from the organization itself. Thus, we believe that by perceiving the implementation of on-site BIM as planned, while working as a trigger for further ongoing change, will be optimal for the study.

*2.3.2 Change Agents*

Building upon the previous section, Weick (1999) advocates the centrality of change agents in continuous change. This agent can be seen as a group or individual in an organization that undertakes the mission of handling and initiating change (Lunenberg, 2010). Weick (1995) links their importance to their ability to make sense of change dynamics which is already underway. *"They recognize adaptive emergent change, make them more salient, and reframe them. They explain current upheavals, where they are heading, what they will have produced by way of design, and how further intentional change can be made at the margins"* (Weick, 1999). Lunenberg (2010) summarize three different types of agents. The first type works to change systems from outside the organization, and are not a part of the company itself. The second focus on the individual; their morale, motivation, turnover, and quality of work. The third focus on changing the organizational structure to improve efficiency and output. The last focus on internal processes, communication, and relationships.

Lunenberg (2010) continues by summarizing three different roles taken by the change agent: The consultant helps employees in creating solutions based on information outside of the company. The trainer helps employees learn a new set of skills to solve future problems. Lastly, the Researcher, in close relation to the trainer, teaches the employees how to evaluate the effectiveness of action plans that have been implemented. Ford & Ford (1995) also emphasize the importance of change agents by stating that they produce change through different communication techniques. Dixon (1997) adds further insight, claiming that change occurs at the level of everyday conversations.

Change agents are also an important aspect of the routine change literature. Feldman (2000) has in great detail described the role of agents, and how we get a better perspective of routines when we do not separate them from the people applying them. Agents responses are situated in organizational, institutional, and personal contexts, which significantly influence the enactment of organizational routines. To account for agency when discussing routines, Feldman (2000) suggests viewing performative routines as a *"flow that includes the broad range of thoughts, feelings, and actions that people experience as they engage in work"*.

We believe investigating the role of change agents and their impact on routine changes will assist us in answering the research question. As highlighted in this section, previous research has emphasized the centrality of change agents (Weick, 1999), and researchers have shown that we get a better perspective of routines if we do not separate them from the people applying them (Feldman, 2000). We further want to investigate their link to on-site BIM, and through a sociomaterial lens, we propose that on-site BIM enables these agents of change. The second proposition is therefore as follows:

Proposition 2: *The implementation of Building Information Modelling at the construction site enables agents of change, which leads to further changes in routines.*

*2.3.3 Artifacts and Sociomateriality*

Research on routines has shown that human-made objects – *"artifacts"* – plays an important role in routine change (Glaser, 2017). Artifacts are the physical manifestation of an organizational routine, and it exists an infinite number of objects that both enable and constrain these routines (Feldman & Pentland, 2003). According to Pentland & Hærem (2015), artifacts have three specific roles when it comes to routine dynamics: they *"create affordances and constraints for organizational actors",* they *"encode the intentions of managers and designers"*, and they *"participate as actors that take actions"*.

Organizations or its managers often create artifacts to guide future routine performances (Feldman & Pentland, 2003). To intentionally alter routines in order to pursue objectives or to implement strategic initiatives, has been studied by several authors (Glaser, 2017; Rerup & Feldman, 2011). These objectives may include performance improvements (Bresman, 2013), implementing new technology (Edmondsen et al., 2001), and adjusting to changes in the environment (Kaplan, 2015). The intention to change a routine within the organization, either arise from the internal performance of the routine (Feldman, 2000), or external influences (Bresman, 2013). Ford & Ford (1995) state that planned change happens when a change agent *"consciously sets out to establish conditions and circumstances that are different than they are now".* Thus, intentionally changing routines often involves organizational actors in the present, trying to influence actions in the future, by creating artifacts to shape ongoing routine performances (Glaser, 2017). When these artifacts are implemented, they *"tend to sink in and become part of the users 'habitual background'"*, and by doing so influence future routine activity (D'Adderio, 2008).

However, studies have shown that to change routines with intention, often lead to unintentional consequences (Rerup & Feldman, 2011). Planned change models have at times dominated the organizational literature (Orlikowski, 1996), but have also been criticized for separating change from the ongoing processes in the organization, while overestimating the rationality of the agents responsible for the change (Pettigrew, 1987). Dunphy (1996) stated that what frequently causes planned change, is the failure of people to create continuously adaptive organizations. However, as long as human actors perform the routines, they also create a potential for continuous change (Tsoukas & Chia, 2002).

The theoretical foundation of sociomateriality also has implications for artifacts in routines, as Feldman et al. (2016) concluded in their article. One sociomaterial assemblage could provide different results in different cases. This line of research refers to artifacts by the term *"materiality".* In addition, sociomateriality often use the phrase *"sociomaterial practices"* instead of routines, however, there is little difference between the two as discussed in previous sections. The field of sociomateriality is relatively new and builds on a thought that the material and social are inextricably related, where *"there is no social that is not also material,* *and there is no material which is not also social"* (Orlikowski 2007). The theory is based on shortcomings in previous literature.

Traditionally, the relationship between materiality and the social have been viewed as separable. For example, the role of materiality has either been downplayed, disregarded, or taken for granted by previous researchers (Orlikowski, 2007; Barad, 2013). Technology and materiality have been treated as a special case by some researchers. This means that materiality has been investigated in specific cases of technology adoption, diffusion, or usage within or across organizations (Barley, 1988). The problem with such an approach is that it generates difficulties generally dealing with materiality in organizational research. For example, materiality or technology would only be considered when a specific event arises, and not as something that is bound to every organizational routine (Orlikowski, 2007).

Another difficulty with this focus on materiality is that it tends to either have a techno-centric perspective or a human-centered perspective. A techno-centric perspective focuses on the effects caused by the technology and is interested in how technology leverages human action. This approach assumes that technology is exogenous, predictable, stable, and performs as intended across time and place. The techno-centric perspective then ignores how technology is bound by historical and cultural influences, as well as different circumstances (Barley, 1988). The human-centered perspective focus on how humans exploit and interact with technology in different situations. This approach treats technology as dynamic and special based on the various meanings assigned to it and the diverse ways in which people interact with it. The human-centered perspective sees technology in different socio-cultural and historical contexts; however, it tends to minimize the role of the technology itself. The technology vanishes in the interaction with actors, as this approach primarily focuses on the human side of the relationship (Button, 1993). Previous literature also suggests that humans and materiality mutually shape each other in a reciprocal or mutual relationship. This entails that the two has an individual purpose when not interacting with each other (Barad, 2003).

To cover the shortcomings in the previous literature, authors like Barad (2003), Law (2004) and Orlikowski (2007) have argued for a new approach that views the social and the material as constitutively entangled. This perspective claims that the two has no characteristics or purpose without each other, and that one gives meaning to the other (Barad, 2003). *"Materials are treated as relational products. They do not exist by themselves"* (Law, 2004). This view of the social and material as constitutively entangled is what we today call sociomateriality. Orlikowski has written several articles about the theory in recent years, where she enhances the inextricably relationship between actors and materiality (Orlikowski, 2007; Orlikowski & Scott 2008, 2014; Orlikowski & Beane 2015).

Looking at sociomaterial practices, Orlikowski & Beane (2015) argues that practice could only exist once it is materialized in specific artifacts, infrastructures, technologies, times, places, or settings. The abstract properties or aspects of the technology does not matter, but how work practices are materially enacted (Introna & Hayes, 2011). This approach emphasizes practices, and that work is ongoing and will be performed differently based on its material enactment through different technologies. In practice, work and material configure each other (Orlikowski & Beane, 2015). Several researchers have looked at sociomateriality in practice within fields such as strategy as practice, organizational change, routine change, etc. (Feldman & Orlikowski 2011; Iveroth, 2011; Orlikowski & Beane, 2015; Feldman et al. 2016).

Orlikowski & Beane (2015) studied how coordination of night rounds at a hospital was enacted with the technology in use. They conducted the study with a sociomateriality perspective. As the previous literature on coordination look at how properties of technology influence different contexts and applications (Jarzabkowski et al., 2012), the findings in this study contrasts the existing literature. While previous studies have looked at the technological properties or patterns of use, Orlikowski & Beane (2015) examine how coordination is materialized through specific technologies. By focusing on material enactments, the authors found several ways in which the night round routines were enacted with different technologies, which affected the coordination significantly. Their findings suggested that the night rounds were materially enacted, especially within the preparatory work (Orlikowski & Beane, 2015).

Iveroth (2011) applied the sociomateriality approach when he investigated IT-enabled change in Ericsson. His article contributes to the field of sociomateriality by creating a framework illustrating how material and social elements coexist during change. His study concludes that materiality and technology have its limitations, for example, could materiality as an ERP system provides a common ground by the *"language"* it creates. However, it has no purpose without the human actors, as they provide the common meaning through translational activities. This describes how human actors, through their actions, transcend the limitations of the materiality (Iveroth, 2011). These findings build on the idea of perceiving the social and the material as constitutively enacted and inextricably related (Orlikowski, 2007). An excellent way to describe this relationship is to compare it to a carpenter and a hammer; both are useless without one another (Polanyi, 1958).

We believe that applying a sociomaterial lens, investigating the relationship between the BIM software and the actors at the construction site, will help us to answer the research question. As discussed in this section, the existing research argues for an inseparable relationship between the artifact (BIM software) and the workers at the construction site (Orlikowski, 2007; Orlikowski & Scott 2008, 2014; Orlikowski & Beane, 2015). In addition, existing research has argued that the artifact provides a language, in which actors develop a common interpretation of. The artifact or software consequently works as both a platform and a basis for changes in routines (Iveroth, 2011). The third and final proposition is therefore as follows:

Proposition 3: *Building Information Modelling provides a language through visualization, which enables the actors to apply their common interpretation to, and thereby change, their routines.*

# 3.0 Methodology

In this section, we will first and foremost describe the design of the research, the methods we applied in order to collect data, and how we analyzed the data. In addition, we will explain the reliability and validity of the data. The purpose of this section is to elaborate on the methods we have used, why we used these methods, and how the methods were conducted.

## *3.1 Research Design*

This thesis aims to look at how the implementation of BIM in the production process has changed the routines in construction projects, within the context of the Norwegian AEC industry.

Considering the philosophical underpinnings, we are conducting research with a constructionist view. Social constructionism, indicate the belief that individuals both affect and are affected by social experiences, and it is built on the premise of social construction of reality (Searle, 1995). Creswell & Creswell (2003) argues that individuals develop subjective meanings from their own experiences and that arguments are relative to a person’s perspective. In that matter, truth becomes relative to perception (Yin, 2003). Individuals construct their own meaning in different ways, even in relation to the same phenomenon. Hence, multiple contradictory, but equally valid, accounts of the world can exist (Gray, 2013).

This study is interested in capturing how individuals experienced the implementation of on-site BIM, and how they interpret its effect on the routines performed at the construction site. A constructionist view supports this mission, as it enables collaboration between the subjects and the researchers, allowing them to tell their stories (Crabtree & Miller, 1999). It will enable the researcher to get a deeper understanding of the participants' actions, as they are allowed to describe their view of reality (Baxter & Jack, 2008). Consequently, the data collection is based on interviews, as it allows us to capture the nuances of the individuals constructed understandings.

From a theoretical perspective, this links to an interpretivist point of view, which *"looks for culturally derived and historically situated interpretations of social life-world"* (Crotty, 1998). It requires researchers to grasp the meaning of social interaction, and are concerned with the empathic understanding of human action rather than with the forces that act on it (Bryman & Bell, 2015).

Considering the state of the research question, we have chosen a holistic case study design, of explanatory nature. A case study can be defined as a detailed analysis, focusing on a bounded system or situation (Bryman & Bell, 2015). According to Yin (2015), a case study is most relevant if the questions one wishes to answer is about *"how"* and *"why"* some phenomena work, and in which case they are asked *about "a contemporary set of events over which the researcher has little or no control".* The same applies to questions that require a thorough description. While the choice of case design is inhibiting comparison between this and future research, it allows us to study the implementation of on-site BIM and its effect on routines more in-depth.

Yin (2015) identifies five different rationales for when to use case designs, in which we define the chosen cases as unique. On-site BIM is a relatively new concept, and while other cases have been documented, we believe the qualities and circumstances of the chosen cases are unique. Yin (2003) adds that a case can also be considered unique if it is one of few distinctive cases, which we believe is fitting for the setting of this study. We describe the nature of the cases we have chosen at a later stage.

Further, we have chosen to use a holistic analysis approach. Yin (2003) identifies two directions within case studies; embedded and holistic. Both approaches refer to a situation where there might be more than one unit of analysis (subunits) within a case, and not just one specific process or situation. The embedded case study examines several embedded units, where they are selected by sampling or clustering techniques. In contrast, the holistic case study aims *to "only examine the global nature of a program or of an organization"* (Yin, 2003).

A holistic approach was chosen as this case study analyses the implementation of on-site BIM at two projects within an organization, looking at the overall picture and not comparing the two cases. The two projects had different characteristics in its use and implementation of on-site BIM, including factors like experience, size, maturity, etc. To only focus on one project would have deprived us of valuable information and perceptions. The holistic approach is beneficial, given the multiple perspectives analyzed as part of this case study.

However, to apply a holistic approach may in some situations be problematic as well (Yin, 2003). The global approach may allow the researcher to avoid examining any specific phenomenon in operational detail. Another issue that may occur is that the study may be conducted at an abstract level, lacking any clear measurements or data. We try to avoid this issue by collecting in-depth data from interviews of several actors related to the implementation of on-site BIM. Nevertheless, it is important to recognize that the holistic approach is inhibiting us from gaining the detailed benefits of one single case study, as well as the benefits from comparing two similar cases with and without on-site BIM.

## *3.2 Case Selection*

In the previous section, we explained the research design, as well as explaining the nature of case studies. In this section, we will describe the chosen cases and empirical context in more detail.

Probability sampling is not appropriate in qualitative research, so in most cases studies purposive sampling is applied. The sampling is done with the goal of the study in mind, where the cases are selected considering several criteria that will allow the research question to be answered (Bryman & Bell, 2015). We have chosen to use this method as it helps to identify cases rich in information, which is prone to provide a more in-depth understanding of the phenomenon (Patton, 2002). One approach within purposive sampling is theoretical sampling, which means that cases are selected because they are suitable for displaying logic and relationships among constructs (Eisenhardt & Graebner, 2007). This approach is straightforward, where the cases are chosen because they are *"unusually revelatory, extreme exemplars, or opportunities for unusual research access"* (Yin, 2003).

The empirical context in this study is two construction projects conducted by Veidekke ASA. Veidekke is the largest Norwegian construction and contractor company and consists mainly of three business areas: Construction, Real-Estate, and Industry (Veidekke, 2018). The organization introduced on-site BIM on selected projects in 2016 and has since then seen an increased rate of on-site BIM projects. This research is focusing on two projects within the construction segment, where we are studying the implementation of on-site BIM and how it changes the routines at the construction site. By using a holistic approach, we can gain insights from these two projects with different specifications, as well as insights from different actors with different roles and perceptions.

The two cases were selected based on several criteria, in order to answer the research question. In addition, the criteria are selected to fulfill the goals of the study, answering the call for further research on the possible changes in collaboration (Mäki & Kerosuo, 2013), as well as the need to study BIM in multiple situations (Vestermo & Murvold, 2016), what the use of on-site BIM implies for the workers, and different BIM tools used in combination (Bråthen & Moum, 2015). We wanted one case that was still an ongoing project and another case where the project was completed, in order to gain different perspectives. We also aimed for cases which had different characteristics when it came to scope, where one of the cases should be larger in size than the other.

On-site BIM had to be present in both cases, as it is central to the research. In bringing BIM to the construction site, you are able to use different types of tools in order to apply the software. As previously mentioned, Van Berlo & Natrop (2015) defines three categories: computer terminals on-site (BIM-kiosk), mobile devices, and specialized environments. For this research, we decided to focus on BIM-kiosk and mobile devices such as tablets and smartphones. We chose these tools as a criterion because the research on these is more extensive than others, providing us with a broader theoretical background. We chose to focus on both tools, instead of just one, as they to a greater degree complement each other, and we believe that excluding one will weaken the results. This will also help us address call for research on different BIM tools used in combination.

It was also important that both cases represented different levels of maturity and exposure when it came to the implementation of on-site BIM. As the purpose of the study is to explore how the implementation of on-site BIM has changed routines in the production processes, we believe that variation in size and maturity of the projects are important, to account for situational differences in the results. Variation in size is also important when looking at possible changes in collaboration, as it provides us with a larger number of groups and actors, working on different parts of the project. Different levels of implementation and exposure were chosen on the same premise. These criteria will give us insights from different perspectives, allowing us to study the use of on-site BIM in multiple situations, and to explore and arrive at a more holistic conclusion in contrast to more situational insights.

The first of the two cases are an ongoing project in the eastern parts of Norway, scheduled to be finished during 2019. We will refer to this project as the *"Cinema Project".* The project started in 2016 and consisted of two apartment buildings, one cinema, one hotel, one pavilion, and possibly one kindergarten. The project used on-site BIM to different degrees on different parts of the project. For example, one apartment building did not feature the software at all, while the pavilion used it throughout the whole process. However, the use of on-site BIM at the Cinema Project should be classified as moderate. The same applies to the workers' exposure to and experience with the software, as the project consisted of some individuals with extensive knowledge of applying on-site BIM and some with no previous involvement. The project consisted of one BIM-coordinator and one BIM-kiosk stationed in the middle of the construction site. Some actors and sub-contractors had access to tablets, although the exact number was not specified.

The second case is a completed project in the eastern parts of Norway, lasting from the beginning of 2017 to the spring of 2018. We will refer to this as *the "Paperless Project".* The project involved building an extension to a local school, consisting of 50 new office spaces with associated facilities such as meeting rooms and public areas. The project was one of the world's first *"paperless"* construction sites, where no printed drawings were allowed to use by contract. This happened because of the initiative from one of the project leaders, resulting in personal engagement and investment from the builder, Statsbygg. Their motivation was to develop a platform for digitizing future construction projects. Both the contractor and the workers had access to 12 electronic handheld devices (tablets) throughout the whole process. In addition, the project had one BIM-coordinator, and one BIM-kiosk stationed close to where the work was being carried out. The use of and exposure to on-site BIM during this project is classified as high. Similar to the other case, the experience of the workers with using the software is classified as moderate, as the project consisted of some individuals with extensive knowledge using on-site BIM and some with no previous involvement.

Both cases have applied the on-site BIM software in a similar fashion but to a different degree. Starting with the BIM-kiosk, it is on a general basis across both cases used by the workers when they need to look at the bigger picture of the project, observing progress (4D), know what the next move is or how the result is presented. It may also be used to calculate the costs of different materials (5D). As it is more often used for tasks of a grander nature, it is less used than the associated tablets. We discovered different ways of how the kiosk was used, similar to what was observed by Bråthen & Moum (2015) in their study on on-site BIM. The first situation is where workers used the kiosk individually to perform various tasks. The second situation is where several people are surrounding the BIM-kiosk, where the workers engage in discussions and exchange views and ideas in regard to what is shown on the screen. In this situation, it acts as a meeting place for professional discussions. The tablets are more frequently used, as they work as a replacement for the printed drawings. On these tablets, you have access to both the drawings, as well as the 3D model. The workers often carry these tablets with them and use them whenever they need more information about their tasks. Although the tablets provide a 3D model, the screen is much smaller than the one in the BIM-kiosk, and consequently, there is less discussion and meetings around this device.

The description above pictures the use of on-site BIM in both of the cases we have chosen. The differences between the cases regarding the use of the software come down to how often it is used, and the accessibility. The Cinema Project uses on-site BIM less frequent than the Paperless Project. It is worth re-mentioning that the former is not required to use the software, as opposed to the latter where the use is contracted. There is also a difference in the accessibility, where the Paperless Project has both more tablets and where the placement of the kiosk is closer to the ongoing work than at the Cinema Project.

We find both of these cases relevant as they match all of the criteria we previously stated. They provide us with a broad range of characteristics, which helps us gain a more holistic conclusion to the research question. We have both a small to medium-sized and a large project, different levels of exposure and experience, as well as different levels of implementation of the software. In addition, we interviewed several individuals with experience from previous projects using on-site BIM. We do not consider these previous projects as part of the study, but we acknowledge that some of the interview subjects may draw on these past experiences. To summarize, we believe that the two cases we have chosen will help us gain broad insights of how the implementation of BIM in the production process has changed routines in construction projects, and to gain a holistic perspective of the situation.

### *3.3 Data Collection*

In order to gain in-depth data, avoiding the study to be on an abstract level, as well as being able to capture the nuances of the individuals constructed understandings, we are integrating qualitative research methods. We are using semi-structured interviews and secondary data in order to best capture the individual descriptions and perception of their relationships and experiences.

The main part of the data was conducted through semi-structured interviews. Eisenhardt & Graebner (2007) describes interviews as a highly effective way of generating intensive and detailed empirical data, even though the data in certain situations may be biased. A semi-structured interview is a style in which the interviewer has a series of more general questions in the form of an interview schedule but may ask follow-up questions in response to what is seen as significant replies (Bryman & Bell, 2015). The interview guide we used during the interviews can be found in the appendix (See appendix 2). This method provided us with the structure to make the interview efficient, without leaving out important questions. The follow-up questions further allow for the possibility to gain more in-depth information on certain topics. This allowed us to obtain subjective descriptions from the interviewees, as well as being able to interpret the meaning of the described phenomenon.

To extract the necessary information, we identified numerous key individuals. These participants were selected according to criteria relevant to the research. One of these criteria was that the informants were able to view the implementation of on-site BIM from diverse perspectives. This criterion entails that the informants are representing different hierarchical levels and functional areas, in order to gain a complete picture (Eisenhardt & Graebner, 2007).  Examples might be from a managerial position, a technical position, or from the position as a construction worker. Further, this criterion entails informants that are using the on-site BIM software, developing the on-site BIM software, and managing the on-site BIM software. The participants should also have different levels of experience within the organization, different levels of experience with on-site BIM, varying in age, and have different educational backgrounds.

The study contains of nine representatives, representing different projects and different parts of the organization (eight men and one woman). See the appendix for an overview of their functions (Appendix 1). They were chosen on the basis that they had some connection to the use of on-site BIM. They represented different hierarchical levels, ranging from on-site workers, coordinators, project leaders, developers, and management. They had varying levels of competence with the use of on-site BIM, where some had little to no experience, some had a mediocre experience, and some had extensive in-depth experience with the software. In addition, they represented different age groups, ranging from mid-twenties to early-sixties. All interviews were audio recorded and transcribed in Norwegian.

We carried on performing these semi-structured interviews until we achieved theoretical saturation. The idea is that we continued to sample data until there was no need to keep collecting in relation to the chosen propositions. According to Strauss & Corbin (1998), theoretical saturation is achieved when no new relevant data is emerging, the researched category is well developed regarding dimensions demonstrating variation, and the relationships between the categories are established.

After conducted the interviews, we gained access to secondary data, which consisted of several PowerPoints, providing us with background information about the chosen cases and information about on-site BIM, as well as different perceptions regarding the use of the software. We further received a study conducted by Veidekke, about the use and perception of the BIM software in general. This study was sent out to all members of the organization. However, we had no part in designing or conducting the study. We learned of the internal survey while conducting the interviews. We further discovered a lack of information about the two cases after the interviews were completed, resulting in the request for more in-depth material. An overview of the secondary data can be found in the appendix (Appendix 3).

### *3.4 Data Analysis*

The data analysis is guided by the research question and the three propositions, presented in the theoretical background. As mentioned in the case design section, we have chosen a holistic view, where we look at the overall picture when analyzing the data, not comparing the two cases. The holistic approach provides us with the opportunity to analyze data from multiple perspectives, creating a complete picture. Nevertheless, it is important to recognize that the holistic approach is inhibiting us from examining the particular benefits of one single case study, as well as analyzing the differences between two similar cases.

One method within data analysis well fitted to case studies is what Yin (2003) refers to as pattern matching. In this method, several pieces of information from the same case may be related to the theoretical propositions. Here we may identify if the patterns in the data match the propositions, or not. We used this approach to create explanations on why or why not the patterns matched, and not endorse or debate the propositions itself (Yin, 2003).

We started by transcribing the interviews before we individually analyzed and interpreted them. In the analysis, we aimed to gain more knowledge on the effects of change agents in the implementation of on-site BIM, how the implementation affected the performance on-site, the sociomaterial linkages between on-site BIM and its users, as well as how the routines in the production process had changed. We then identified different relationships and patterns, and separated these into different classifications, related to the chosen propositions. Within these classifications, we also created different sub-categories. An example of these sub-categories was *"learning"* within the analysis of change agents.

We further applied a research approach identified as abduction or systematic combining (Dubois & Gadde, 2002). We moved back and forth between the findings and the literature, to stay flexible and to secure that we were aligned with the theory. The abductive approach is helpful when trying to discover new variables and relationships, and builds more toward refinement of existing theories than inventing new ones (Dubois & Gadde, 2002).

### *3.5 Validity and Reliability*

To establish the quality of empirical social research, four tests have commonly been used, even though the list is much more complex. These are defined by Yin (2003) as external validity, internal validity, construct validity and reliability.

According to Bryman & Bell (2015), validity is concerned with the integrity of the conclusions that are generated from the research. To firstly address the external validity; we have no interest in generalizing the findings, in the sense that we are not studying representative cases. The ability to generalize the study is a common complaint around case studies, and very few cases are likely to satisfy this complaint (Yin, 2003). However, Yin (2003) suggests that the generalizing should not address other cases, but instead researchers conducting case studies should try to generalize findings to theory. In this analytical generalization, the researcher will try generalizing a particular set of results to some broader theory. This has been the focus of this study as well.

To improve the internal validity, we have chosen to use the pattern-matching technique mentioned in the previous section. One common critique of case studies has been that they are based on subjective data and that they fail to create a sufficiently operational set of measures (Yin, 2003). To increase construct validity, Yin (2003) suggests selecting the specific types of modifications that are to be studied, and then justify why you will be using selected measures to reflect these changes. This is something we have accounted for by clearly defining specific parameters in relation to efficiency, as well as defining both change itself and change in routines.

Johnson (1997) also addresses two other types of validity which are important in qualitative research; descriptive validity and interpretive validity. The first refers to the accuracy in reporting descriptive information. We will address this by using investigator triangulation, in which there will be two people present to observe both interviews and other encounters, and at the same time, we will record the interviews. The second type mentioned by Johnson (1997) is interpretive validity, which refers to *"accurately portraying the meaning attached by the participants to what is actually being studied".* We addressed this by conducting precise preparatory work to ensure quality when developing the questions for the interviews. It was also crucial that the questions were linked to the research question.

Concerning reliability, it is described by Bryman & Bell (2015) as the question of whether the results of the study are repeatable. Brink (1993) states that reliability is *"concerned with the consistency, stability, and repeatability, as well as the researcher's ability to collect and record information accurately".* However, this does not imply that the goal is to replicate the results of the study, but conducting the same case over again (Yin, 2003). This definition is more directed towards reliability in a quantitative setting, and is difficult to achieve considering the choice of completing a case study. However, having proper documentation of the steps taken and the information gathered throughout the study, will help other researcher doing the same research, which improves the reliability. This is something we have done throughout this study, by carefully explaining the details of the case and the methods we have used, as well as attach the transcribed interviews and the interview guide.

Further, Golafshani (2003) argues that the term of reliability in qualitative research corresponds with what Guba & Lincoln (1981) termed *"dependability",* which again has close ties to the term reliability in a quantitative setting. Dependability is a way of showing that the findings in the research are consistent with the raw data that we collected. The technique mentioned to establish dependability is called inquiry audit or external audit. This entails having another researcher not involved in the research process examine both the process and product of the research study. Due to the nature of the study, the resources we had available, as well as the time limit, we will not be able to perform an inquiry audit. However, it should be mentioned that several of the interviews were conducted together with another experienced researcher, studying different effects within the same field. We believe that having an experienced researcher with us, increased the quality of the interviews we performed.

# 4.0 Empirical Findings and Analysis

In this section, we will present the empirical findings related to the research question, which is as follows: how has the implementation of Building Information Modelling in the production process changed the routines in construction projects? We do this by answering the three propositions presented in previous sections. We believe answering the first proposition, identifying how the implementation of on-site BIM affects the efficiency at the construction site, will help us to recognize routine changes. By answering the second proposition, investigating the role of change agents and their impact on routine changes, we will gain a better perspective of routines, as we do not separate them from the people applying them. Finally, we believe that answering the third proposition, investigating how BIM provides a language through visualization, will prove useful as the software consequently works as both a platform and a basis for changes in routines. Next, we will present the three propositions separately, in the order stated above. The quotes that are used in this paper are translated from Norwegian, and the wording may in some instances seem a bit off.

### *4.1 The implementation of on-site Building Information Modelling increases the efficiency in the production process*

The findings argue for a change in efficiency at the construction site. According to the informants, there has been an increase in efficiency due to changes in their routines. Several unnecessary activities are no longer performed, and processes have changed in nature and importance. However, because of the nature of the projects, it proves challenging to confirm where the increase in efficiency is located.

> *"We know we profit from using on-site BIM, but we do not know where"* - Informant 7

> *"We save a lot of time by using on-site BIM"* - Informant 5

Despite the uncertainty of where the efficiency increase is located, we have seen some indications. Several of the informants argue for efficiency change as a consequence of changes in the routines, which leads to cheaper and less time-consuming activities and a reduction of the number of errors occurring at the construction site, which is the three performance metrics applied in this research. The secondary data gathered from internal studies conducted by Veidekke supports the findings implying that on-site BIM increases the efficiency of construction projects.

A majority of the informants described on-site BIM software as a time-saving tool which, amongst other factors, reduce waiting time, time spent walking between the construction site and the barracks, and decision time. Before the implementation of on-site BIM, the contractor had to wait several days for adjustments, printing, and delivery of the paper drawings. Once a mistake or error was identified in the drawings, the contractor had to contact the architect to make adjustments and then send it back to the contractor. The contractor then had to send it to a printing company that printed a sufficient amount of copies for all the workers at the construction site. However, with on-site BIM the routine has changed, and both the contractor and the workers get access to the updated drawings digitally at any time desired without having to wait for the printing or the architect. The internal study from Veidekke also highlight this as an effect of on-site BIM and argue that the improved access and availability of drawings will save time (Veidekke 2018).

> *"An issue is that it takes two days before the printed papers arrive, which makes it difficult to control that the drawings the workers come in to get are correct or outdated. Once we have the drawings on an iPad everyone always has the most recent updated drawings available."* - Informant 1

> *"It is the delivery of the drawings the cost, and not making them"* - Informant 6

> *"When you order new drawings, you need the consultants and the building physicist to control, then you need to send them to the printing company who prints out the drawings and drives them back, then you need to sort the papers. So, you could imagine that several days are lost compared to if you had it digitally and could perform "two punch" and then you have everything in the 2D and 3D model. This is something we have seen that increase the efficiency in the projects."* - Informant 6

Another way the informants argues that on-site BIM saves time is by enabling the workers to access the fully sized model at the construction site instead of having to walk down to the barracks to look at specific drawings. Before the implementation of on-site BIM, the workers had to walk from the construction site down to the barracks to check the drawings, or to discuss uncertainties. When a project instead applies the on-site BIM software, the workers no longer have to leave the construction site to check drawings, as they are downloaded to both the tablet and BIM-kiosk, a significant change in their routines.

> *"The BIM-kiosk is primarily used for morning meetings and coordination between the workers, so they don't have to walk down to the barracks to look at the model and drawings"* - Informant 1

> *"By walking from the construction site to the barracks, you waste a lot of time because you need to abort your working activities, walk down to get the drawings, walk back, prepare the work and restart the activity you just aborted."* - Informant 1

> *"You have everything directly on your iPad. If you need to find out how someone has to set up or perform their job, you can control it directly at the site, instead of just building wrong and later have to re-do your work or walking down to the barracks to check the drawings."* - Informant 1

The third way in which the respondents highlights how they save time is in the decision-making process. The pre-BIM procedure had the workers engaging with the contractor to solve problems on-site, where often the contractor further had to contact the architect. This was a very time-consuming routine. However, with on-site BIM this routine has changed, and the workers can easily interact directly at the construction site by discussing the model in the BIM-kiosk. They no longer need to include other parties when solving simple issues anymore. The secondary data we received from Veidekke also discuss on-site BIM´s ability to make decisions more efficiently and find solutions faster (Appendix 3).

> *"The efficiency has increased. We reduce the costs by removing the printing machine. It is the delivery of the drawings that cost, and not making them. Now we can invite everyone on to one platform to have a third-party control of the drawings, and this saves time as well. It is difficult to see the savings immediately, but with time we see that we save time and costs on activities that we used to perform two times a day which took 15 minutes"* - Informant 6

> *"A large part of the progress is when the workers meet, discuss and solve issues. In such cases do they often use the computer and the model at the barracks? However, when we have BIM at the construction site is it easier, as you don't have to abandon your work and the site to discuss and solve issues."* - Informant 5

> *"There is a lot of time to save in the small decisions in the everyday activities."* - Informant 3

The informants have also described several ways in which on-site BIM contributes to cost-efficient projects. One way is that on-site BIM saves the contractor a significant amount of money regarding paper printing. Without applying BIM in the construction process, Veidekke has to budget with a very high amount of costs for paper. Every time a drawing or sketch is updated it needs to be printed and delivered by a printing company, with enough samples for all relevant workers on-site. Once a drawing is adjusted, they need to print out just as many copies once again. This is costly and can be avoided by using BIM-kiosks and tablets on-site, as these contain all drawings available once they are updated.

> *"I made an estimate of how much we spent on printing, and it was 120.000 NOK only on building X"* - Informant 1

The software also enables cost savings due to an easier method for procuring materials. With on-site BIM, the contractor may directly gather measurements of materials from the model and thereby make it easier to order the correct amount of materials, instead of spending time and effort on calculating an estimate of the required materials. The data we received from Veidekke (Appendix 3) also enhance the improvement of procurement routines as one of the advantages of implementing BIM at the construction site.

"BIM provides benefits in terms of ordering materials and detailed measurement estimates. The subcontractors' material lists are digitally synchronized through iCloud on all iPads, which enables all material orders to be performed directly at the construction site. This way we have developed good routines for ordering and time savings" - Informant 6

> *"You do things differently, you do not make manual estimates of all walls before you make an order anymore. You type in what kind of wall you want, and then you withdraw the number of materials before you make the order. It is more like a three-step process than a continuous process where*

*you go through every drawing to control your estimates. This is, without doubt, a lot faster"* - Informant 1

Furthermore, the respondents argue for a reduction in the number of errors during the construction process, because it is easier to identify and handle errors in the drawings at earlier stages with the BIM software. Reports received from Veidekke on the Paperless Project supports this view (Veidekke 2018). On projects without BIM, errors in the drawings are often identified at a later stage, which creates delays in the projects. However, with the BIM software on-site, the contractor can perform comprehensive crash tests and identify errors much earlier.

*"I will show you an example from building A (one of the projects at the Cinema Project). Here you can see that we have a major problem, as the ventilation system goes through the door. Issues like this are easy to identify with BIM before you start to work on it"* - Informant 5

According to the respondents, it is easier to discuss solutions with the various subcontractors once the relevant people can gather around a BIM-kiosk to solve issues. Previously, the sub-contractor had to approach Veidekke who then communicated with the relevant workers individually in order to come up with a solution. However, the implementation of on-site BIM has created a change in the routine, where the relevant workers now may discuss the potential solutions directly with each other.

*"In situations where it is needed do you bring up BIM, this could be in cases with minor issues, and the contractors are then able to solve the issue directly at the construction site."* - Informant 5

*"BIM increase the number of discussions because people see the benefit from it"* - Informant 3

*"BIM mitigates the risk of human-based errors in terms of wrong measurements."* - Informant 5

However, while the number of errors at the construction site has been mitigated, some informants still claim that the extent of the errors occurring has increased. This is because the software has enabled more complex buildings to be built.

> *"BIM has led to significantly less error, but the errors are also more complex. It is easier to build more complex buildings. Because when you make drawings on a computer, things are more easily calibrated, and when you run all these crash tests it enables you to identify the crashes prior to building. This makes building cheaper; however, this technology also allows more expensive and complex buildings to be built."* - Informant 7

Beyond these changes, on-site BIM has also contributed to changes in the communication routines, enabling subcontractors to interact directly once an issue occurs, instead of going through the main contractor.

The findings provide strong indications for a more efficient construction process, once BIM is implemented in the production process. The software seems to improve the existing routines and eliminate non-profitable activities at the construction site. We have discovered clear indications that on-site BIM saves time as it reduces waiting time, decision time, and procurement time. The software reduces costs, as projects need to spend less money on paper printing. The shift in the routines for procurement will also save money. Finally, the implementation of the BIM software in the production process will reduce the number of errors during the production process. This is because on-site BIM makes it easier to discover the mistakes in the drawings at an earlier stage, and it enables decision-makers to make faster decisions to solve errors.

## *4.2 The implementation of Building Information Modelling at the construction site enables agents of change, which leads to further changes in routines*

The informants all recognized the existence of specific employees pushing for the use and implementation of BIM at the construction site. These employees are going in front, being viewed as the heart of the implementation process. Most of them are doing this, even though it is not a part of their official work description. They are testing out new ways to enable and promote the advantages of the software while facilitating further use. This leads to more employees changing their routines, concerning new ways of collaborating, moving from regular 2D drawings to 3D models, etc. Most of the informants recognized several such agents:

> *"Maybe you have talked with X; he is very dedicated to getting BIM out on-site. [...] It is people like him who moves this forward."* - Informant 7

Some of the informants also recognized themselves as agents of change, describing a deep connection and interest for the software:

> *"Even though we have had BIM at the construction site for a little while, there is no gathering around it; it has not reached wide enough. There is, on the other hand, some "local enthusiasts" that uses BIM, if you can call them that. [...] There are quite a few IT-related things connected with BIM [...], and it became my little baby, where I have been involved a lot"* - Informant 9

This interest in the new software saw several of the local enthusiasts working towards creating new solutions more appropriate to their situation, as they recognized the potential of on-site BIM. One example surrounded the electricians, who had a tough time using the existing software. Both the BIM-kiosk and the tablet offered smaller screens than the drawings they were used to, which made it impossible to mark specific and small detailed wires, which reached across several sections. This issue usually saw the electricians not using the software to its full extent. This challenge gave one local enthusiast incentive to find a new solution, creating a movable station, with a much larger screen. He connected this station to the tablet. The large screen made it possible to mark the crucial wires, which is necessary to perform their work. The incentive and new invention from the enthusiast saw the electrician change their routines, now being able to use the digital model instead of paper drawings. Another example revolved around the execution of the Paperless Project, which started with the initiative of one enthusiast:

> *"We had a BIM-kiosk earlier, but this one is the first with VR-technology. Because I knew we could create a better version, so we did. We displayed it at several schools, and then I met the director of a company who wanted to see the new tech. He thought it was really cool that we had taken it a step further. Then I opened my big mouth and told him that this program could make us paperless. I saw his eyes lit up, and my eyes lit up as well, and it was just like a dream came true. We sat there and played with the thought. […] Then I got a meeting and showed them what I intended to do."* - Informant 6

All of the informants expressed an understanding of why BIM is being implemented at the construction site, and they also expressed the need for more training on the subject. This also became evident in Veidekke's (2018) survey, where the majority rated themselves as having low competence with using the software. On the statement *"I want more training on BIM"*, almost 92% of the respondents (544) answered *"yes"*.

> *"When it comes to training, the employees often realize themselves that they have problems and that they need training."* - Informant 8

Some employees received training directly from the company itself. Veidekke offers an internal learning-portal, containing different courses related to the use of BIM. However, these courses are not required and are usually offered to those who ask for it. The only one required to participate is the new trainees. The informants expressed the notion that the training came down to the initiative from the local enthusiasts:

> *"More often there are local enthusiasts that say: "Now we have to raise the competence level on this project"".* - Informant 8

The informants also provided several examples of their own initiative, when it came to raising the level of competence among their employees, consequently resulting in changes in their routines:

> *"No, Veidekke doesn't require us to go through the training. […] I asked who wanted it and provided training to those who showed an interest. This is to get them going. So, providing training is my own initiative."* - Informant 1

> *"I haven't got any more coursing than what I received at school. I trained people on the previous project, without getting any direct orders from Veidekke."* - Informant 7

This initiative to provide training and promote the use of on-site BIM also extends outside the employees of Veidekke, involving subcontractors. The informants explained that as there are usually no requirements in the contracts when it comes to the use of on-site BIM, local enthusiasts instead try to promote the software and provide support if needed:

> *"We haven't required any of them (subcontractors) to use it out on the construction site. So, it is all about supporting them, tell them what it is, and why they should use it. And we have seen that there are 2-3 firms that have purchased iPad's in order to learn how to use the technology."* - Informant 5

Local enthusiasts not only played a part in learning and training their colleagues on the use and benefits of on-site BIM. The interviews also uncovered that these individuals played an important role in influencing and transforming their co-workers, enabling other agents of change:

> *"They hated me in the beginning. […] in the end, it was the electrician who lectured the others, he stole the show. He thought it was amazing. And it was him who thought it was most difficult at the beginning […]. Most of them came around and thought it was cool at the end of the project."* - Informant 6

During the interviews, it also becomes evident that local enthusiasts play a significant factor regarding which projects that became so-*called "on-site BIM projects".* Some informants explain that construction projects usually are very focused on costs and deadlines, which prevents experimentation with new technology and new routines, as these often take time to implement. Workers often continue working in the same manner as they are used to. However, if the local enthusiasts express interest in making their project an on-site BIM-project, they are usually allowed to, in which case they get support from a regional BIM-technician. Some informants also expressed that there is a correlation between the level of experience of the workers with on-site BIM and which projects that use on-site BIM:

> *"The use of on-site BIM was not given three years ago, and some are now on their first real project with on-site BIM. While others are on their fourth. So, I believe that the ones who have used on-site BIM on another project, see its value, and will consequently use it more often and in several projects. So, the experience matter. […] If you have a construction manager that is enthusiastic, then it will happen more often."* - Informant 8

The consensus between the informants seems to be that each project is its own *"master",* with local enthusiasts leading the way for the use of on-site BIM. However, even though the local enthusiasts are to some extent responsible for creating new solutions, training new employees, and deciding which projects become *"BIM-projects",* the organization itself facilitates for the emergence of these enthusiasts. Instead of pushing or forcing the use of the BIM software, they rather offer support in the form of BIM-technicians, either remote or on-site, to projects that request it. The interviews also showed that the organization supports local initiatives, like the execution of the Paperless Project. They also provide funds to support a BIM-network, where local enthusiasts work to improve and distribute the BIM-kiosk, on top of their regular duties. This shows that the management of the organization is an important factor in nurturing agents of change:

> *"The philosophy here is that we believe in good examples. We have been working towards bringing these examples into the light, and instead of pushing it (on-site BIM), we have supported those that want to enlighten/evolve things. […] And then the others follow usually. [...] We*

*have no demands or requirements when it comes to the use of on-site BIM on the different projects."* - Informant 8

*"The focus on technology has accelerated here at Veidekke, and you won't get any questions if you would like to test new tech."* - Informant 6

Even though the company itself does not require the use of on-site BIM, the informants recognized the need for someone to take charge for change to happen. Some admit that they are willing to change their routines, as long as someone steps forward to illustrate why and how. It is not enough to have the software present and on-site:

*"You need someone to carry this, or else it will fall. If nobody does it, we only have a box standing there. The value is equal to zero. You need a local enthusiast. [...] Who this person is, does not matter."* - Informant 9

*" [...] someone needs to say: "Let's gather here (around the BIM-kiosk) and discuss it". Someone needs to take the initiative."* - Informant 3

Throughout the interviews, it also became evident that the implementation of on-site BIM has met some resistance. The underlying factors varied, but a combination of generational change, uncertainty, and general unwillingness to change old work habits stood out as most common. These factors were also evident in the survey conducted by Veidekke (Appendix 3). As one informant pointed out, *"changing your routines is never fun".* It became clear that local enthusiasts were instrumental in overcoming this resistance. They lead by example, initiating the use of the software, as well as displaying to their peers the benefits and functionality of on-site BIM:

*"They had their "nails out" in the beginning when they had to use tablets and all that because they were used to drawings. But during the project, they were very satisfied. They didn't use anything else. [...] We want them to think "We need this box (BIM-kiosk), this box can do so much for us".* - Informant 9

To sum up the findings regarding change agents, we found multiple examples of enthusiast that initiated change in the routines in terms of modifications of the technology itself. They further influence the beliefs, attitudes, intentions, and behavior of other individuals, as well as influencing the skills and competencies of their colleagues through training in the subject of on-site BIM. The organization does not force the use of the software, but they facilitate for the emergence of local enthusiasts and provide support to local initiatives. We have also seen that several individuals are willing to use the on-site BIM software, and as a consequence change their routines, as long as someone shows them the way and guide them in the right direction.

## *4.3 Building Information Modelling provides a language through visualization, which enables the actors to apply their common interpretation to, and thereby change, their routines*

Several of the informants have described their relationship with the on-site BIM software. They explained how their routines change as the software enables them to interpret the data differently. On-site BIM illustrates the buildings and drawings in a 3D model, which is argued to have changed how the workers interpret the available data. This has led to changes in routines at the construction site.

The informants have described their relationship with the on-site BIM as one where the software provides illustrations that enable the workers to interpret the available data in a whole new way.  The 3D illustrations supplied by on-site BIM has enabled the workers to have better knowledge and understanding of what they are building, without requiring the same amount of experience as before. This aspect of on-site BIM has also been discussed and highlighted in the report from the Paperless Project (Veidekke, 2018). The software also makes it easier to communicate between workers from different parts of the project, as well as workers who speak different languages. This makes it a handy tool, as construction projects consist of several different groups with different jargons, and the projects often engage workers with language barriers. The BIM software enables the discussions to be more productive as the model plays a central role in the discussions as a tool for illustrations.

> *"To read and interpret a drawing with heavy details is not always easy, it requires experience. But plain geometry is much easier to relate to."* - Informant 3

> *"[..] and we have the issue with communication between workers. The workers speak many different languages, and it is difficult when you don't completely understand each other, there is a high risk for misunderstandings. A 3D model, on the other hand, is applicable and easy to understand no matter what language you speak. And the distance from a 3D model to execution is a lot shorter"* - Informant 9

We have through the interviews identified strong indications that the software is enacted with new roles at the construction site. Informants have described that new positions such as BIM-coordinators and a BIM-network at the headquarters have appeared due to the software. The BIM-coordinators especially work on implementing and pushing out the software. The establishment of such roles has changed the way that routines are performed at the construction site. One example is the role of the BIM-coordinator, who are pushing the subcontractors to use the BIM software, either by providing training or constraints to their work. We believe this change the routines since new roles have been established. However, the research has provided no clear evidence for how the routines have changed in detail, beyond the fact that these new actors promote the use of BIM software at the construction site.

> *"All the regions have BIM technicians, and if you want to apply BIM to a project, you can get help from the BIM technician."* - Informant 9

> *"We have X who educates the workers on sight in the use of BIM. In Veidekke we also have an internal training portal where we engage in BIM exercises"* - Informant 5

> *"They (Veidekke) assigns BIM-coordinators with high competence to the major projects to aid, assist, and promotes the use of BIM. The strategy is that the whole organization should have the technical competence of BIM, and not just a few BIM technicians"* - Informant 9

Several of the informants have described that the BIM-kiosks works as a platform or a tool for discussion among workers from different parts of the project, as well as between the various groups and Veidekke. This implies a shift in the communication routines at the construction site. Before the software was implemented, all problems or inquiries went through Veidekke, who had to act as a mediating party and find a solution with each of the subcontractors. Now, the subcontractors meet by the BIM-kiosk and discuss the current challenge, as well as potential solutions.

> *"[...] They communicate more with each other than just with Veidekke"* - Informant 3

> *"When several workers are scheduled to work tightly will they meet at the BIM-kiosk to plan the work and to get greater insight in what should be done and what the others are doing"* - Informant 6

> *"Once we gathered the workers at the BIM-kiosk, it resulted in discussions and solutions we wouldn't have had otherwise."* - Informant 3

Some of the informants made us aware that some of the workers do not trust that the model is fully updated. They have experienced situations where the model is not detailed enough or not updated. The respondents that have discussed this uncertainty and challenge have been working on the Cinema Project, and their role in the projects are not as a BIM-coordinator. Also, Veidekke themselves has highlighted this as a challenge in their report after the Paperless Project. This way the language BIM provides can act more as an obstacle which does not increase or improve the communication.

> *"I have to say that we can't completely trust it (BIM), you have to manually check if the model illustrates the reality"* - Informant 2

> *"There could be things that have been changed at the drawings that haven't been adjusted in the model. We require that someone work with the drawings in the model at all times, to ensure that it always gets updated with the drawings. This is supposed to be happening, but we have seen some examples of situations where it hasn't been the case. This creates uncertainty of whether the model is outdated or not"* - Informant 5

Although this challenge has been highlighted by some of the informants, the majority argues that this is not an issue, indicating that on-site BIM provides an advantage as the workers can now be confident that they build after the updated drawing. This is also supported by the survey from Veidekke (Appendix 3). They argue that BIM software on tablets and kiosks will mitigate the risk of workers using different or outdated drawings. When the workers no longer have to check if their drawings are updated manually, and they no longer have to spend time getting new drawings, the risks of errors in the construction process is mitigated. The main contractor does not have to order, print, and distribute new drawings once changes are made either. This entails a change in the routines at the construction site.

> *"Previously you had to go and get the drawings every day, the issue with this is that it is a high risk that at least one of the workers use an outdated drawing. However, the software updates the drawing everytime you open the program, which enables the workers to be certain that they always have the most recent drawings"* - Informant 7

> *"You no longer work on the wrong basis and drawings"* - Informant 6

> *"The workers put down the drawings at the end of the day, and if changes are made they suddenly start the next day with two drawings, and if you then pick up the wrong drawing error and mistakes will be made"* - Informant 1

To sum up the findings, the respondents have described how the BIM software enables the workers to interpret the available data in another way. The model seems easy to interpret and understand, and has a central role in the discussions at the construction site. The software promotes discussions among the different subcontractors, also with language barriers, which is a shift in the communication and coordination routines from before on-site BIM. We have discovered a disagreement between the respondents on whether the software increase or decrease the likelihood of applying wrong drawings in the production process, however, it seems that those with the most experience with on-site BIM remain positive in regard to this issue. Finally, the findings indicate that the BIM software creates new roles at the construction site once it gets implemented. These actors aim to educate the workers in using the software, promote BIM, and ensure that it works as intentioned at the construction site. These individuals are seen as change agents which we discussed in earlier sections.

# 5.0 Discussion

This thesis has aimed to explore how the implementation of Building Information Modelling in the production process has changed the routines in construction projects. The following sections discuss the empirical analysis of the gathered data. The discussion is divided into four main sections, where the first section discusses the findings in light of the research question, and the last three discuss the findings in light of the propositions.

## *5.1 How has the implementation of Building Information Modelling in the production process changed the routines in construction projects?*

The overarching research question throughout this study has focused on how the routines in the production process have changed as a consequence of the implementation of BIM at the construction site. During the study, we have observed several changes in the routines, and in the following section, we will discuss these in closer detail.

Some organizational routines may simply emerge, but a great many routines are the product of explicit attempts to design efficient, effective work practices (Pentland & Feldman, 2008). Among other things, organizations often intend to guide future routine performances by pursuing goals such as improved efficiency (Bresman, 2013) and by designing artifacts (Feldman & Pentland, 2003) with material properties and functions intended to meet these goals (Simon, 1970). Artifacts are the physical manifestation of an organizational routine (Feldman & Pentland, 2003), and lies at the center of such efforts to intentionally change routines (Simon, 1970). The research conducted in this study adds to these statements.

While the study did not uncover whether Veidekke had intentions to change their routines specifically, it revealed that the organization had implemented on-site BIM in their strategy, with the purpose of improving efficiency at the construction site. However, as the artifact was designed by the organization with certain constraints, it is fair to assume that Veidekke anticipated several of the routine changes we observed.

The findings reveal several routine changes as a consequence of the implementation of BIM in the production process – some more noticeable than others. These routine changes are characterized by actual performances by specific people at specific times in specific places, describing the performative aspect (Feldman & Pentland, 2003). The most obvious was the change in the use of physical drawings and blueprints, where on-site BIM made the workers move away from these tools, and instead use digital models stored in their tablets or in the BIM-kiosk. This is a significant change in the routines, as the production process is still dominated by 2D paper drawings (Bråthen & Moum, 2015).

Lofgren (2007) describes a situation, where different activities at the construction site must be carried out twice, making the workers run back and forth between two locations. The research showed that the workers now had access to a considerable amount of information in their pocket, removing the routine of walking back and forth to the barracks to print out new drawings when starting on a new or different part of the project. With on-site BIM, it was also possible to exclude the printing company in the line of communication whenever there is an error in the model, simply making the architect make changes and upload it to the database.

Further, we observed a change in the communication routines. Van Berlo & Natrop (2015) argued that bringing BIM to the construction site would create a useful communication tool, which this research confirms. The on-site BIM created a platform for discussion amongst the various external and internal actors on the construction site, changing the way they communicated. Instead of discussing ideas, errors, or ways to proceed in specific meetings or through a mediating party, we observed that the implementation of on-site BIM made workers from different parts of the project initiating more casual meetings at the BIM-kiosk or surrounding their tablets on the construction site.

We propose that this makes on-site BIM a boundary object. Boundary objects are an arrangement that allows different groups to work together without consensus (Star, 2010). It qualifies the way in which actors maintain coherence between interactive social worlds (Trompette & Vinck, 2009). Wenger (2000) stated that a boundary object can be broken down into four dimensions: it facilitated dialogue between social worlds, several activities are made possible, different parts of the object can serve as a basis for dialogue between actors, and it renders the information interpretable. Judging from the results, we suggest that on-site BIM covers all the mentioned dimensions. Star & Griesmer (1989) also points out that not all artifacts are boundary objects, stating that they have to be meaningfully and usefully incorporated into the routines of actors working in diverse fields. We have shown that this is the case for on-site BIM, strengthening the proposition that it works as a boundary object.

The changes in routines we have presented are clearly caused by the implementation of on-site BIM. However, we propose that the magnitude of the routine changes is affected by different factors, and as a consequence varies between projects. This supports Feldman et al.'s. (2016) study, stating that novel amalgamations of theories, artifacts, actors, and routines – sociomaterial assemblages – could provide different results in different cases, as they involve different participants with diverse backgrounds and relationships to the artifact (Suchman, 2007).

This becomes evident in the two cases we examined. In the case of the Cinema Project, the research shows several of the mentioned routine changes, but only to a certain degree. The workers who have access to the tools are using tablets to look at the model, and they have experienced some changes in their communication routines. However, the BIM-kiosk is rarely used, and while they have access to the 3D model, they often choose to use drawings instead. This is similar to the findings in Pentland & Feldman's (2008) study, where they documented that after implementing a new artifact, it was only used to some extent. Paradoxical, the workers show a positive attitude toward on-site BIM, and they believe that the software is beneficial. In the Paperless Project, we experience all of the mentioned routine changes to a high degree. On-site BIM was being used alongside the BIM-kiosks, communication routines have changed, and the workers expressed a positive attitude toward the changes.

We propose that the differences between the projects come down to factors such as uncertainty, exposure to/experience with the software, the influence of change agents, and projects specifications. Uncertainty regarding whether the model was updated with the newest information, caused some workers at the Cinema Project to rather use the drawings. This was also observed by Mäki & Kerosuo (2013), where inaccurate and insufficient information in the models proved to be a challenge when using the BIM software. As we will discuss in the following sections, change agents are an essential factor in routine changes. We propose that if the Cinema Project had seen a more substantial amount of change agents, and if the agents on the projects had been more persistent and calmed the uncertainties, the use of on-site BIM and the changes in routines would have been more extensive. It is not enough to simply implement on-site BIM. The workers rely on someone to guide the way, being a good example, and to take the initiative using the software. This is supported by Harstad et al. (2015), which underlines the importance of sufficient guidance and training when new tools are being introduced at the construction site.

We also recognize that the constraint put on the Paperless Project regarding the use of drawings, had a significant impact as well. The workers were required to use on-site BIM, and the only routine change that emerged naturally was the change in communication routines. However, we believe the Paperless Project shows the impact that guidance and change agents have on routine changes, turning several of the more skeptic workers into promoters of the software. This may also be due to the required exposure to on-site BIM. As a consequence, we further propose that by requiring the workers to use on-site BIM in the Paperless Project, more change agents emerged, which will cause further routine changes in future projects.

When artifacts such as on-site BIM are implemented, *they "tend to sink in and become part of the users 'habitual background'",* and by doing so influence future routine activity (D'Adderio, 2008). In the projects that we have studied, we suggest that on-site BIM has yet to reach this level. This may happen as a symptom of time. We believe that the implementation of on-site BIM is an ongoing process, where the routines continuously change from project to project as a result of the unique specifications and preconditions. This supports the statements made by Bråthen & Moum (2015). Further, it supports Feldman's (2003) study, where she describes how routines are recursively reproduced and yet adapt each time they are invoked. We believe the stage where on-site BIM will be a part of the user's habitual background will be reached when workers use the software without the initiative of change agents, and without being required to use it.

## *5.2 The implementation of on-site Building Information Modelling increases the efficiency in the production process*

The first proposition focused on the consequences of BIM concerning efficiency, and was phrased *as "the implementation of on-site Building Information Modelling increases the efficiency in the production process".* This section will discuss how the study found evidence for an increase in the efficiency in terms of waiting time, costs, and number of errors during the production process. The proposition derives from the existing literature on the BIM software, where several researchers argue for, and expect, an increase in the efficiency once BIM is implemented in the production process (Chen & Kamara, 2008; Bråthen & Moum, 2015; Van Berlo & Natrop, 2015).

The empirical findings support the proposition. Even though there was some uncertainty regarding where the increase in efficiency was located, there was no doubt according to the informants that the implementation of BIM in the production process has increased the efficiency. This is aligned with the findings made by Bråthen & Moum (2015). The potential of BIM in the production process described by Van Berlo & Natrop (2015) is supported by the findings in the study, which states that benefits will be achieved once the software is fully implemented in the production process.

Throughout the study, we have applied three performance metrics to measure efficiency; time, cost and errors. We found evidence that supports that BIM is a time-saving tool when utilized at the construction site. The informants stated that the software saves time in terms of delivery time, decision time, waiting time, and time spent on unnecessary activities.

Chen & Kamara (2008) argued that the implementation of BIM in the production process would increase the availability of the drawings on-site, which consequently would improve the efficiency. Several of the informants have supported this statement through the interviews, as they emphasize how much time is wasted by having to walk down to the barracks. Some respondents made significant estimates on how much time is being wasted when workers walk down to the barracks to get drawings or to discuss issues. This is a big source of time wasting in the production process, and since BIM enables the workers to access drawings directly at the construction site, will BIM reduce the time wasting at the construction site significantly. The study also confirms that the pre-BIM routines suffered from more time spent on waiting for delivery of new drawings and minor decisions made by the main contractor, consultants, or the architect.

Svalestuen et al. (2017) claimed that the implementation of BIM in the production process would make it easier to make decisions faster, and thereby reduce the production time. This complements Van Berlo & Natrop (2015) who argued for increased communication on-site. The research we have conducted supports both studies, as we have found evidence for increased communication among the subcontractors, which also made decisions easier and faster to make. The workers are now able to use the BIM-kiosk as a platform for discussion among them. It enables them to make decisions they otherwise would have to wait for others to make, such as the main contractor, consultants, or architects. By being able to make minor decisions and have discussions much closer to the construction site, as well as working closer to the issue at hand, on-site BIM enables significant time-saving. We propose that BIM acts as a platform for communication which enables more direct interactions among the on-site workers. By doing so, the decision time will be reduced because the on-site workers are enabled to make minor decisions. Therefore, BIM plays a time reducing role at the construction site.

The workers are also able to identify how much and what kind of material they need directly in the model and make orders on the spot. This saves the project a significant amount of time and money, as they previously have spent time making manual estimations of all materials needed, and manual orders. All material requirements are now found in the cloud and are easily accessed and thoroughly calculated. By being able to make accurate estimates in the model, BIM leads to cost reductions in the production process, since inaccurate estimates lead to wrong measures of materials procured and a waste of financial resources.

The findings also provide evidence on how BIM at the construction site enables the contractors and workers to identify issues and errors earlier, as well as how the software has made it easier to solve issues in the production process. This is in coherence with Svalestuen et al. (2017) who states that BIM on-site makes it easier to find and solve issues earlier. The workers identify mistakes in the drawings directly in the model in advance, which makes it easier to address these issues before beginning to build. Although this thesis is focusing on the production process, it is worth mentioning that this effect is just as important in the designs process, because the software enables the architects and consultants to make more accurate and better drawings, to begin with. This adds to Eikeland's (2001) study, stating that although the construction processes are generally seen as having a specific order, in practice there is often an overlap in time between the core processes.

The BIM software also enables the workers and contractors to more simply view the big picture and full context at the construction site, which mitigates the risk for wrongdoings due to errors in the drawings or bad interpretation of the drawings. However, while it has been significantly fewer errors in the production process, we have found some signals that the severity of the errors is more significant. This is because the BIM software enables contractors and firms to build more complex buildings.

We propose on-site BIM as a cost-saving initiative because the time saved and the errors avoided by the use of the software will directly reduce the costs on construction projects. We believe the study provides strong indications that the efficiency at the construction site will improve once on-site BIM is successfully implemented. This is mainly through time-saving and a reduction in the risk of making mistakes in the production process, which will also reduce the costs of projects. In addition, the estimating materials in the BIM model enable significant cost savings in the procurement process.

### *5.3 The implementation of Building Information Modelling at the construction site enables agents of change, which leads to further changes in routines*

The predicted statement was: the implementation of Building Information Modelling at the construction site enables agents of change, which leads to further change in routines. The empirical findings support this proposition. The following section will further discuss this statement, and how the findings contribute to its confirmation. The proposition in mention consists of two parts; one addresses the connection between BIM and the role as an agent of change, the other addresses how these agents have played a central role in creating additional changes in the production process.

Assessing the existence of change agents; they were discovered in both of the cases we encountered during the research. At least in the sense where an agent of change can be seen as an individual, or a group, in the organization that undertakes the mission of initiating or handling change (Lunenberg, 2010). Change is seen as the event in which something appears to become something else

(Ford & Ford, 1994), e.g., alterations in how an organization functions (Huber, 1993), but also the alteration and strengthening of existing knowledge and skills (Sitkin et al., 1998). Multiple examples were presented in the findings, where these individuals initiated actions regarding modification of the technology itself, or in an attempt to influence their colleagues by enhancing their skills and competence on the subject of on-site BIM.

Concerning the first part of the proposition, Bartley (1986) suggest that technology takes the role of a material trigger, creating both anticipated and unanticipated changes in social dynamics. This coincides with the findings, which suggest that the introduction of on-site BIM has created new functions in the organization; namely the role of the change agent. For the majority of the informants, facilitating change in the organization is not a part of their original job description. However, because they either recognize the benefits of the software, see its potential, or simply have a deep interest in its functions, these individuals choose to take the role as an agent. For example, some informants described the on-site BIM software as *"my little baby",* elaborating on their fascination and motivation for further changes.

Change agents often possess certain characteristics which make them more likely to act and to be successful at that. Literature from the likes of McCabe (2011), Lindegaard (2011), Anderson (2010), and Lunenberg (2010), present several of these traits, a sample being empathy, structuring, capacity, openness, energy, and proximity. An argument can be made that the change agents we encountered during the study, may inhibit several of these characteristics, and as a result would eventually become an agent of change over time, without the impact of the on-site BIM. Some simply want to change for the sake of change (Vermeulen et.al., 2010). However, the common factor among the agents we encountered was their passion and interest in on-site BIM. Without a more in-depth psychological analysis of the individuals in question, we suggest that on-site BIM was the influence, enabling these agents. This effect is also observed by Orlikowski (1992), who suggests that technology both enables and put a constraint on, human action.

In the second part of the proposition, we address whether the change agents caused further changes to the routines. Agents recognize change, tries to make it even more significant (Weick, 1999), and are particularly important in assisting other to recognize the benefits of adopting new ways of working (Ford & Ford, 1995). In many occasions, people need to change, and change agents are there to make sure that they do (Tsoukas, 2005). They do this by explaining current upheavals, where they are heading and how further changes can be made (Weick, 1999).

The interviews revealed that one way the agents caused further change was through the creation of new solutions and ways of working, which directly affected the routines in the production process. Change agents try to reframe emergent changes (Weick, 1999), which was clearly exemplified through the creation of the movable station for the electricians. This made the workers switch from drawing lines on blueprints, to using the 3D model, making it easier to avoid errors and being more efficient. This localized attempt to handle a novel difficulty is what Tsoukas & Chia (2002) defined as situated improvisation, where the agents search for new ways of carrying out specific tasks (Smets et al., 2012). The Paperless Project is another example of the impact a change agent had on the routines of an entire project. We believe the findings demonstrate several changes which would not have been present if it weren’t for certain individuals’ initiative and passion.

Furthermore, it has been shown that change agents influence the beliefs, attitudes, intentions, and ultimately the behavior of individuals (Armenakis et al., 1993). This became evident during the interviews, which also revealed that change was made by influencing the skills and competence of the workers, which is shown to contribute to organizational routines (Cohen & Bacdayan, 1994). In this case, the agent takes the role of the trainer, teaching employees new problem-solving abilities (Lunenberg, 2010). Training and learning almost exclusively came down to the initiative from certain agents. We also discovered that through learning and exposure to the software, the change agents were able to change the attitude of several workers, creating additional agents. This is an interesting effect. As the proposition is supported, we believe that by generating more agents of change, both the speed and extent of the changes in the routines will multiply.

We further suggest that the role of the change agents has been vital to the development and use of the on-site BIM software, which has caused several changes in the routines at the construction site. By imposing this software on their colleagues, presented its benefits, and raising the level of competence, the agents have made it more visible, laying the foundations for further use. This is somewhat relatable to Davies & Harty's (2013) study on on-site BIM, stating that technical skills were adopted into the construction project through personal relationships rather than formal processes. However, the findings indicate that the management of the organization facilitates the emergence of change agents by highlighting the good examples, supporting local incentives such as the execution of the Paperless Project, and by providing funds to groups like the BIM-network. We believe this supports the idea of bottom-up change, with top-down support, an implementation approach suggested by Martin Fischer (2018). As we have found support for both changes in routines and improved efficiency as a consequence of the implementation of on-site BIM, we further suggest that this implementation method may be beneficial.

There is no doubt that the management of the company has an internal focus on on-site BIM, and that by encouraging people to present their ideas, they play an important role in the growth of the software. However, we suggest that without the initiative of change agents, on-site BIM would not have seen the development or usage it has today, and the changes in routines would have been less significant. As the findings display, people are willing to use new software, and they are eager to change, as long as someone takes the initiative to show them the way.

## *5.4 Building Information Modelling provides a language through visualization, which enables the actors to apply their common interpretation to, and thereby change, their routines*

The final proposition derived from the sociomateriality literature, which is based on a theory where the material and the social are inextricably related (Orlikowski, 2007). The proposition was phrased *as "Building Information Modelling provides a language through visualization, which enables the actors to apply their common interpretation, and thereby change, their routines."* The empirical findings support this proposition. The proposition is very similar to the key finding in Iveroth's (2011) article, stating that *"the technology provides a language which the actors interpret"*. Several of the informants have provided strong evidence by enhancing how the model makes it easier for the workers to interpret the drawings and perform their work, as one of the informants stated, *"everyone can relate to geometry"*.

The model enables the actors to see the full context of the project more easily, while they simultaneously are able to use the detailed drawings. This has changed the way the employees work as they now can build with a greater understanding of the project. The findings show indications of disagreement amongst the respondents on whether the on-site BIM software reduces or lead to some degree of uncertainty if the model and drawings are updated or not. Some of the respondents on the Cinema Project seemed skeptical that the BIM software is fully updated and that it is detailed enough, and they argue that this has created some problematic situations. On the other hand, the respondents at the Paperless Project, the management, and BIM technicians are confident that the implementation of BIM at the construction site will mitigate the risk of using outdated or wrong drawings. They seem to trust that the software will always be updated with the recent drawings. These respondents have more BIM related roles, and they argue that the risk of using wrong or outdated drawings are reduced by applying BIM software on-site.

In addition, by being able to see the context of the work they perform, the workers can identify mistakes and mitigate the risk for errors and wrongdoings more easily. Also, previous research supports this positive effect from BIM (Azhar et al.,2015; Bråthen & Moum, 2015). The BIM software has gained a more central role in discussions on-site, which has changed both the nature of discussions and the routines. In this way, the software could be seen as a language that is much easier to interpret than previously. This role of the software is the core of the proposition and is aligned with Iveroth's (2011) key findings. We propose that the software provides a language which improves the communication and understanding of workers in construction projects.

Looking at how on-site BIM and the users coexist, we have identified several other indications that support the sociomaterial approach. For instance, the study illustrates how roles seem to be established once the BIM software is introduced at the construction site. Veidekke have hired BIM technicians that work solely on implementing BIM. The software has increased the frequency of change at the construction site, which has created a need for these roles. We propose that these roles would not exist without the BIM software, and the BIM software could never have been applied without these BIM actors. This is in coherence with the theoretical approach of sociomateriality (Orlikowski, 2007; Orlikowski & Beane, 2015). It is natural to assume that once new roles are needed in projects, the routines will also change. We, therefore, propose that by creating a need for new actors on construction projects, the routines at the construction site will change.

The introduction of BIM in the production process has affected the coordination, and the way employees interact, according to the research. The subcontractors interact directly with each other to a higher degree, and the decisions are made quicker and by different actors. Minor decisions are made on-site, which is similar to the findings that Orlikowski and Beane (2015) found during their study on hospital night rounds. Their study concluded that the coordination of the night rounds changed once the technology was introduced. Similarly, we propose that the software enables the workers to use the BIM-kiosk as a platform for discussion. The main contractor gathers all the relevant workers and subcontractors around the kiosk to discuss and solve minor issues. This is different from the pre-BIM routine, where the main contractor solved issues with one subcontractor at the time inside the barracks. As a result, we propose that the pattern and routine for solving issues and coordination has changed significantly once the BIM software was implemented in the production process.

We argue that the study supports the sociomateriality approach, which argues for how the technology and the actors coexist and how they together create new settings. This is because the BIM software and the actors using it have created a new setting for the construction industry. Neither would provide any purpose without one another. BIM has enabled the contractors to develop new routines and roles, which would not exist without the software. The actors use and interpret the BIM software and the models to improve their ability to construct buildings more efficiently. This is in coherence with the existing literature (Orlikowski, 2007; Iveroth, 2011, Orlikowski & Beane, 2015).

The findings and discussions on the sociomaterial effects of BIM at the construction site conclude that actors interpret the multidimensional illustrations provided by the BIM software, and it enables a shift in routines in terms of coordination and communication. We see some different opinions on whether the BIM software increase or decrease the risk of building after the wrong or outdated drawings, however, the majority of the respondents argue that once BIM is successfully implemented at the construction site, the risk of applying wrong drawings will mitigate.

# 6.0 Theoretical Implications

With this thesis, we have responded to the calls for further research within the use of Building Information Modelling at the construction site. The use of BIM on-site is a relatively unexplored area; however, there is an increasing trend to include the software in construction projects. This study has aimed to advance the understanding of the implementation of this software, and its effect on routines by looking through the lens of organizational change theory, routine change theory, and sociomaterial theory. We have answered calls for further research on the possible changes in collaboration (Mäki & Kerosuo, 2013), on-site BIM in multiple situations (Vestermo et al., 2016), what the use of on-site BIM implies for the workers, as well as studying different BIM tools used in combination (Bråthen & Moum, 2015).

The study contributes to research on how change agents affect routines and how new software can enable more agents. Change agents can arguably be relevant for any technology implementation, and by facilitating for the existence of such agents, organizations might experience more extensive and rapid change. Moreover, this study adds to existing sociomaterial literature where we argue for how the technology and the actors coexist, as well as literature discussing the creation of common language, enabling actors to apply their common interpretation of routines. It also adds to the literature surrounding artifacts, stating its importance in changing organizational routines and improving routine performances.

Finally, the study contributes to the on-site BIM literature, which is relatively lacking in research. We build upon already existing studies and findings regarding the effect the implementation of on-site BIM has on both efficiency and which changes in routines it entails. We support existing research on the importance of guidance and training when new tools are being introduced to the construction site. Further, we add to the literature by suggesting that by requiring the use of on-site BIM in the early stages of a project, may have provided positive results.

# 7.0 Practical Implications

This study demonstrates how routines at the construction site change once BIM gets more implemented. Due to the complexity of construction projects, and the low degree of similarity between them, the findings will not be comparable to similar projects. However, the study has illustrated the need for change agents in the organization and on projects that seek to implement BIM in the production process. These actors play an important role in driving the technological change behind the routine change. This thesis also contributes by providing evidence for increased efficiency by successfully implement on-site BIM. In this thesis, we have applied time, cost and errors as performance metrics, and we have found evidence for an improvement of all three of them. This thesis should, therefore, mitigate the uncertainty of whether BIM at the construction site is efficient, especially for projects similar to the cases we studied. The study also provides further information on how routines change when projects have BIM software on-site. We have discovered changes in terms of procurement, coordination, and decisions. The practical implications of this study will hopefully lead to more use of BIM software at the construction site.

# 8.0 Limitations

The research contains some limitations. Firstly, the study is mainly based on interviews with nine employees with different roles at Veidekke. Although this is a sufficient number of informants to learn of the effects of on-site BIM, is it not enough informants to draw any strong conclusions. Even though the interview objects inhabit different roles at the construction site providing valuable nuances, all the informants are from Veidekke who serves as the main contractor. It would be valuable to get more insights from the subcontractors to investigate the subject from other angles.

Further, we chose a holistic case study design, which inhibited us from analyzing the detailed benefits of one single case study, as well as analyzing the differences between two similar cases. The choice of using a case study design also inhibits us from generalizing the results.

We believe we achieved great insight from the on-site observations of how the construction site is organized. However, due to complexity in both the industry and the routines, it is difficult to observe and draw any conclusions based on observations of the activities and coordination at the construction site. We have therefore primarily based the research on the insights and descriptions from the informants.

This research is a qualitative study, which is based on conversations and subjective opinions of several informants. These subjective opinions are helpful in providing information about how the BIM software has changed processes and routines at the construction site. However, it would be valuable to supplement this with numerical data to confirm whether it is profitable or not. Even so, the nature of the construction industry makes it challenging to compare profitability and efficiency in different projects, as all projects are different and are affected by exogenous factors.

# 9.0 Future Research

In the light of the research and its limitations, we urge researchers to conduct further studies to achieve greater insights in the digitalization of the construction industry. We recommend future researchers to continue researching the impact on-site BIM has on routines, as well as efficiency, the impact of change agents, and the role of sociomateriality, but to a greater extent, increasing the number of respondents in order to achieve greater confirmation of the results. We would encourage future research to use surveys to increase the number of respondents and to confirm the findings achieved through interviews.

Furthermore, the study is a case study of one main contractor, Veidekke, containing two different cases. Future research should be performed across several main contractors to identify which effects are firm-specific, and which effects are a direct consequence of the BIM software. We also recommend researching different acors other than the contractor, e.g., subcontractors, advisors, and suppliers, to gain insight from different angles regarding the effects of BIM at the construction site.

Finally, we recommend comparing quantitative data from the project with and without BIM in the production process. Studies should investigate how on-site BIM might enable an increase in the efficiency of projects by comparing similar cases and by looking at the budgets and financial reports from different projects. This would provide more robust evidence for an increase in the efficiency of projects.

# 10. Conclusion

This study was set to explore how the implementation of Building Information Modelling in the production process changed the routines in construction projects. In answering the research question, we responded to calls for further research on the possible changes in collaboration (Mäki & Kerosuo, 2013), on-site BIM in multiple situations (Vestermo & Murvold, 2016), what the use of on-site BIM implies for the workers, as well as studying different BIM tools used in combination (Bråthen & Moum, 2015). This study supports previous studies showing that the implementation of on-site BIM caused changes in the use of paper drawings (Bråthen & Moum, 2015) and in the communication between workers at the construction site (Van Berlo & Natrop, 2015). It further suggests changes in the way workers access information, and changes during the process of handling errors on-site and in the models. Overall, the findings indicate that the implementation of BIM at the construction site causes routine changes in the production process.

Previous research has argued for an increase in efficiency once BIM was implemented in the production process (Bråthen & Moum, 2015; Van Berlo & Natrop, 2015; Chen & Kamara, 2008). The thesis confirms this increase in efficiency as well, even though efficiency is a broad concept. Specifically, we found that on-site BIM is a time-saving tool, as increasing communication at the construction site makes it easier to make fast decisions, and you have access to large amount information in your pocket, removing the issue of walking to the barracks. We also found evidence that on-site BIM enables the workers to identify issues earlier, supporting the findings of Svalestuen et al. (2017). We propose that routine changes cause many of these increases in efficiency.

The findings propose on-site BIM as a boundary object as it created a platform for discussion among different actors from different social worlds, which enabled the actors to apply their common interpretation and thereby change their routines. We have also shown that the magnitude of the routine changes varies between projects. The latter was affected by factors such as dealing with uncertainty amongst workers, exposure to the software over time, project specifications, and the influence of change agents. We propose that on-site BIM enables these change agents which causes further routine change, through creating new solutions, and taking initiative to train and guide the employees in the use of the software. The findings support Harstad et al. (2015), which underlines the importance of sufficient guidance and training when new tools are being introduced at the construction site. We propose that requiring the workers to use on-site BIM, at least in the early stages of the implementation, will both remove uncertainties and create more agents of change, causing more extensive routine changes. We also suggest that using a bottom-up implementation method, with top-down support may be beneficial when implementing on-site BIM, supporting the statements of Fischer (2018).

Further, we found support for a sociomaterial approach, concerning how the technology and the actors coexist and how they together create new settings. This research identifies how BIM creates a language, which due to the common interpretation by the workers, enables more direct communication and a change in routines. New roles were created as a result of the implementation of on-site BIM, and this study showed that they are dependent upon each other.

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# Appendix

## Appendix 1. Overview of Interview Objects

Informant 1: BIM-Coordinator, The Cinema Project

Informant 2: Operation Manager, The Cinema Project

Informant 3: Project Engineer, The Cinema Project

Informant 4: Quality Assurance Manager, The Cinema Project

Informant 5: Project Engineer, The Cinema Project

Informant 6: BIM-Coordinator, Paperless Project

Informant 7: Engineer, Paperless Project

Informant 8: BIM-Coordinator, Skøyen (HQ)

Informant 9: IT Operator, Skøyen (HQ)

## Appendix 2. Interview Guide

Introduksjon

- Fortell oss om din rolle og hva du gjør i selskapet?

Bruken av BIM

- Kan du forklare hvordan du bruker BIM-kiosker i jobben?
    - For hvilke andre formål er BIM-kiosker brukt på byggeplassen?
- Kan du utdype din erfaring med BIM og BIM-kiosker?
- Hvorfor bruker du BIM-kiosker?
    - Er dette et krav fra byggherren, eget initiativ eller krav fra ledelsen til Veidekke?

BIM-kioskers rolle og effekt

- Hvordan har implementeringen av BIM-kiosker påvirket arbeidet ditt? Hvordan har det påvirket byggeprosessen?
    - Endret rutinene dine seg da BIM-kiosker ble introdusert? Hvordan? For eksempel, antall møter, samarbeid og kommunikasjon på tvers av lag, bytte i roller, etc.
- Vil du beskrive BIM-kiosker som viktig for at du skal kunne utføre arbeidet ditt? Hvorfor?

- Hvilke effekter har du opplevd etter implementeringen av BIM-kiosker på byggeplassen? Eksempler er å spare tid, kostnadsbesparelser, mindre feil, bedre kommunikasjon, etc.?
    - Har du noen eksempler på direkte kostnader og besparelser fra bruken av BIM-kiosker på byggeplassen?
    - Er det noen utfordringer eller ulemper ved dagens bruk av BIM-kioskene?
    - Hvordan vil du beskrive holdningen til BIM-kiosker på byggeplassen? Føler du det er en forbedring?
    - Hvordan vurderer du hvor mange feil som utføres i en byggeprosess? Har implementeringen av BIM-kiosker redusert dette antallet?

Veidekkes implementering av BIM

- Hvordan har Veidekke forberedt deg og dine kolleger for BIM-kiosker?

Er det noe du vil legge til at intervjuet ikke har dekket?

**Appendix 3. Overview of Secondary Data**

Document 1: Presentation of Veidekke's BIM-kiosk

Document 2: Presentation of the Paperless Project

Document 3: Internal survey about BIM (Relevant questions only)

# Preliminary Thesis Report

Sebastian Cedrick Johansen

Henrik Kjærvik

BI Norwegian Business School

Preliminary Thesis Report

*"Digitalization of the Construction Industry: Implementation of BIM in the Execution Phase"*

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BI Oslo

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Programme:

Master of Science in Business, Major in Strategy

Supervisor:

Ragnhild Kvålshaugen

# Table of Contents

# Summary

This preliminary thesis report will form the basis for our master thesis. The aim of our thesis is to investigate the use of BIM stations on-site in a construction project, and the effects this will have on project activities and productivity. Our research question is:

*How will the implementation of BIM (Building Information Modelling) at the construction site affect the execution phase of the construction process?*

The main objectives we will investigate in order to answer our research questions are:

- How will the implementation of BIM stations at the construction site affect the efficiency and productivity of a project?
- How are the processes and activities performed at the construction site affected by a more significant use of BIM on-site?
- How will key activities at the construction site change in terms of importance and nature?

We will use triangulation, a mix between qualitative and quantitative methods, where our quantitative outcomes function as support for our qualitative results, which will be our main focus. Our primary source of data will come from conducting a case study of Veidekke's project in Nydalen, including interviews, participant observation and a questionnaire survey.

Our first step will be to gather information about the technology, as well as more in-depth material on the case in question. We will then process this information, and complete our theoretical framework, before constructing interview- and survey schemas. Further, we will provide an overview of relevant interview objects, which will be followed by conducting the interviews and sending out the questionnaire surveys.

# 1. Research background

### *1.1 The construction industry*

The construction industry is known as the construction of buildings and infrastructure, which entails the construction of railways, homes, shopping malls, airports, universities, roads, water and sewer lines etc. The industry is important for economies as it has strong influence on the GDP and employment rate (National Research Council, 2009). The construction industry can be divided into two phases, the planning or design phase, and the construction or execution phase (Bråthen & Moum 2015). Our paper will primarily focus on the latter.

The productivity in the industry is challenging to measure, and there is no general productivity metrics for the construction industry (National Research Council, 2009). One of the reasons why it is difficult to measure, is because it is divided into 4 segments; residential, commercial/institutional, industry and infrastructure (Huang et al. 2009), which has significant differences in terms of cost level, expected building time etc. However, the productivity in the construction industry generally describes how well, how quick and to which cost buildings and infrastructure can be constructed (National Research Council, 2009).

### *1.2 The BIM-technology*

BIM is a digital representation of physical and functional characteristics of a facility, traditionally used as a tool in the planning phase of a construction project. However, in recent years it has been applied more often in the execution phase as well (Murvold et al. 2016). Several contractors have stated that BIM leads to less errors and rework, lower costs, and increased collaboration (Cant, 2014). This paper will be focused on BIM stations, which are computers placed at the construction site where the workers can access the information they seek (Murvold et al. 2016).

Hewage & Ruwanpura (2006) discovered a demand from the workers for a mobile, real-time information source on site. The on-site workers wanted the opportunity to view 3D and up-to-date drawings, as well as accessing information relevant for the project, such as weather updates, safety information or technical information. Ruwanpura et al. (2012) conducted a research on the i-Booth. This is an on-site communication framework designed to provide the workers with material management, updated drawings and work demonstrations. This innovation turned out to have a positive effect on productivity and worker satisfaction. Davies & Harty conducted in 2013 a case study of the use of mobile tablets at construction sites, these was called “SiteBIM”. These tablets were intended to provide the workers with updated versions of the BIM model. The results of this study indicated that the SiteBIM had a positive influence on the performance of the construction project, in terms of waste and less growth in the cost of service installations.

Atkninson (1998) highlights poor communication as one of the main sources to errors in the execution phase. On-site BIM stations and tablets has been shown to improve this error, as this technology increase the accessibility of updated information and drawings in a less time-consuming matter (Harstad et al. 2015). A challenge in the implementation of the on-site BIM stations is the significant resistance towards new technology in the construction industry (Brodie & Perry 2001; Scott et al. 1994). The resistance from a worker, increase with his age and experience within the field (Hewage et al. 2008). Hardin (2011) argues for the importance of sufficient training when using the BIM in the execution phase. Bråthen & Moum (2015) explained how Skanska launched a training program were the firm's BIM coordinator provided the workers with sufficient knowledge in how to use BIM in their work day.

There is still a limited amount of research on the use of BIM on-site, and new cases and perspectives are important to cover the knowledge gap.

# 2. Resource issues

### *2.1 Different types of construction projects*

As mentioned earlier is the construction industry very large. It is defined as the construction of all buildings and infrastructure. Even when we divide the industry into the four segments; residential, industry, commercial/institutions, and infrastructure, will the different projects have a high degree of inequalities (National Research Council, 2009). These differences arise from size, budget, available tools and machines, location etc. The high degree of inequalities within the segments make it challenging to compare the projects.

***2.2 No general productivity or performance metric***

It is challenging to measure performance and productivity in the construction industry, and it has not been developed a general productivity metric. (National Research Council, 2009). We have yet to decide for a productivity metric, and will investigate this further.

***2.3 Limited research conducted previously***

The use of BIM on the construction site is still in early phases, and there has been conducted a limited amount of research on this. Also, one of our chosen perspectives, the sociomateriality approach, is in its infancy. The challenge combined with this is the fact that we cannot use previous literature as fundamental guidance to the same degree as if we have conducted the research in more traditional fields.

# 3. Resource Statement

In our thesis, we will look at the use of BIM on-site. We will examine the consequences of applying BIM in the execution phase. We will conduct a case study of Veidekke, and look at two projects with similar characteristics in Nydalen, but with different degree of use of BIM in the execution phase.

***3.1 Resource question***

We have formulated a research question which this paper will investigate and try to answer. The research question derives from the knowledge gap that exist in the literature regarding on-site utilization of BIM and BIM stations. Our research question is phrased as follows:

*How will the implementation of BIM (Building Information Modelling) at the construction site affect the execution phase in the construction process?*

The purpose is to investigate what happens when a firm decides to utilize BIM in the execution phase. We seek to identify the changes in processes and productivity caused by BIM. However, we have yet to decide what productivity metric we seek to use in our paper.

### *3.2 Resource objectives*

In our research, we have a few research objectives we will investigate to able to answer our research question.

- How will the implementation of BIM stations at the construction site affect the efficiency and productivity of a project?
- How are the processes and activities performed at the construction site affected by a more significant use of BIM on-site?
- How will key activities at the construction site change in terms of importance and nature?

We will investigate if BIM will decrease the amount time spent on waiting due to lack of communication or slow decision-making processes. Our paper will also examine if the amount of errors and rework decrease when utilizing the BIM stations. Furthermore, we will compare actual time and costs spent on the project with the predicted building-time and costs. However, as mentioned, we yet to specifically decide which metrics to use.

### *3.3 Relevance of the topic*

The literature is limited regarding the use of BIM on-site, however we aim to complement the existing literature by studying what effect the implementation of the technology has on a project, by conducting a case study. The use of BIM at the construction site has in recent years increased, and we seek to mitigate the knowledge gap that exist regarding the utilization of BIM on-site.

# 4. Literature Review

In this section, we will provide a literary review, presenting the theories and models that is relevant to our research questions, as well as the associated research objectives. By providing a strong grounding in related literature, and identify gaps in the research, we will be better able to deliver comprehensive empirical research. (Eisenhard, Graebner, 2007) To avoid uncertainty regarding certain ideas, this section will also contain definitions of key concepts and notions, as some are prone to interpretation.

To best capture the essence of our research question and objectives, we will in this literary review focus on the concept of sociomateriality; the assumption that technology and organizational activities are inseparable, the institutional based view; in which performance differences are explained by an organization's laws, rules and routines, as well as the concept of strategic change, specifically aimed at the synergy between technology, organization, their processes, strategy, and people, and the importance and effects of innovation implementation. We believe that by using the concepts of sociomateriality, institutional based view and strategic change we will be able to better understand the consequences and effects implementing new technology will have on the organization's activities, as this is the core of our research question.

### *4.1 Institutional-based view*

Douglass North (1991) describes institutions as "the humanly constraints which structure human interactions". Peng et al. (2013) highlights that the institutional based view is as the third major theory in strategy. This theory considers the formal and informal institutions, which make the boundaries of the organization, as the source to performance differences. Examples of formal institutions are laws, regulations and rules, while norms, culture and ethics are examples of informal institutions Peng et al. (2013) contributes with two propositions where the first argue that actors pursue their interests within the framework given by the institutions. The second proposition argues that where there is a lack of formal constraints, the informal constraints will play a bigger role.

Börner and Verstagen (2011) highlights how firms' and employees' actions are influenced by the institutionalized routines and norms in a firm, but at the same time argue that the informal institutions are affected by the actions performed by the firm or its organization. This creates a mutual influential relationship between the actors and institutions. This relationship describes a process of change, however in many situations is the organization resistant for change.

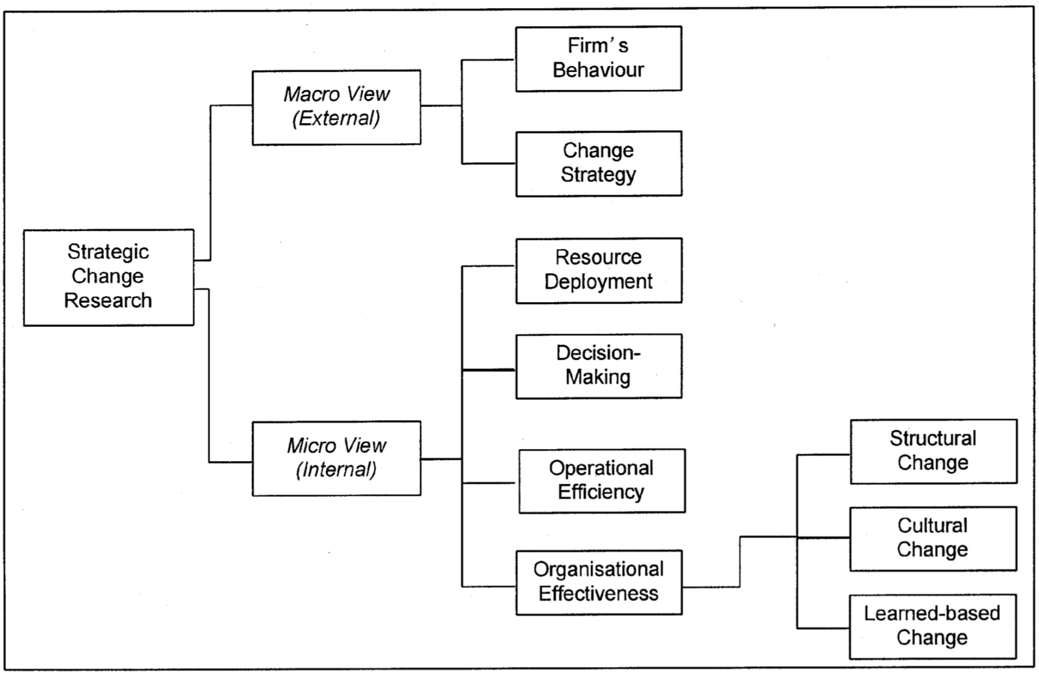
LaPlante (1991) provides empirical examples where technological implementations suffers from resistance for change within the organization. One example she provides is from Premier Hospital Inc. in Illinois, where the hospital manager attempts to introduce a computer based booking system for conference rooms at the hospital. However, while the technology works without any problems, the manager is unable to fully implement this system, because the employees refuse to use it, and instead continue using the old manual system. In this example, the manager discovered that a successful implementation of new technology depends not only on the technology, but also on the reception by the employees. Börner and Verstagen (2011) confirms this, stating that once the resistance to change is overcome, routines change more easily.

### *4.2 Strategic Change*

The ever-changing environment in today's business world require companies to extend their conventional approach to change (Hsiao & Ormerod, 1998). The emergence and implementation of radically new technology, such as BIM, is forcing organizations to transform themselves into adaptive enterprises, as the "*old-rules of the game"* don't apply anymore (Tidd & Pavitt, 2005). In order to effectively manage their critical success factors, affected by the complexity and uncertainty of the new technology, the firm needs to establish synergy between technology, organization, processes, strategy, and people (Hsiao & Ormerod, 1998). These are some of the reasons why it is critical for firms in the construction industry to be able to manage and enable strategic change.

During the last decades, there has been several attempts at defining strategic change. Greiner and Bhambri (1989) defined strategic change as a "*shifting interplay between deliberate and emergent processes (…) leading to major changes in strategy and/or organization, which result in a realignment between* *the firm and its environment"*. Later, Wiersema and Bantel (1992) were to define it as an absolute change in product diversification level, while Giola et al. (1994) argued that it *"involved a redefinition of organizational mission and purpose or a substantial shift in overall priorities and goals to reflect new emphases or direction"*.

For the aim of this research, however, we have chosen to follow Rajagopalan and Spreitzer's (1997) definition: *"Strategic change represents a radical organizational change that is consciously initiated by top managers, creating a shift in key activities or structures that goes beyond incremental changes to pre-existing processes"*. They later added that this change must be in alignment with its external environment. This definition clearly defines strategic change as a "radical" change, rather than an incremental or "ordinary" change. According to Hopkins (1987), a strategic change can be viewed as "radical" if: (a) the change is significantly different from how the organization previously did business; (b) the change has far-reaching effects; (c) the change affects the emotional state of organizational members, creating insecurity and uncertainty. We believe that the implementation of BIM in the execution phase of the construction process fits well into these definitions of both strategic change and radical change.



Pettigrew (1988) created an overview of the strategic change literature, which later was adapted by Hsiao & Ormerod (1998) (See figure 1). They divided the literature into macro and micro perspectives, which further resulted in six sub-categories. In order to restrict the extent of our research, we have chosen to focus on the categories we found to be most relevant concerning our research question. Consequently, our main focus will be on the sub-category *"Operational Efficiency"*, as well as key insights from the macro perspective on *"Firm's Behaviour"*.

Hsiao & Ormerod (1998) explained that the purpose of the macro perspective was to *"understand how firms link competitive performance to their abilities to adapt to major changes in their environment"*. Further, it aims to analyse how an organization manage major external changes, such as industry-wide adaption of new technology.

Looking at operational efficiency, Hsiao & Ormerod (1998) states that it *"analyses strategic change through the rejuvenation of a firm's process by improvement and innovation"*. Improvement focus on incremental change in order to improve already existing processes. Innovation, however, engages in what is termed "redesign" or "reengineering", referring to the abandonment of existing methods to participate in radical reforms. In other words, it tries to break away from the old rules and assumptions about how to organize and conduct business. Hammer (1990) stresses that reengineering, or process innovation, should be both broad and cross-functional in scope.

In his book, Davenport (1993) addresses the importance of technology as an enabler of process innovation, and its implications for key business processes. However, many researchers are critical to the actual impact of an investment in innovation and new technology. Morton (1991) found a negative correlation between technology investment and productivity/profitability, while others (Loveman, 1994; Baily, 2011), found no significant gains at all. Davenport (1993) addressed these results by stressing that to really benefit, there needs to be a change in a process, and that the role of technology is to make new process designs available. Hammer (1990) supports this by stating that *"the organization* *should not use technology to automate an existing process, but to enable a new one".*

Davenport (1993) further suggest nine different opportunities enabled by process innovation, which presume the business objectives of time efficiency, reduction of cost, etc. One of these opportunities are the informational impact, in which technology can be used within a process to capture information about process performance. A second opportunity is the analytical impact, where this information need to be analysed. Further opportunities are automational, sequential, tracking, geographical, integrative, intellectual and disintermediating.

### *4.3 Sociomateriality*

The sociomateriality approach address the assumption that the organization, activities and technology should be looked at separately, and argues that there is an inseparability between the social and technical aspect (Orlikowski & Scott, 2008). This approach, with other words, looks at the social and the material as inextricably related, were there could be no material without the social, and no social which is not also material (Orlikowski 2007).

The traditional organizational literature on materiality tends to either ignore the role of materiality in the organizational life, or just to study specific cases of use of technology and material. By only looking at materiality under special circumstances we ignore the role of materiality in the everyday life of an organization. This is a weakness in the literature because organizations and its employees interact with materiality and technology all the time and not once in a while or under specific circumstances. The materiality aspect of an organization affects the organization and its employees (Orlikowski, 2007).

Orlikowski (2007) argued for this approach by providing two empirical cases. One of these examples was how researchers interact with Google´s technology, PageRank. She argues that the PageRank technology in information search affects how researchers´ look for information, while the researchers influence the results provided by PageRank and Google´s search engine. PageRank would have no value if no researcher´s used it, as it continuously is updated with the searching activities. Equally would the researchers´ product be of no value if there would be no search engine. The researching activities could not be divided from the technology. This illustrates the core of sociomateriality, that the materiality and the social should be treated as inextricable.

Reich, Rooney & Hopwood conducted in 2017 a research looking at emergent learning at work with a sociomaterial perspective. They looked at three cases, one of whom were at a railway construction site. They argued that the role of blueprints is not only as guidance and a future plan for the construction, but blueprint will also be changed continuously with the site-walks and situations at the construction site. This sociomaterial view of blueprints is valuable and highly relatable for the purpose of this paper.

Even though more research has been conducted in the field of sociomateriality in recent years, the approach is still in its infancy and has therefore also received limited attention (Akhlaghpour et al. 2013). There is a need for further research in this field because it lacks depth and presence. The theory has to be applied and investigated in more projects and case studies.

# 5. Research Design

For our thesis, we have decided to use a mix between qualitative and quantitative methods. More specifically, the main focus of our study will be on qualitative results, however, by including quantitative results we will be able to improve our overall outcomes. In quantitative methods theory drives the formulation of the research questions, which leads the collection of data, which in turn adds to the existing theory (Bryman & Bell 2015). Qualitative research, on the other hand, are often more concerned with outcome, as well as generation of theory, rather than testing it. Qualitative data are often very attractive to use as it offers rich information, although it may prove difficult to analyse (Miles, 1979).

This combination of methods is usually labelled *triangulation*, which is described by Bryman and Bell (2015) to "*combine the specificity and accuracy of quantitative data, with the ability to interpret characteristics and complex perceptions, provided by qualitative data".* This implies that we will use one method associated with a specific type of research, and cross-check our results with a method associated with another type of research.

We have made our choice of qualitative and quantitative methods, drawing inspiration from studies using similar methods, such as Stiles' (2001) study on the effect of the board of directors on the corporate strategy, although with some moderations. Our primary source of data will come from conducting a case study of Veidekke's project in Nydalen, which we will describe further down in the paper. During the case study, we will conduct interviews with a variety of key individuals, perform a questionnaire survey, as well as collecting data through participant observation.

The next sections will provide a more in-depth explanation of our choice of research design, as well as how we plan to approach the framework that we have established.

***5.1 Case Study***

A case study can be defined as a detailed analysis, focusing on a bounded system or situation (Bryman & Bell, 2015). It is a common research design, appearing to be quite popular in the business environment. A case study will provide us with the opportunity to study the totality of a complex phenomenon such as a construction project. According to Yin (2015), a case study is most relevant if the questions one wishes to answer is about "how" and "why" some phenomena work. The same applies for questions that require a thorough description. We believe that this makes case study the most appropriate research method to illuminate the experiences regarding the use of BIM kiosks.

At the same time, we believe that a case study is a suitable option considering our choice to use the triangulation method, with a combination of qualitative and quantitative methods. This due to Knights & McCabe's (1997) observation, where they suggest that *"a case study provides a vehicle through which several qualitative methods can be combined, thereby avoiding too great reliance on one single approach".*

According to Bryman & Bell (2015), researchers should choose cases where they expect learning will be the greatest. Eisenhardt & Graebner (2007) states that the case or cases should be selected for their suitability in enlightening certain constructs, as well as their likelihood of offering theoretical insight. For our case study, we have chosen to analyse one of the projects conducted by the Norwegian contractor Veidekke. Veidekke is one of Scandinavia's largest contractors and property developers, who carries out all types of construction projects (Veidekke, 2018). The case study will focus on one of the ongoing projects of Veidekke in Oslo. The large project includes hotels, a large cinema centre, several business premises, 149 apartments, as well as a kindergarten spread over 60.000 square meters.

What makes this project especially interesting, is that it involves the use of BIM at different levels, ranging from intensive use to only a small exposure, during different parts of the project. Eisenhardt & Graebner (2007) stresses the importance of observing contrasting patterns in the data (e.g., high use and low use), which we believe Veidekke's project can provide. The project is complex, which makes the potential of BIM huge. We also consider this to be what Yin (1994) defined as a *"typical"* or *"representative"* case, which tends to exemplify an everyday situation or form of organization. Studying a typical case of some phenomenon may be a good platform to explore the mechanisms at work, often leading to numerous distinctive conclusions. Due to being in the early stages of our research, we are currently awaiting more in-depth information about the project.

### *5.2 Primary Data*

In order to obtain rich information about our research object, we need primary data about the impact of BIM, and how it has affected the construction process at Veidekke. Primary data analysis is by Bryman & Bell (2015) defined as data we as researchers have collected, and that the one collecting the data conducts the analysis. In this stage, we will be performing interviews as well as partake in participant observation.

Eisenhardt & Graebner (2007) describes interviews as a highly effective way of generating intensive and detailed empirical data, even though the data in certain situations may be biased. There are many different interview styles which may be applied, however, we will be using semi-structured interviews. This is a style in which the interviewer has a series of more general questions in the form of an interview schedule, but may ask follow-up questions in response to what is seen as significant replies (Bryman & Bell, 2015). We believe that this choice of interview style will provide us with the structure to make the interview efficient, without leaving out important questions. At the same time the follow-up questions allows for the possibility to obtain more in-depth information on certain topics.

To be able to extract the necessary information, we will have to identify numerous key individuals, who are able to view the effects and implementation of BIM from diverse perspectives. It is important that the individuals that are chosen differs in their hierarchical levels and functional areas, in order to get a more complete picture (Eisenhardt & Graebner, 2007). As mentioned, we will also use another research method called participant observation. This refers to the collection of data while being an observant in a social setting. We believe that by observing the use of BIM in the execution phase, we will get a better understanding of its effects and how it is actually put into use.

As our source of quantitative data, we will also be conducting a questionnaire survey. This survey will be sent to individuals that are somehow affected by the implementation of BIM in the execution phase at Veidekke, which we need to identify. Our plan is to develop a questionnaire survey which provides clear answer options in order to map the use of BIM-kiosks, as well as the users' attitude and behaviour towards it. We would also like to add an option in which the respondents may elaborate on their answer, and write more freely. We believe that by providing clear answer options, the threshold for answering is lower, and at the same time it becomes easier to compare the answers. This questionnaire survey will be used to support our main findings, which occurs from our qualitative research.

### *5.3 Secondary Data*

In addition to our primary data, we will also have access to different forms of secondary data. Secondary data occurs when we as researchers analyses data collected by someone else (Brymann & Bell, 2015). Documents and data that might prove useful are records from different meetings regarding the project in question. We will also search for data published by other institutions in order to get a better understanding of the technology in use, as well as an insight into previous research on the matter. The use and gathering of secondary data is often less time consuming and more cost efficient than primary data, however, it might also exist a lack of familiarity, as well as low control over the quality and research methods when obtaining these data (Bryman & Bell, 2015), which we need to be aware of.

### *5.4 Validity and Reliability*

The importance of validity and reliability in a case study varies between different studies, according to how appropriate the researcher feel they are. Yin (1984) put much emphasis on these factors, while others like Stake (1995) didn't consider them at all. Often, research with a more qualitative standpoint tend to ignore the salience of these factors (Bryman & Bell, 2015).

According to Brink (1993) many qualitative researchers tend to avoid using the concepts of validity and reliability as a whole, and rather focus on other constructs. One of these constructs were created by Guba & Lincoln (1981), who chose to substitute the concept of reliability and validity, with the concept of *"trustworthiness",* which contained four different aspects. In 1985 Lincoln & Guba changed their initial definition, stating that trustworthiness are defined as credibility, transferability, dependability, and confirmability (Lincoln & Guba, 1985). Even if there is an ongoing discussion surrounding the use of validity and reliability in qualitative research, we chose to consider both as important factors. In the next sections, we will explain how we will work towards improving both elements.

According to Bryman & Bell (2015), validity is concerned with the integrity of the conclusions that are generated from the research. To firstly address the external validity, we have no interest in generalizing our findings. We are conducting a case study, in which we are interested in understanding the complexity of our chosen project. To improve our internal validity, we have chosen to use the triangulation method as mentioned earlier. By using this approach, we combine different methods that have non-overlapping weaknesses and strengths in order to provide better evidence (Brewer & Hunter, 1989).

Johnson (1997) also addresses two other types of validity which are important in qualitative research; descriptive validity and interpretive validity. The first refers to the accuracy in reporting descriptive information. We will address this by investigator triangulation, in which we will be two people present to observe both interviews and other encounters, and at the same time we will record our interviews. This might create uncertainty among our interview objects, however, we believe that the nature of our questions will provoke sensitive answers that might frighten the participants. We will of course ask our interview objects for permission before recording.

The second type mentioned by Johnson is interpretive validity, which refers to *“accurately portraying the meaning attached by the participants to what is actually being studied”*. We will address this by providing our interview-objects with a copy of the interview after it has been transcribed. By doing so we open up for dialog and make sure that our perception of their answer is correct. To further improve the validity of our research, it is important to do precise preparatory work to ensure quality when developing the questions for our questionnaire survey and interviews. It is also important that the questions are linked to the research question in the thesis.

In terms of reliability, it is described by Bryman & Bell (2015) as the question of whether the results of the study are repeatable. Brink (1993) states that reliability is *“concerned with the consistency, stability and repeatability, as well as the researcher’s ability to collect and record information accurately”*. Put simply, when there is high reliability, the research can be performed again by different individuals, which in turn will get the same result. This definition is more directed towards reliability in a quantitative setting, and is difficult to achieve considering our choice of using a case study.

However, Golafshani (2003) argues that the term of reliability in qualitative research corresponds with what Lincoln & Guba (1985) termed *"dependability"*, which again has close ties to the term reliability in a quantitative setting. Dependability is a way of showing that the findings in our research are consistent with the raw data that we collected. The technique mentioned to establish dependability is called *inquiry audit* or *external audit.* This entails having another researcher not involved in the research process examine both the process and product of the research study. Due to the nature of our paper, the resources we have available, as well as the time limit before submission, we will not be able to perform an inquiry audit.

# 6. Motivation

Both authors of this paper study Master of Science in business, with a major in Strategy at BI Norwegian Business School. We are both very interested in the intersection between business and IT. Writing about digitalization in the construction industry is therefore something we find very interesting. Especially because the industry is in the middle of a digitalization process driven by the BIM technology. BIM is something we found fascinating once we read more about it, and we look forward to learning more about BIM and its implications.

# 7. Timetable

| | |
|---|---|
| January | • Hand in preliminary report by 15th.<br>• Continues search in literature<br>• Establish contact with Veidekke<br>• Get access to relevant data and information from Veidekke |
| February | • Process the information gained from Veidekke<br>• Complete the theoretical framework<br>• Formulate the interviews<br>• Get an overview of relevant interview objects |
| March | • Conduct the interviews<br>• Conduct the participant observation<br>• Conduct the survey |

| | |
|---|---|
| | • Analyze the information gained from the interviews, survey and observation |
| April | • Continue analyze the information gained from interviews, survey, and observation<br>• Start writing the thesis |
| May | • Continue writing the thesis<br>• Improve language and context<br>• Complete the master thesis |
| June | • Hand in the master thesis |

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