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# The Applicability of an Internal Learning Platform at a Construction Firm

## A case study at Skanska USA Building

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Master's thesis 2015:1

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# ABSTRACT

Todays increased awareness regarding safety aspects as well as higher precision processes and better technological solutions have implied high demands on the construction industry. Consequently, the importance of increased effectiveness and efficiency has been profound, demanding reliable, on-time deliveries, high safety and technological solutions. Against this background, Building Information Modeling (BIM) has become increasingly important and gradually implemented in the construction industry. Firms have realized the potential of BIM, and accordingly, Virtual Design and Construction (VDC)-applications[1] are widely used to withdraw information from the models and continuously develop them. In an effort to enhance the applicability of the BIM-technology in general and the VDC-applications in specific, firms have increasingly invested in performance enhancement through corporate education in such applications.

This thesis was conducted as a single case study at a construction firm, Skanska USA Building (USB), by evaluating their corporate education efforts of VDC-applications for BIM through their internal learning platform. There remains a missing link between the training and the applicability of what is being taught to the employees through the firm's learning platform. Therefore, the purpose of this thesis was to investigate and analyze the applicability of the firm's VDC-learning platform – The College of VDC. Furthermore, the study aimed to provide recommendations for how the firm could increase the applicability of the courses taught through their learning platform.

By conducting a case study through observations, interviews and surveys, as well as by performing a literature study, the results and analyses provided conclusions and recommendations.

The study showed that a learning platform induces knowledge creation and knowledge development by its nature as a tool for learning and for information handling. Additionally, the study suggests several methods to ensure the applicability of the learning experience derived from courses of the learning platform, such as: hands-on exercises with real-life examples and advanced training, the possibility to utilize the knowledge gained from the courses on the actual projects, and frequent training and practice of the BIM-software. In order to increase the applicability of the courses taught through the VDC-learning platform at USB, the firm is recommended to continue to conduct similar surveys on a regular basis and to meet the demand of more hands-on as well as more in-depth and advanced training by using a workshop approach during the courses. This implies that, instead of the regular lecture format with a lecturer explaining how to perform things, there is a mutual communication between the course attendant and the instructor. The course attendants would be allowed to learn by working in the models themselves, which induces the knowledge creation process.



*Key words: knowledge management, knowledge creation, construction industry, BIM.*


[1] The term for how to use building information models

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Taraneh Vosough

Gothenburg, December 2014

TABLE OF CONTENTS

# TABLE OF FIGURES



# TABLE OF TABLES

# 1 INTRODUCTION

*This chapter provides a background regarding the topic and research area of the thesis. The purpose of the thesis is described followed by a short problem analysis and a presentation of the research questions. Lastly, the outline of the report is presented.*

## 1.1 BACKGROUND

The construction industry has up until recently been relatively unchanged and has long sought techniques to reduce project costs, increase productivity and quality, and decrease project delivery time (Azhar 2011). Architects and engineers have traditionally delivered drawings and specifications to clients without having a proper quality assurance procedure. The human factor in such traditional working methods has undeniably implied defects and quality problems later on in the production process of a construction project, causing delays and additional financial resources. As technology has rapidly changed and enhanced, many areas of production and business (outside of construction) are being strongly developed, leaving the construction industry behind. Increased awareness regarding safety aspects as well as higher precision processes and better technological solutions have required high demands on the construction industry. Thus, the importance of increased effectiveness and efficiency has been profound, demanding reliable, on-time deliveries, high safety and advanced technological solutions in the construction industry.

Against this problematic background and nature of the construction process, BIM (Building Information Modeling) has become increasingly important and gradually implemented in the construction industry in order to increase the efficiency through improved collaboration among project members (Dossick & Neff 2010). BIM enables the developers to design optimized buildings digitally in three dimensions as well as to provide with information and plans about the time and cost of the project (Bryde et al. 2013). Such simulation efforts offer a unique possibility to detect important conflicts to be resolved prior to the initiation of the construction projects. The virtual and parametric nature of BIM allows any changes in the models to change other instances throughout it as well, improving the effectiveness and coordination of projects.

Firms have realized the potential of BIM, and accordingly, Virtual Design and Construction (VDC)-applications [2] are widely used to withdraw information from the models and continuously develop them. In an effort to enhance the applicability of the BIM-technology in general and the VDC-applications in specific, firms have increasingly invested in performance enhancement through corporate education in such applications. Skanska USA Building (USB) is a provider of construction services within the building construction sector in the United States and one of four business units within the Skanska USA Inc. USB currently has approximately 2000 employees based in 26 offices around the country (Choquette 2014a). In an attempt to enhance performance and remain competitive, USB introduced and implemented a profound corporate education system consisting of courses in 2011: a VDC-learning platform referred to

[2] The term for how to use building information models

as The College of VDC. The vision of the platform is to educate and enable the employees to understand and utilize information models through VDC-applications in their daily work in order to make fact-based decisions.

According to Whyte and Lobo (2010), a learning platform can form a digital infrastructure for project delivery, where the digital objects provide mechanisms for accountability and control as well as for mutual knowledge sharing. The term digital infrastructure represents the set of objects associated with coordination of knowledge across multiple knowledge boundaries in the delivery of projects (Whyte & Lobo 2010).

Although short-term questionnaires are used as feedback tools immediately after each course held at USB, there remains a lack of long-term follow ups on the applicability aspects of the courses as well as the course attendants' perceived learning experience. A long-term evaluation of the applications taught through The College of VDC is missing, which causes unawareness regarding the fulfillment of its intended vision.

## 1.2 PURPOSE

The purpose of this study is to investigate and analyze the applicability of a VDC-learning platform at USB. Furthermore, the study aims to provide recommendations for how the firm can increase the applicability of the courses taught through their VDC-learning platform.

Project-based organizations have in research been shown to have difficulties in maintaining and sharing knowledge. Usually knowledge is applied and created in a project, but due to lack of time, people working in multiple projects and a huge workload, members of these projects have difficulties in sharing knowledge within the organization. A learning platform concerning BIM is an approach to overcome these difficulties by means of common practices that can be developed through training and feedback-loops, so that the company can maintain this knowledge and keep it up to date. Therefore, looking at such a learning platform is of interest in particular in these types of organizations and will contribute to the research field.

## 1.3 PROBLEM ANALYSIS AND RESEARCH QUESTIONS

A step towards fulfilling the purpose of the thesis is to explore and understand the learning platform used at USB in teaching VDC-applications to the employees. Today, USB uses a shorter form of survey to evaluate their training sessions directly after they have been conducted. However, there remains a missing link between the training and the applicability as well as the usefulness of what is being taught to the employees. The VDC Director of Staff Development at the company has identified a need for further evaluating the learning platform. Consequently, an understanding through data gathering and statistical analysis is desirable in order to find the causes of today's insufficient applicability.

The above-mentioned problems lead to the following research questions:

**RQ1:** In what way does a learning platform support knowledge development internally?

**RQ2:** How can the applicability of the learning experience be ensured?

These research questions will be studied in a single case study in which a firm, here USB, uses a learning platform for performance enhancement through corporate education.

## 1.4 DELIMITATIONS

Skanska Group is a construction company that operates worldwide. However, this study will solely focus on USB, which operates on the American market. Furthermore, the VDC-learning platform is utilized by USB all over the United States of America but the study will only be conducted at the Boston office. Even though the concept of a VDC-learning platform is widely used in the construction industry, this study will exclusively focus on prescribed conditions and requirements at USB.

While the VDC-learning platform will be evaluated, the focus will be on the effectiveness of the learning program itself rather than specific modeling or analysis techniques. This implies that the content of the educational material will not be analyzed. For example, specific elements and techniques on how to perform certain construction actions will not be considered.

## 1.5 OUTLINE

*Theoretical Framework:* The theoretical framework addresses knowledge management in the construction industry, followed by theory regarding the importance of evaluation and theory about building information modeling. The theoretical framework is later on used to evaluate and discuss the case study's findings in order to answer the research questions.

*Research Methodology:* The research methodology chapter presents the study process, with respect to its research strategy, approach and design. Furthermore, descriptions of the literature study, the data collection and the data analysis are provided. Lastly, the ethical considerations and the trustworthiness of this study are discussed.

*Case Description:* The case description chapter focuses on a specific case at a construction firm; Skanska USA Building. An introduction to the firm is provided followed by the firm's VDC-learning platform and its evaluations.

*Results and Analysis:* This chapter presents the results of the case study. Relevant data is presented in charts and tables in order to illustrate the outcome of the study. Furthermore, the results are further analyzed and validated by the researcher in collaboration with the internal employees at the case study firm.

*Discussion:* This chapter presents a discussion regarding knowledge management through learning platforms as well as a comparison of the results to the research field with respect to tacit and explicit knowledge methods. Lastly, the contribution of this study to the research field will be discussed and suggestions will be given for future research.

*Conclusions and Recommendations:* This chapter provides a concluding summary of the results generated from this thesis. The research questions are answered and recommendations are provided to the firm addressed in this case study.

# 2 THEORETICAL FRAMEWORK

*This chapter presents the theoretical framework of the study, which later on is used to evaluate and discuss the case study's findings and to answer the research questions. The chapter provides an introduction to knowledge management in the construction industry, followed by theory regarding the importance of evaluation and theory about building information modeling.*

## 2.1 INTRODUCTION TO THE RESEARCH FIELD

A precondition for a competitive firm is to continuously develop the organization and its employees, as well as to constantly manage and improve the process of creating knowledge. As argued by Bergman and Klefsjö (2010), the aim when improving a process is to learn and gain experiences from the process in order to avoid that the same type of problems repeatedly occur, and by avoiding that, the quality of that process could increase. According to Batalden and Stoltz (1993), continuous improvement includes constant examination of processes in order to find better methods, which could continuously meet the customer expectations. Construction work is often done on a project basis, with different customer requirements between projects. The construction industry is somewhat associated with great risks, delays and poor performances (Carr & Tah 2001). This indicates that there is a growing need for having useful knowledge at the right time in order to be successful in satisfying the customers.

There are different approaches in project-based firms to support knowledge acquisition and transfer; amongst them training and educational activities. A learning platform consisting of digital tools as well as educational content and learning processes could support training and knowledge development. As mentioned before, a learning platform as such can, according to Whyte and Lobo (2010), form a digital infrastructure for project delivery, where the digital objects provide mechanisms for accountability and control as well as for mutual knowledge sharing.

It can be argued that when individuals acquire new knowledge, the organization plays a key role in articulating and amplifying that knowledge. Therefore, a learning platform used by an organization should preferably give individuals competences that are worthwhile and applicable to their needs of day-to-day projects (Nonaka 1994). A precondition in ensuring that applicable competences are being taught is to continuously review and improve the educational system. As stated by Jones and Hughes (2004), effective evaluation leads to effective systems.

## 2.2 KNOWLEDGE MANAGEMENT AND KNOWLEDGE CREATION

A fundamental task for an organization is how effectively and efficiently it can deal with information and decisions in an uncertain environment. Any organization that deals with a changing environment needs to create information and knowledge (Nonaka 1994). How organizations can do this need to be studied. Knowledge management can be defined as the creation, reformulation, sharing and bringing together of different types of knowledge

(Quintas 2008). According to Nonaka (1994), information is a flow of messages and knowledge is created and organized by the very flow of information, anchored on the commitment and beliefs of its holder. Nonaka (1994) emphasizes that what contributes to the development of new knowledge is the interaction and communication between individuals. Similarly, Scarbrough and Swan (2001) highlight the importance of social networks in spreading new ideas that will translate into knowledge commodities. Nonaka (1994) concludes organizational knowledge creation in terms of a process that organizationally amplifies the knowledge created by individuals, and crystallizes it as a part of the knowledge network of an organization. Furthermore, Nonaka (1994) elaborates on two different types of knowledge: tacit knowledge and explicit knowledge, where the former has a personal quality and is hard to formalize and communicate, and the latter can be transmittable in formal, systematic language. Tacit knowledge can be acquired through experience, i.e. through observation, imitation and practice. Tacit knowledge is personal and cannot be codified (Quintas 2008). Explicit knowledge can be gained through for example documents and books. According to Nonaka (1994), knowledge is created through four different patterns of interaction between tacit and explicit knowledge: (1) from tacit knowledge to tacit knowledge, (2) from explicit knowledge to explicit knowledge, (3) from tacit knowledge to explicit knowledge and (4) from explicit knowledge to tacit knowledge, see Figure 1.

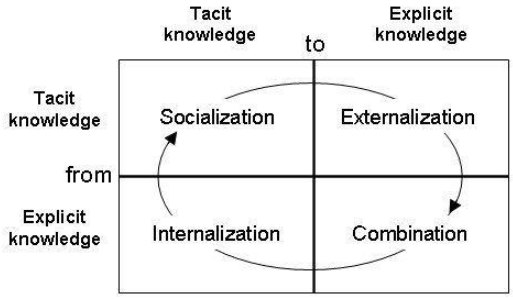


**FIGURE 1. MODES OF THE KNOWLEDGE CREATION (NONAKA 1994)**

The process of sharing tacit knowledge through shared experience is called socialization. According to Quintas (2008), organizations survive, innovate and prosper because people within them generate knowledge, where a part of this happens through experience and socialization. The process of sharing explicit knowledge is referred to as combination and can be done by reconfiguring existing knowledge through for example modern computer systems (Nonaka 1994). The third and fourth pattern of interaction between the knowledge types can expand over time through a process of mutual interaction. The conversion of tacit knowledge into explicit knowledge is called externalization, e.g. explaining what to do through a manual and the conversion of explicit knowledge into tacit knowledge is called internalization, e.g. organizational learning or learning-by-doing. Similarly, Scarbrough and Swan (2001) discuss that knowledge is increasingly generated by users in the context of its application. Nonaka (1994) highlights the fact that organizational knowledge creation can take place only when the four modes of knowledge creation are managed organizationally. Blackler (1995) points attention towards knowing as something that people do, instead of regarding knowledge as

something that people have, where the prior focuses on the systems through which knowing and doing are achieved.

## 2.3 Knowledge Management in the Construction Industry

Organizations need to support individuals, groups and networks in order to facilitate the exchange of information by making strategic efforts to assist information and knowledge flow (Egbu & Robinson 2008). An environment that supports and promotes education and training is important in creating and sustaining a knowledge culture. Furthermore, in order to improve performance, an environment that allows workers to create, capture, share and leverage knowledge is required (Ribeiro 2009). However, according to Love et al. (2005), few construction organizations have implemented knowledge management systems to collect, organize, convert and connect their knowledge systematically. Hartmann and Fischer (2007) discuss two different knowledge groups in construction projects; product (design) knowledge and process (sequencing and scheduling) knowledge. The former, representing the design of a facility, is possessed by the design team and the latter, related to how to build a facility, is possessed by the construction team (Hartmann & Fischer 2007). Due to the often-conflicting viewpoints of these two knowledge groups, information-rich tools are needed during the knowledge communication process to coordinate between the opinions and concerns specific to each party (Straus & McGrath 1994). Hartmann and Fischer (2007) stress the fact that it is important to develop business processes for the communication of knowledge to be incorporated into the philosophies of construction firms.

## 2.4 Applicability of Learning Platforms

A cornerstone in knowledge management is to continually reinvent the organization through learning, which requires organizational routines that support the ability to create, absorb and assimilate new knowledge as well as to abandon outmoded knowledge and routines (Quintas 2008). According to Sheehan et al. (2008), construction firms seeking to manage knowledge have essentially two options:

1) To capture construction knowledge in documents, databases, intranets, etc., i.e. through the 'explicit knowledge' approach.
2) To focus primarily on people and develop ways in which they can exchange their 'tacit knowledge' in order to facilitate innovation.

Furthermore, Quintas (2008) states that developing a people database and providing access to expertise is a way of managing knowledge. Good knowledge management practice in construction firms requires knowledgeable people who are supported by information and data sources in order to generate informed decision-making (Sheehan et al. 2008). Whyte and Lobo (2010) note that knowledge tend to be lost in construction work as learning often fails to be transferred between projects, and hence, there is a need for coordination between disciplines in project-based firms as new knowledge is developed. Visual representations play a major role in mediating knowledge, where the communicative and interactive properties constitute them as central elements of knowledge work (Ewenstein & Whyte 2007). Digital tools can be used

to enhance the knowledge creation process and knowledge can be shared through them, fulfilling the targets of communication, learning, reviewing and capturing knowledge (Whyte & Lobo 2010). However, Sheehan et al. (2008) stress the fact that technology solutions do not work "off the shelf", but require careful project management to realize potential benefits. Training can help to improve staff skills and therefore increase knowledge (Al-Ghassani et al. 2008). Using expert master classes to share expertise will enhance the knowledge management process (Quintas 2008). According to Sheehan et al. (2008), mentor/apprentice relationship is the simplest and most effective approach to ensure that knowledge sharing exists in construction firms.

According to Nonaka (1994), redundant information, i.e. the existence of more information than the specific information required by each individual, can play a major roll in facilitating the product development process. Redundancy can be built by wide access to company information and sharing of redundant knowledge between individuals promotes the sharing of individual tacit knowledge (Nonaka 1994). According to Numagami et al. (1996), it is a practical requirement that everyone in an organization is given access to necessary information since efficient knowledge creation requires quick inquiry and processing of existing knowledge and information. Furthermore, Nonaka (1994) emphasizes on the importance of redundant information since it makes the interchange between hierarchy and non-hierarchy more effective in problem solving and knowledge creation. Such interchange enables all members of the organization to participate in the process. According to Nonaka (1994), the main requirement for the design of the knowledge-creating organization is to provide the organization with a strategic ability to acquire, create, exploit and cumulate new knowledge continuously and repeatedly in a circular process.

## 2.5 The Importance of Feedback

The use of information systems and learning platforms require proper feedback in order to make sure that the systems are being utilized in an effective and efficient way. Sheehan et al. (2008) stress that there is a growing need to clearly identify, evaluate and measure the concrete impact of knowledge initiatives or projects on business and organizational performance. According to Robinson et al. (2008), the strongest argument for measuring the performance of knowledge assets and knowledge management is to demonstrate its business benefits so that the resources and support necessary for a successful implementation can be provided.

Firms can approach their knowledge management initiatives in different ways. One way is through after-action reviews, which is a way of capturing learning from experience (Quintas 2008). Sheehan et al. (2008) highlight the powerful approach of reviews when transferring knowledge between projects, and sustained competitive advantage can be gained by reflecting on past experiences that enable project-based competencies. Project learning aims to enhance understanding of key project experiences, where lessons learned are acquired by acknowledging the successes and failures and applying these insights to improve future projects (Sheehan et al. 2008). Without having a learning approach in an evaluation process, experiences and lessons learned risk to get lost due to deficient systematics in the process

(Svensson et al. 2009). It is important to facilitate lessons learned and successful learning can potentially offer organizations many benefits, including greater predictability, lower defects, greater efficiency and reduced project risk (Sheehan et al. 2008). Therefore, it is important to establish systematic learning through reviews that are built into the project process.

Organizational knowledge management technologies must be simple to use in order to be effective, where learning management systems are vital, providing theoretical access to learning on demand (Maurer 2001). Organizational routines, such as using a learning platform, can be seen as a fundamental mechanism in the process of knowledge creation (Bloodgood 2009). When implementing a learning platform and educating the employees for specific objectives, it is crucial to evaluate its usefulness, which can be done through a feedback-system. A common reason for the lack of evaluation and feedback is that it is not done at the proper time or that the users do not regard the result of the evaluation as relevant (Thomas 2011). Therefore, it is important to provide the users with incentives to take their time for analysis and reflection (Costa et al. 2006).

## 2.6 BIM – Efficient Design and Construction

Many construction firms have developed information systems designed to facilitate the storing, sharing, integration and utilization of data and information (Ribeiro 2009). These systems provide the infrastructure for facilitating the integration of knowledge management into everyday business and are often associated with improved organizational flexibility, quicker access to information, fast responses to changing conditions, greater innovation and improved decision making (Ribeiro 2009). According to Whyte and Lobo (2010), digital infrastructures are used for the delivery of physical infrastructures.

Building Information Modeling (BIM) is an IT-enabled approach of digital representations of all building information in the form of a data repository (Gu & London 2010). The BIM-technology allows an accurate virtual model of a building to be digitally constructed (Azhar 2011). BIM has successively been playing a major role in recent years as it supports through all stages of the building process, from early conception to demolition. According to Barlish and Sullivan (2012), various stakeholders interact when BIM is being utilized. Thus, depending on the purpose of using BIM, its benefits can be defined differently. Since there is no agreement on the definition of BIM among multiple stakeholders (Barlish & Sullivan 2012), a definition by BuildingSMARTalliance (2010) will be utilized for the purpose of this study; “A Building Information Model (BIM) is a digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle from inception onward.” This definition does not solely focus on one group of stakeholders, but on the entire life-cycle of building information. Companies that acquire and implement the concept of BIM can take on a significant competitive advantage.

Within the Architecture, Engineering and Construction industry (AEC-industry), there has for a long time been an increased need for technologies to decrease project costs, increase the productivity and quality aspects and reduce project delivery times (Azhar 2011). The field of

application for BIM is wide and the definitions vary. The McGraw-Hill Construction-report *The Business Value of BIM*, a commonly referenced document by contractors, defines BIM as, "The process of creating and using digital models for design, construction and/or operations of projects." Another definition focuses on the design perspective of BIM: "an intelligent 3D virtual building model that can be constructed digitally by containing all aspects of building information — into an intelligent format that can be used to develop optimized building solutions with reduced risk and increase value before committing to a design proposal" (Woo et al. 2010). According to Boland et al. (2007), digital 3D representations allow more daringly shaped structures to be built cost effectively. Furthermore, digital 3D representations enable the elements of the building to be dynamically interconnected, so that multiple actors can share their knowledge more openly (Lacourse 2001). In addition, digital 3D enables richer and more detailed knowledge transfer and interactions (Boland et al. 2007), because previously tacit design knowledge has become explicit through the digital 3D representations (Yap et al. 2003). The usage of terms describing BIM is widely spread, where VDC is one of them (Succar 2009).

BIM combines software with process thinking and can be referred to as a multidimensional framework consisting of three fields, namely; technology, process and policy (Succar 2009). Due to its diversity, BIM could be used to demonstrate the entire building life-cycle (Bazjanac 2004). BIM enables efficient collaboration, improved data integrity, intelligent documentation, distributed access and retrieval of building data, multidisciplinary planning and coordination, and high quality project outcome through enhanced performance analysis (Gu & London 2010). The simulated environment of BIM enables architects, engineers and constructors to visualize what is to be built and identify any design, construction, or operational issues (Azhar 2011). Furthermore, BIM can be used to optimize the construction process with regards to five dimensions: height, width, depth, time and cost (Bryde et al. 2013). As an example, Peterson et al. (2011) have found that the introduction of BIM allows educators to design class projects that teach students to generate project plans for simulating real-world, complex projects. Furthermore, by integrating more detail and reality in class projects, which is enabled through BIM, students will better be able to learn how to apply different formal methods to specific project contexts (Peterson et al. 2011). Even though it is proven that BIM could bring an increased productivity and economic benefits to the AEC-industry, the real practice adoption of the system is yet not spread in the anticipated pace (Azhar 2011). According to Gu and London (2010), there is a lack of clarity on the applicability of the BIM-approach. Azhar et al. (2008) further argue that the underlying reasons could be divided into technical and managerial aspects, where the managerial aspects include lack of clear instructions of how to apply or use BIM. Therefore, the need for proper training in applying the practical adoption of BIM is crucial (Gu & London 2010). Furthermore, Gu and London (2010) stress the importance of a reflective practice among industry players in order to provide useful feedback for BIM-development and integration, and to critically evaluate the applications and their impacts on the industry.

# 3 RESEARCH METHODOLOGY

*This chapter presents the execution of this study, with descriptions of the literature study and the data collection as well as the data analysis. Lastly, the ethical considerations and the trustworthiness of this study are discussed.*

## 3.1 STUDY PROCESS

The main research strategy for this study is a qualitative one, but quantitative research has been conducted as well. The former focuses on describing findings in words while the latter describes findings in numbers (Bryman & Bell 2011). A qualitative research strategy is used to generate new theory instead of testing existing theory (Bryman & Bell 2011). This research strategy is primarily chosen due to its usefulness in fulfilling the purpose of the study. The strategy is motivated differently depending on various stakeholders' views. For the company, it is valuable to learn the right things and do things in the right way to stay competitive. From a societal point of view, it is crucial to do the right things in the right way to fulfill the safety aspects as well as to keep down costs. Hence, improving the VDC-learning platform in order to enhance the knowledge creation process is crucial in many ways. The quantitative data gathered in this study is used to gain insights in the current situation, while qualitative data provide more in-depth material.

The study is both an exploratory one as well as a descriptive one, with the intention to gain more insight into how a construction firm focuses on performance enhancement through corporate education. According to Saunders et al. (2009), a researcher does an exploratory study when the aim is to gain further understanding of the selected topic and a descriptive study is often done as a complement in order to obtain a correct view of the current situation.

The research questions presented above required different approaches to be answered, both through a literature and empirical study. The research approach of this study was an abductive one, where theory was developed in an iterative process of gathering literature and empirical data. In such an approach, data gathering and analysis are done simultaneously (Dubois & Gadde 2002). Various activities like report writing, literature review, data collection and analysis were done iteratively due to their interdependency.

The research design of this study is a single case study, which according to Bryman and Bell (2011) is defined as a specific study and analysis of a single case. In order to be able to generalize the findings from a case study to another context, there is a need for rich amount of data and thick descriptions (Bryman & Bell 2011). Therefore, multiple sources of data have been gathered such as observations, interviews and surveys, and will be discussed in the forthcoming sections.

A process chart illustrating the methodological process of this study is presented in Figure 2. Initially, a master thesis proposal was written and research questions were elaborated upon. Subsequently, an initial literature study was performed and the methodology of the study was determined. The main part of the study process was constituted by an abductive loop, where

empirical findings were continually analyzed against a continous literature study. The final analysis was iteratively validated internally before the final results and discussion were presented. Lastly, conclusions and recommendations were provided to the firm and a thesis report was finalized, which also leaves suggestions for future research.

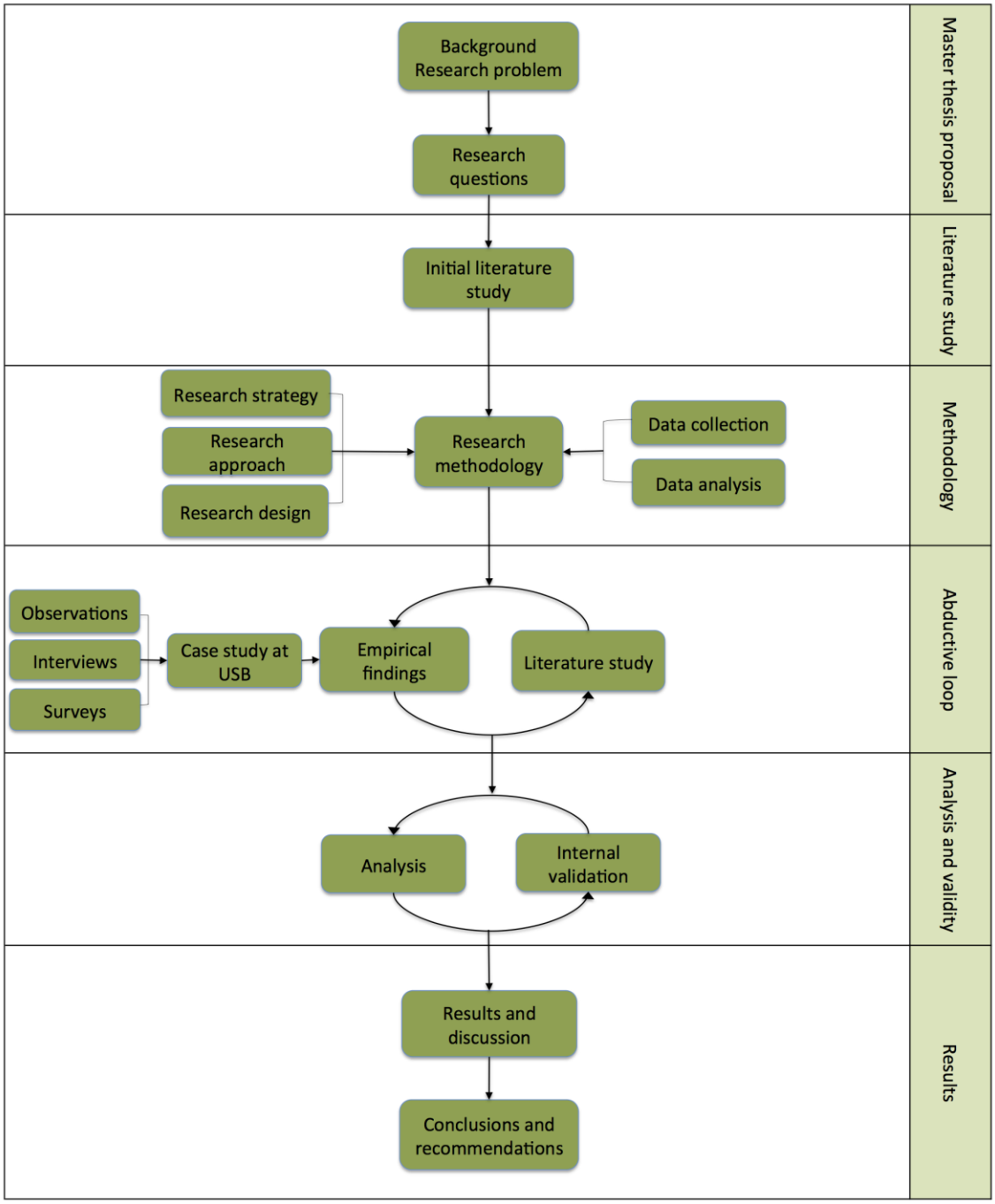


**FIGURE 2. PROCESS CHART ILLUSTRATING THE STUDY PROCESS**

## 3.2 LITERATURE STUDY

The literature study laid the foundation for the theoretical framework of this research project. The literature study was conducted in order to get an initial understanding for the research field and to be able to validate the findings from the empirical study. According to Hart (1998), the literature study aims to express certain views on the topic to evaluate available documents in relation to the proposed research. The literature study was performed by gathering secondary data from information found in databases, articles and books. This study was based on prior research within the field of knowledge management and knowledge creation in firms and was directed towards certain topics within this field based on the research questions. Initially, a systematic search approach was conducted, which was significated by research through a search engine based on selected keywords (Rienecker & Stray-Jörgensen 2004). The most commonly used search engine was Chans, where some keywords were: *knowledge management*, *knowledge creation, construction firms* and *BIM*. This search resulted in several sources, which were followed up by snowball sampling. Such a search method implies follow up research on the interesting sources through the referencing of them (Bryman & Bell 2011), which was an effective method for processing the relevant topics of the study.

## 3.3 DATA COLLECTION

The data for this research was collected through primary sources with the intention of fulfilling the purpose of this specific study. The nature of the research strategy chosen for this study, i.e. qualitative and quantitative research, implied the use of different data collection methods; observations, semi-structured interviews and surveys. The idea behind such a multi-method data collection was to be able to answer the research questions and to provide the firm with recommendations as well as to draw conclusions in order to contribute to the research field. The methods were conducted in a certain sequence, starting broad with observations followed by semi-structured interviews, which helped in narrowing down the gathering to specific survey questions. This specific sequence happened logically due to the nature of the study.

### 3.3.1 OBSERVATIONS

Observations were a helpful start in understanding the current situation at USB and how the learning platform was formulated and utilized. Several observations took place in different formats in order to get an insight into the different ways of learning. Two observations were conducted through different self-paced online courses from The College of VDC, with the intention of getting insight into the learning experience in such a format. In addition to this, one passive observation took place during an in-person training course. The purpose of the passive observation was to observe the class attendants and the instructor's teaching methods as well as to observe the interaction between these parties. Notes were written down during the observations in order to be able to go back and refresh the input that was gained. Since the study is delimitated to the effectiveness of the learning program rather than the content of the educational material, there was no need to actively participate in the class as a researcher.

By observing the educational courses within the learning platform at the firm, important understandings were obtained regarding how the teaching and learning was conducted. Furthermore, the observations induced an apprehension of the firm and its knowledge creation process and prepared for the interviews.

### 3.3.2 INTERVIEWS

Due to the exploratory and descriptive nature of the study, semi-structured interviews with experts and other knowledgeable people were a valuable source of data. Semi-structured interviews mean that the interviewer prepares some brief and simple questions in advance to use as a guideline, but does not need to follow the questions entirely (Kvale 1996). The interviewee has the opportunity to speak freely, and if allowed by the interviewee, the interview can be recorded so that the answers can be listened to again. According to Bryman and Bell (2011), this is a good way to ensure that the answers are recited correctly.

A total number of five semi-structured interviews, during approximately 30 minutes each, were held face-to-face or by phone with employees at different departments and with different positions at the firm. The prepared interview questions were sent to the interviewee by e-mail beforehand by request. With the interviewees' permission, the face-to-face interviews were audio recorded and helped in verifying the information from the sessions. The interviewer took notes throughout the interview in order to be able to go back and remember specific parts of the interview. The role of the targeted interviewees ranged from the manager of the learning platform to an instructor of the courses and to course attendants. The manager of The College of VDC was valuable to interview in order to gain understanding of the strategic idea behind the effort of such a learning platform. Similarly, the instructor's thoughts and opinions provided input into the goal and purpose of the courses. Course attendants from different departments, taking different courses from the learning platform, were interviewed in order to provide an understanding of the collective opinion of the courses. An enclosed template with the interview questions can be found in Appendix I – Interview Templates. The collective outcome of the interviews provided insight into the purpose and goal of the courses as well as the perception of the courses and helped in designing the survey questions.

### 3.3.3 SURVEYS

The main part of the data collected during the study was through long-term follow up surveys that were sent out to former course attendants by email using the program Survey Monkey. The surveys intended to follow up on some questions in addition to the traditional course surveys. The data gathered prior to conducting the surveys had lead to the relevant questions of it. With an understanding for The College of VDC through the observations as well as an understanding for the collective opinion of the courses through the interviews, the survey questions were formulated specifically to realize improvement potentials. Some of the questions were of multiple-choice character and some were open-ended ones, and the combination of these question types were used for the purpose of the analysis. The surveys provided statistics and useful insight on what to improve and were of descriptive nature intended to contribute to answering the research questions.

The target groups of the surveys were randomly selected from an attendance list through statistical functions in Microsoft Excel. The attendance list contained all prior course attendants since the start of the classes in 2011. The wide range in time, from October 2011 to June 2014, was chosen in order to decrease the bias of the study. The College of VDC is broken down into three main levels, the 100, 200 and 300-levels. Each level represents a certain advanced degree, where the 100-level is the least advanced. The College of VDC and its levels will be discussed further in chapter 4. 200 course attendants from each level were selected, which induced a total number of 600 attendants from all three levels. If there were any duplicates, i.e. course attendants who had participated in several courses, then the highest level of the cumulative courses taken were selected. After the removal of the duplicates, the target group for the surveys included a total number of 508 course attendants, where 169, 167 and 172 course attendants belonged to the 100-level, 200-level and 300-level respectively. The same survey questions were sent to all courses and its attendants, except for the VDC 101 class, which had one survey question less than the other ones. Templates of the survey questions can be found in Appendix II – Survey Templates.

The surveys were sent out together with information regarding the purpose of it and the intent to achieve improvements based on the responses received. In order to increase the response rate, an email reminder was sent out after one week. A list of VDC-courses with their corresponding number of surveys sent to attendants, number of responses received and the response rates are presented in Table 1 below. The strikethroughed cells indicate the courses that were removed from the analysis due to lack of sufficient data. These courses are in a pilot phase, which is why so few have taken them, hence being removed.

**TABLE 1. STATISTICS FOR THE LONG-TERM FOLLOW UP SURVEYS**

| Course Name | # Surveys Sent | # Surveys Received | Resoponse Rate |
|---|---|---|---|
| VDC 101 | 169 | 57 | 34 % |
| VDC 201 | 39 | 20 | 51 % |
| VDC 202 | 61 | 28 | 46 % |
| VDC 203 | 67 | 19 | 28 % |
| VDC 301 | 28 | 6 | 21 % |
| VDC 303 | 11 | 5 | 45 % |
| VDC 304 | 19 | 9 | 47 % |
| ~~VDC 308~~ | ~~8~~ | ~~2~~ | ~~25 %~~ |
| ~~VDC 310~~ | ~~1~~ | ~~0~~ | ~~0 %~~ |
| VDC 311 | 17 | 6 | 35 % |
| VDC 312 | 39 | 14 | 36 % |
| VDC 313 | 14 | 5 | 36 % |
| VDC 314 | 32 | 6 | 19 % |
| ~~VDC 317~~ | ~~1~~ | ~~1~~ | ~~100 %~~ |
| ~~VDC 322~~ | ~~2~~ | ~~0~~ | ~~0 %~~ |
| | | | |
| **Total** | **508** | **178** | **35 %** |

In addition to the above mentioned long-term follow up surveys, a specific survey was created and sent out to the VDC 314 live webinar course with the intention of gathering information about the perceived effectiveness of the live webinar teaching format in comparison to the in-person training format. The survey was sent to 25 course attendants, where seven of those responded. The specific course, VDC 314, was chosen as a request from the firm and the live webinar format had only been conducted once for that course. The template of the specific VDC 314 survey questions is enclosed in Appendix II – Survey Templates.

## 3.4 DATA ANALYSIS

The nature of qualitative data entails that analysis inevitably is performed simultaneously as the data collection (Miles & Huberman 1994). On the other hand, the quantitative data has to be analyzed when the data collection is completed (Bryman 2002). The collected data was analyzed in order to answer the research questions of this study. Different data types required different analysis methods. The quantitative data was divided into responses from each course and analyzed through Microsoft Excel, where statistics were presented through different charts such as columns charts, bar charts and pie charts. This method was chosen due to the simplicity of presenting quantitative data through illustrative representations. Collecting responses from each course was done to find differences and similarities between the courses. The qualitative analysis was performed through coding, where the responses from the interviews and the open-ended questions form the surveys were categorized into different fields. Coding means that data is broken down into component parts, which are given names (Bryman & Bell 2011). Patterns of similar responses were gathered into categories, in order to get a collective view of how the learning platform at the firm can support knowledge development internally, which is specifically connected to the first research question of this study. Furthermore, the categories also simplified the understanding of different improvement opportunities to ensure the applicability of the learning experience, which is directly related to the second research question of this study. The quantitative data illustrated the current situation, however, the qualitative data helped in understanding and explaining the current situation as well as to find improvement possibilities for a desired future state. As an example, the qualitative data with the open-ended responses could explain some of the quantitative scores in the surveys.

The quantitative and qualitative data analysis helped in creating assumptions, which were confirmed by further analysis of the gathererd data. Some data, such as duration of the courses and duration of hands-on model training in the courses were gathered in collaboration with the superviser at the firm in order to evaluate the assumptions. Based on the collective conclusion of the analysis, as well as the results from evaluating the assumptions, improvement proposals were elaborated upon and will be presented in chapter 5.

One validation method used during the analysis process was response validation, where the researcher validated the results in collaboration with the internal employees at USB. According

to Miles and Huberman (1994), forming conclusions in the analysis process require to be verified, which is why the conclusions, incuding the results from the assumptions, were discussed and verified several times together with the Corporate Senior Vice President and the VDC Director of Staff Development at the firm. In addition to this, the conclusions were discussed and verified by a VDC Content Specialist as well as a Marketing Manager within VDC/BIM.

When analyzing the quantitative and qualitative data from the interviews and surveys, it was stressed that those responses were the perceived experience of people. Therefore, understanding how knowledge is created and shared or how applicable their learning experience have been in their daily work, all depend on the perception of the interviewees and the course attendants. The results of the data analysis represented the empirical findings, which is presented in chapter 5.

## 3.5 Ethical Considerations and Trustworthiness

Ethical considerations are an important aspect when conducting a study. The context and nature of this study did not imply harm or deception to the course attendants. However, since the learning experience of the personnel was investigated, it was important to ensure that they did not feel that their position was threatened. The interviews and surveys contained opinion-related questions, and therefore, the interviewees' integrity was protected and the confidentiality was assured through anonymity. Furthermore, the interviewees were given the opportunity to review their answers together with the researcher at the end of the interviews. This further validated the findings and provided a security for the interviewees as well.

In order to contribute to the research field, as well as to enhance the learning platform at USB, the trustworthiness of this study is crucial. As stated by Bryman and Bell (2011), the trustworthiness of a study can be divided into four parts; credibility, confirmability, dependability and transferability.

Credibility means that there can be several views of the social reality, where the researcher has to ensure that the social world has been correctly understood (Bryman & Bell 2011). For this study, primary sources have been used in order to achieve credibility. Confirmability refers to the researcher's objectivity in conducting the study and can together with credibility be assured through triangulation, meaning that more than one source or method is used when collecting data (Bryman & Bell 2011). As mentioned before, the data collection of this study constituted of observations, interviews and surveys. Furthermore, the course participating interviewees were randomly selected and the surveys were targeted towards a number of course attendants by a random sample selection through a statistical tool. While complete objectivity is impossible, this was the chosen method to decrease the bias as much as possible.

Dependability means that the same result can be achieved irrespective of when and how many times the study is performed (Bryman & Bell 2011). Since this study is conducted in order to fulfill the present needs and expectations of USB, the dependability of the study can be argued as insufficient. However, due to the collective method of this study performed, with a

literature study to support the empirical study, this issue is considered as a minor one. If the study was to be replicated in a near future, the findings are likely to be similar.

Transferability refers to whether the findings from a specific study can be generalized to other contexts across social settings, or to the same context at another point in time (Bryman & Bell 2011). The primary source for this study consists of survey responses from employees at a specific construction firm, USB, which implies that the findings can be considered as quite specific for this study. However, the findings of this study can be generalized to other construction firms and contribute to the development of performance enhancement through corporate education, which implies that this study can be regarded as transferable.

# 4 CASE DESCRIPTION

*The following chapter describes a specific case at a construction firm. An introduction to the firm is provided followed by the firm's internal learning platform and its evaluations.*

## 4.1 INTRODUCTION TO SKANSKA USA BUILDING

Skanska USA Inc. is a provider of construction, preconstruction consulting, general contracting and design-build services to a broad range of industries including science and technology, healthcare, education, high-tech, aviation, transportation, sports and entertainment. Headquartered in New York with 32 offices across the country, Skanska USA has approximately 7 000 employees and the revenues for 2010 were $4.8 billion, representing 30 percent of Skanska Group's global revenues. One of four business units is Skanska USA Building (which is the focus area of this research and also referred to as USB); a leading provider of construction services within the building construction sector with approximately 2000 employees based in 26 offices (Choquette 2014a).

## 4.2 BIM AND VDC AT USB

USB began building a centralized internal BIM-structure in 2008 that is being referred to as Virtual Design and Construction (VDC), a multi-disciplinary performance model for the design and construction of capital facilities developed by Stanford University (Khanzode et al. 2006). There are other terms used in the industry to describe building models, such as VDC (Succar 2009). At USB, the term BIM is used to refer to the model itself, and VDC is used to refer to the many ways models are utilized, such as constructability reviews and scheduling[3].

According to Jim Becker, a Corporate Senior Vice President at USB, the new world of VDC has the potential to leverage USB's ability as builders to new heights. As technology is changing rapidly, there is a desire to remain at the forefront of the business, implying a great demand on proactiveness. A reactive organization might be less costly in the short term, but a proactive organization will be more cost efficient in the long run (Rowe & Nejad 2009).

## 4.3 AN INTERNAL LEARNING PLATFORM AT USB

In an attempt to incorporate the centralized internal BIM-structure, USB implemented a profound corporate education system in 2011: a VDC-learning platform referred to as *The College of VDC*. The strategic idea behind implementing such an education system through a VDC-learning platform was to fulfill goals regarding competitiveness, efficiency and safety[3]. As mentioned in the introduction, the vision of the platform is to educate and enable the employees to understand and utilize building models through VDC-applications in their daily work in order to make fact-based decisions. The intention is not that everyone should become experts in BIM, but that everyone should be able to take advantage of models in ways that directly support their current role.

[3] Mike Choquette (VDC Director of Staff Development at USB) interviewed on 10 April 2014.

USB has stated three key principles regarding their VDC-learning platform to be fulfilled by 2015, namely that; VDC will become an integral process within their operations, the VDC-methodologies will be incorporated in all design-build projects and all projects valued over ten million dollars, and all project-based personnel will be trained as users[3].

### 4.3.1 The College of VDC

The College of VDC is not an institution for higher learning, but rather a learning program for VDC within USB. The courses are intended to highlight how USB makes use of the software tools, focusing on their internal processes and the features that they use most often[3].

The VDC-applications are taught through courses given in three different training formats: live webinars, self-paced online courses and in-person training sessions. Live webinars are held online, where the instructor teaches over the Internet in a real-time setting, allowing the course attendants to follow from a remote location. The self-paced online courses allow the course attendants to manage their learning experience in their own manner by following a pre-recorded video material of for example a PowerPoint slide show presented vocally by the instructor. This format allows the attendants to learn the material in their own pace. The in-person training format represents the classical school setting, where the instructor and the students have a class session in a specific location such as a classroom or a conference room. The training format and location is normally determined together with the office training coordinators, where the most common format is in-person training. The self-paced online training format is an alternative for those people who cannot attend the regular classes, and the live webinar format is available for remote staff who would prefer taking courses with a live instructor (Choquette 2014b).

The applications are structured in four different levels, with each level representing different levels of complexity. The 100-level is the basic application level, presently containing a single course called VDC 101: Introduction to Virtual Design and Construction. This course provides a Skanska-specific overview of VDC and how attendees can learn more. The 200-level courses provide detailed background information on the VDC-applications within a specific area of interest, such as Project Planning. The 300-level courses focus on specific software processes and workflows necessary for a user to work independently on VDC-related tasks, such as 3D coordination of building equipment prior to construction. The 400-level courses will be created and taught ad-hoc, meaning that these courses are developed on an as-need basis. However, due to the nature of the 400-level courses and the fact that none have been developed yet, these are not considered as part of this study. Figure 3 illustrates The College of VDC, with its levels and examples of some of the courses.

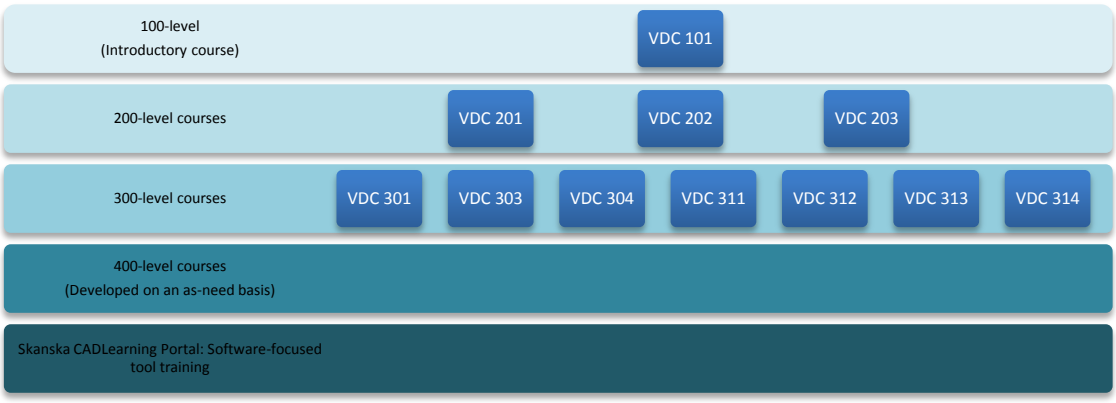


**FIGURE 3. THE COLLEGE OF VDC**

All courses are supported by software-focused tool training in programs such as Autodesk Revit and Navisworks. Adjacent to The College of VDC, the *Skanska CADLearning portal* is available to all employees for further information and support in using BIM. For example, it provides detailed self-paced user interface training in the software such as picks and clicks to achieve a specific set of goals.

The total number of course attendants in The College of VDC to date are; 1616 employees have attended the 100-level course (VDC 101), 585 employees have attended the 200-level class and 673 employees have attended the 300-level classes (Choquette 2014b). Employee turnover and the evolution of the industry require USB to continually develop, update and teach their courses. The rapid development of this technology and feedback from attendees support and drive this ongoing development.

### 4.3.2 CURRENT EVALUATIONS OF THE LEARNING PLATFORM

Today, USB uses a shorter form of survey to evaluate their training sessions directly after they have been conducted. As an example, the surveys are used to investigate the attendants' overall experience from the class and what they thought about the instructor, what they will do differently as a result of what they have learned and how they recommend the course to be improved. When the results are evaluated and followed up, adjustments are made to the courses. Although these small short-term surveys are used as feedback tools, there remains a lack of follow up on the applicability of the courses and the attendants' learning experience. A long-term evaluation of the applications taught through The College of VDC is missing, which cause unawareness regarding the fulfillment of its intended vision. As mentioned before, the VDC Director of Staff Development at USB has identified a need for further evaluating the learning platform in order to make changes and improvements to ensure that the efforts of The College of VDC are paying off.

# 5 RESULTS AND ANALYSIS

*This chapter presents the results of the case study at USB based on the observations, interviews and surveys conducted. Relevant data is presented in order to illustrate the outcome of the study. Furthermore, the results are analyzed in this chapter, which is supported by the quantitative and qualitative data gathered. The analysis was validated by the researcher in collaboration with the employees at USB. The qualitative and quantitative data from the surveys can be presented upon request to the author of this report.*

Quantitative and qualitative data was gathered in order to understand the current learning platform with regards to its usefulness as well as its contribution to knowledge development internally at USB. The quantitative data was gathered through the surveys and was evaluated to provide results and possibilities for conclusions. The qualitative data, gathered from observations, interviews and the open-ended questions in the surveys, was used as an explanation to the outcome of the multiple-choice statements. The quantitative data was derived from the multiple-choice statement responses in the surveys. An overview of the relevant quantitative results from the long-term follow up surveys are presented in Figure 4. The question formulations shown in the figure can be seen in their complete form in Appendix II – Survey Templates.

| College of VDC<br>**Follow up Survey Results** | VDC 101: Introduction to VDC | VDC 201: VDC Planning for Account Management | VDC 202: Information and Design Management | VDC 203: VDC for Project Planning | VDC 301: Safety | VDC 303: Visualization | VDC 304: Model Building | VDC 311: VDC in Estimating | VDC 312: Coordination and Clash Prevention | VDC 313: 4D Sequencing | VDC 314: Prefabrication and CAM | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total # surveys sent | 169 | 39 | 61 | 67 | 28 | 11 | 19 | 17 | 39 | 14 | 32 | |
| Total # responses received | 57 | 20 | 28 | 19 | 6 | 5 | 9 | 6 | 14 | 5 | 6 | |
| Response rate | 34% | 51% | 46% | 28% | 21% | 45% | 47% | 35% | 36% | 36% | 19% | **Question Average Score** |
| My background and/or prior training enabled me to get the most out of the course. | N/A | 3,9 | 3,9 | 3,7 | 3,2 | 3,2 | 4 | 3,5 | 4,1 | 4,6 | 4 | **3,8** |
| The course was relevant for my position. | 3,9 | 3,7 | 4 | 3,8 | 3,8 | 3,6 | 3,9 | 3,8 | 4,1 | 4,8 | 3,7 | **3,9** |
| The instructor's teaching methods (e.g. screen projections, power point slides, oral pre | 3,9 | 4,0 | 4,4 | 4,2 | 4,2 | 4,4 | 4,1 | 4 | 4,4 | 4,8 | 4,3 | **4,2** |
| The course met my expectations regarding my learning experience. | 4,0 | 3,8 | 4,1 | 4,1 | 3,8 | 3,4 | 3,8 | 3,7 | 4,1 | 4,8 | 3,7 | **3,9** |
| I have been able to apply what I learned to my current role at Skanska. | 3,4 | 3,5 | 3,4 | 3,1 | 3,2 | 3,4 | 3,1 | 3,2 | 3,5 | 3,8 | 3,5 | **3,4** |
| What I learned in this class may be applicable in a future role or on a future project. | 4,1 | 4,0 | 4,3 | 4,0 | 4,2 | 3,6 | 3,7 | 4,2 | 4,2 | 4,6 | 4,0 | **4,1** |
| After taking the course, I have more knowledge about how to use building information | 3,9 | 3,8 | 4,0 | 4,1 | 4,0 | 3,6 | 3,8 | 3,7 | 4,2 | 4,5 | 4,2 | **4,0** |
| The course enhanced my knowledge of Autodesk Revit and/or Navisworks. | 3,7 | 3,6 | 3,9 | 4,2 | 4,0 | 3,2 | 3,9 | 3,7 | 4,4 | 4,5 | 3,8 | **3,9** |
| **Course Average Score** | **3,8** | **3,8** | **4,0** | **3,9** | **3,8** | **3,6** | **3,8** | **3,7** | **4,1** | **4,6** | **3,9** | **3,9** |

**FIGURE 4. QUANTITATIVE RESULTS OF THE LONG-TERM FOLLOW UP SURVEYS**

The figure presents the average score of each multiple-choice statement throughout the courses, as well as the average score of each course. The orange-marked section addresses the applicability-related questions and will be elaborated upon further down in section 5.4. The average score of each course is illustrated in the chart in Figure 5. The average score of all courses was 3.9, which is marked by the red line.

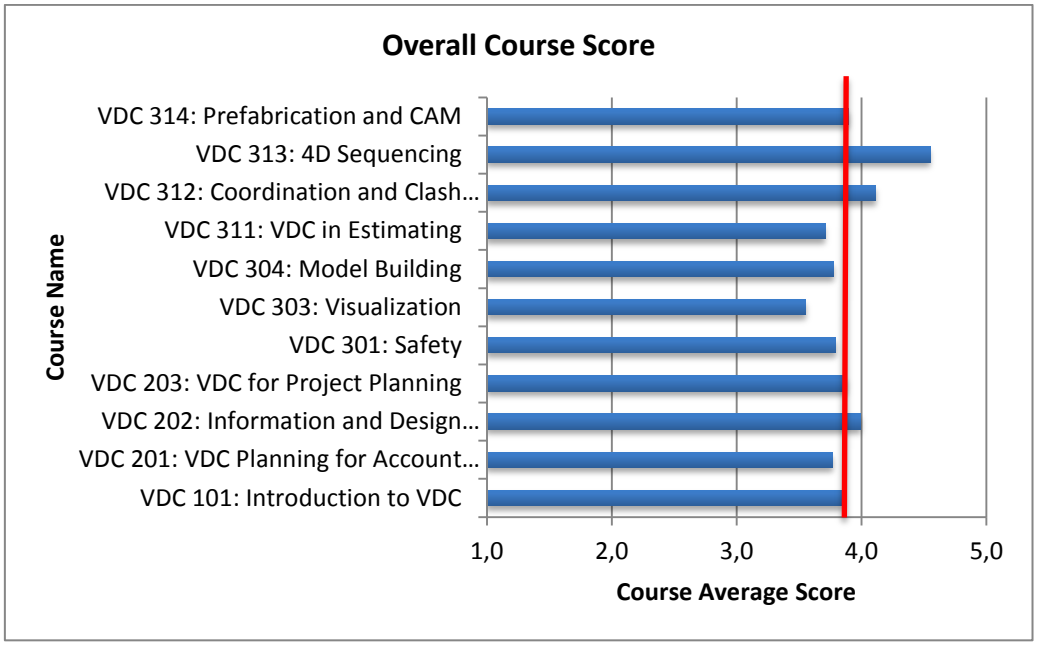


**FIGURE 5. OVERALL COURSE SCORES WITH AN AVERAGE OF 3.9**

Another multiple-choice statement that provided statistics was: *The course was relevant for my position*, where the results of that question is presented in Figure 6 below, with an average of 3.9 throughout all courses.

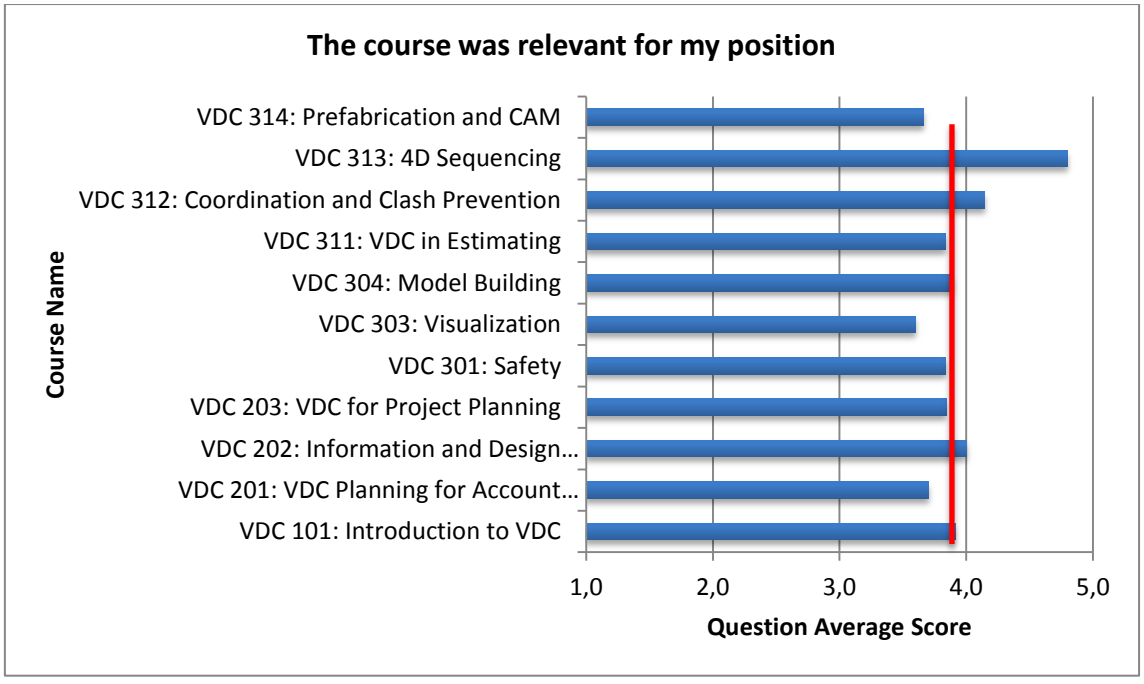


**FIGURE 6. SCORES REGARDING THE RELEVANCE OF THE COURSES WITH AN AVERAGE OF 3.9**

Figure 4, 5 and 6 show fairly positive results, at a first glance indicating that the courses are appreciated. Hereafter, the results of the study have been divided and presented in the following sections of chapter 5: 5.1, 5.2, 5.3 and 5.4. These four areas represent the main

outcome of the study and are chosen due to their aggregative character and will provide a more in-depth analysis of the data gathered.

## 5.1 KNOWLEDGE DEVELOPMENT IN BIM

As mentioned before, the vision of The College of VDC is to increase the knowledge regarding how to use information models in the employees' daily work. Although knowledge is difficult to measure, the inputs from the interviewees and the survey respondents have provided insight into their perceived learning experience and knowledge gained.

In the long-term follow up surveys, a question related to the perceived knowledge gained from the course about how to use BIM was asked. The result from that specific multiple-choice statement can be seen in Figure 7 below.

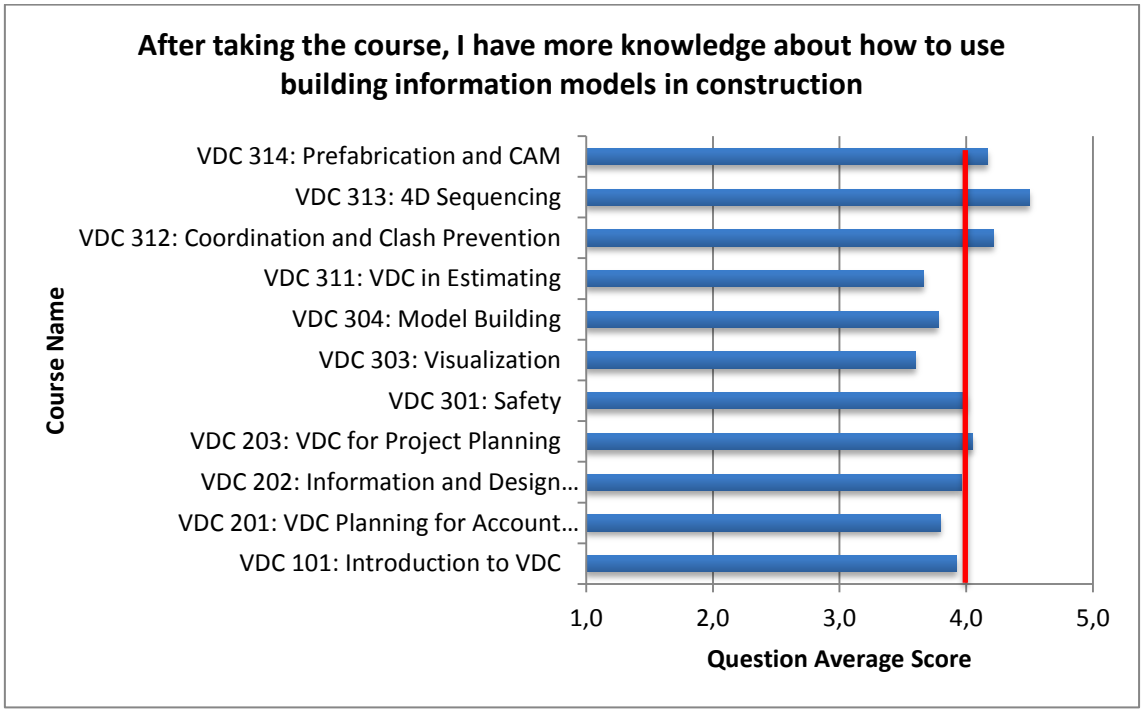


**FIGURE 7. SCORES REGARDING PERCEIVED KNOWLEDGE GAINED WITH AN AVERAGE OF 4.0**

The chart in Figure 7 shows an average score of 4.0, which corresponds to *Agree* in the multiple-choice list of answers. This might indicate that people have gained more knowledge from the course about how to use BIM. This can also be validated by some interviewees, where for example one interviewee, who works in VDC daily and who took several courses form the 300-level, stated that she learned things in class that she could start using the following day. Another interviewee who took the VDC 304 course mentioned that he learned that the software was a great tool in his job as a superintendent. Overall, the interviewees mentioned that they learned about different ways to distribute information to the next stage in their processes by using new knowledge gained in BIM-software.

The survey respondents were asked if they would be interested in the teaching material for future reference, and if so, what type of material they would be interested in. 60 percent responded that they wanted online access to the material, e.g. an email with walkthroughs, an online link with a step-by-step guide, videos on "how-to" et cetera. 36 percent requested PowerPoint slides of the teaching material and 19 percent requested paper handouts. Having access to the teaching material after the courses can contribute to further assurance of knowledge gained because one can repeatedly use the material as support in the learning process.

## 5.2 Applicability of the Courses

Although section 5.1 indicates that the course attendants have gained more knowledge from the courses about how to use BIM, another result is that the perception of being able to apply the new knowledge to their current role at the firm was relatively low. The multiple-choice statement regarding the applicability of the new knowledge gained resulted in an average of 3.4 only, which is significantly lower than most statements in the long-term follow up surveys. A chart of that specific multiple-choice statement can be seen in Figure 8.

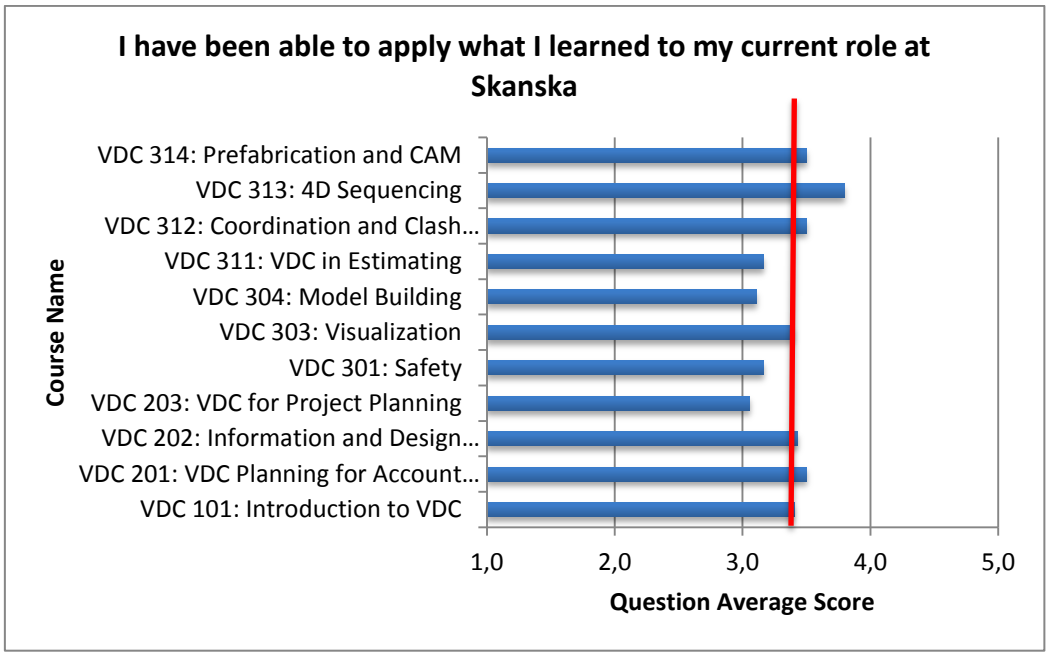


**FIGURE 8. SCORES REGARDING THE APPLICABILITY OF THE KNOWLEDGE GAINED WITH AN AVERAGE OF 3.4**

Further analysis regarding the applicability of the gained knowledge to the current job role was done in order to gain a deeper understanding of the issue. By analyzing the open-ended responses from the question: *What would have made the course more applicable or useful to you in your work?*, interesting categories could be assessed. Throughout all course levels of The College of VDC, four areas were identified as main categories to that open-ended question:

1) The possibility to utilize BIM-software (Revit and/or Navisworks primarily) on the respondent's current project
2) More hands-on exercises with real life examples from projects
3) Learning about the benefits of BIM/VDC for the clients
4) More training and frequent practice of the software

In addition to these four areas, a fifth category was identified directly linked to the responses from the 300-level survey respondents.

5) More in-depth and advanced training for the 300-level courses

The third category: *learning about the benefits of BIM/VDC for the clients,* incorporates the scenario of those employees working on selling the usage of BIM/VDC in a project to the client. Incorporating BIM/VDC in a project is advantageous in several ways but requires a higher wilingess to pay for the client. Therefore, learning about the benefits of BIM/VDC for the client is highly relevant and could be an order winner for the project. A table of some of these qualitative responses of each category can be found in Appendix III – Qualitative Responses.

Another open-ended question that was analyzed within the field of applicability was: *Could the course have been taught differently in order to be more effective? If so, how?* One main point that was identified from the responses was that there is a request for more hands-on examples in the courses. Of those who responded to the question, 20 percent would have liked working more hands-on in the courses. The following two quotes are presented to exemplify that request:

*"Incorporating live models and letting the employees work with these models during the training session."*

*"I would recommend that the course be taught like an actual BIM coordination meeting. Make it hands-on and teach me how to merge all the files into one combined REVIT file and then show/let me run the reports hands on."*

There is a need for learning how to work in the models, instead of just learning about what is possible to do with them. More hands-on examples and exercises in class could also improve the issue with applicability in their daily work.

One open-ended question that proved similar results as the above-mentioned ones was: *Were there any topics or materials that the course did not include that could have been included?* Of those who responded to the question, 14 percent requested further navigating or editing the models and 14 percent highlighted the need for more hands-on exercises or more advanced in-depth training.

The above-mentioned responses and categories imply a clear demand for the courses; more hands-on exercises and more advanced training.

## 5.3 TRAINING FORMATS

The open-ended question mentioned above: *Could the course have been taught differently in order to be more effective? If so, how?,* provided another main point, namely that the in-person training format is preferred. As an example, for VDC 101, 22 percent of those who responded to the question preferred the in-person training format. Similarly, the quantitative data support this result, where VDC 101 is chosen as the representative course, see statistics in Figure 9, Figure 10, Figure 11 and Figure 12 below. The numbers in the figures represent the number of respondents and their corresponding percentage.

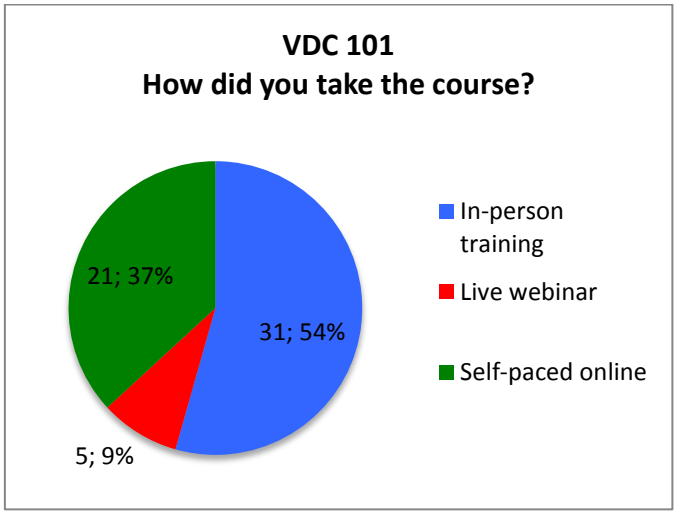


**FIGURE 9. STATISTICS ON THE DISTRIBUTION OF COURSE FORMATS TAKEN BY VDC 101 ATTENDANTS**

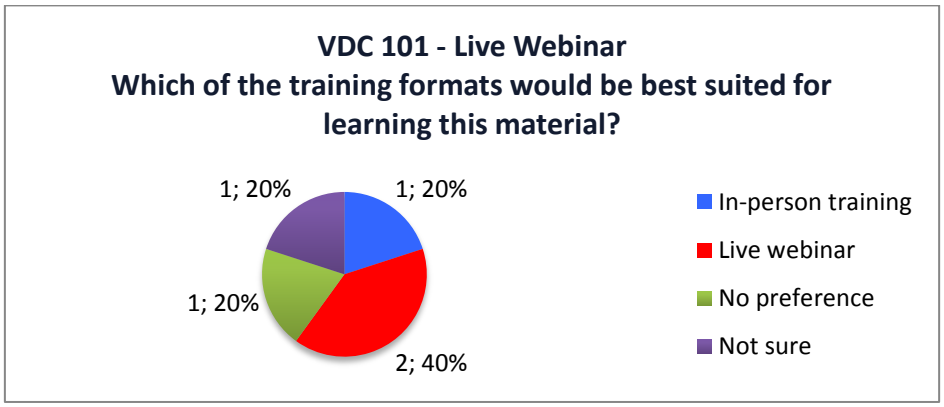


**FIGURE 10. STATISTICS ON THE PREFERRED TRAINING FORMAT AMONGST THE LIVE WEBINAR ATTENDANTS FOR VDC 101**

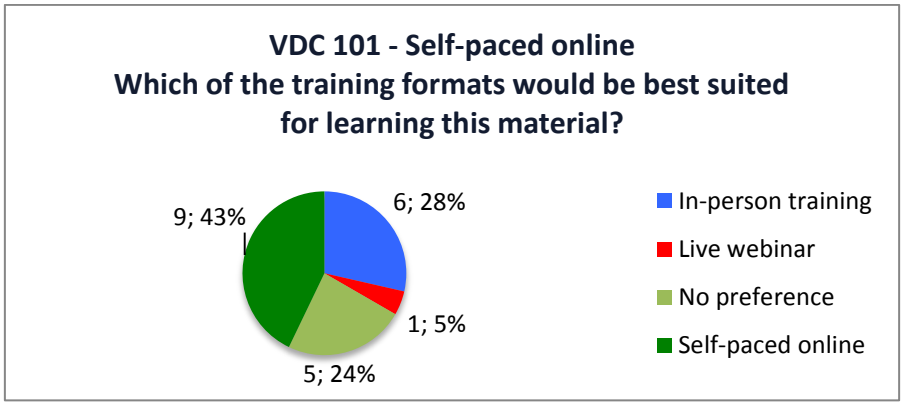


**FIGURE 11. STATISTICS ON THE PREFERRED TRAINING FORMAT AMONGST THE SELF-PACED ONLINE ATTENDANTS FOR VDC 101**

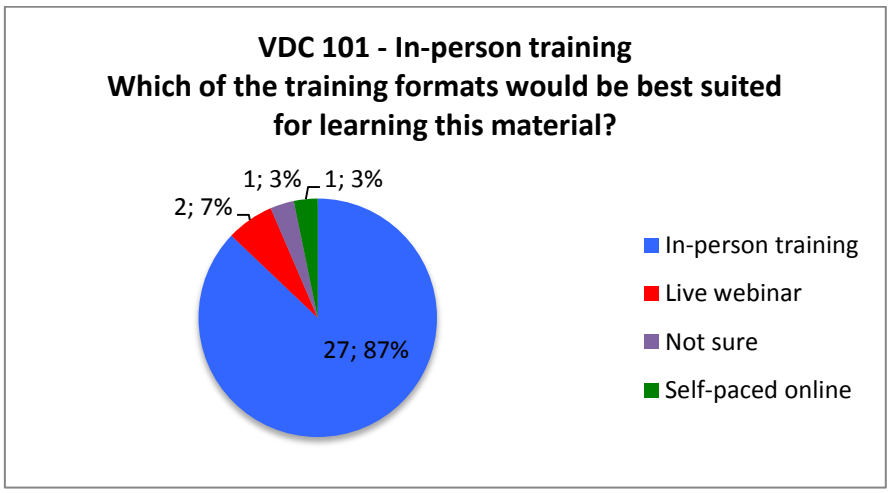


**FIGURE 12. STATISTICS ON THE PREFERRED TRAINING FORMAT AMONGST THE IN-PERSON TRAINING ATTENDANTS FOR VDC 101**

Throughout those courses that provide different training formats, i.e. VDC 101, VDC 201, VDC 202, VDC 304, VDC 313, the responses show that the in-person training format is more preferred than the other formats. In Figure 9, Figure 10, Figure 11 and Figure 12, where VDC 101 is representing all courses that provide different training formats, the in-person training format is clearly the best suited according to the respondents. As an example, in VDC 101, 87 percent of those who took the course through the in-person training format prefer it that way. Even for those who took the course through the live webinar or self-paced online format, a significant proportion (20 percent and 28 percent respectively) seems to prefer the in-person training format. There are similar results in the other courses providing mixed training formats as well. Some courses solely offer the in-person training format and a majority of those preferred that format as well. However, this result might be biased, because course attendants might not have tried other formats.

Although the above results indicate that the in-person training format is preferred, results from the specific survey that was sent out to the VDC 314 live webinar course attendants suggest an alternative outcome, see Figure 13 below.

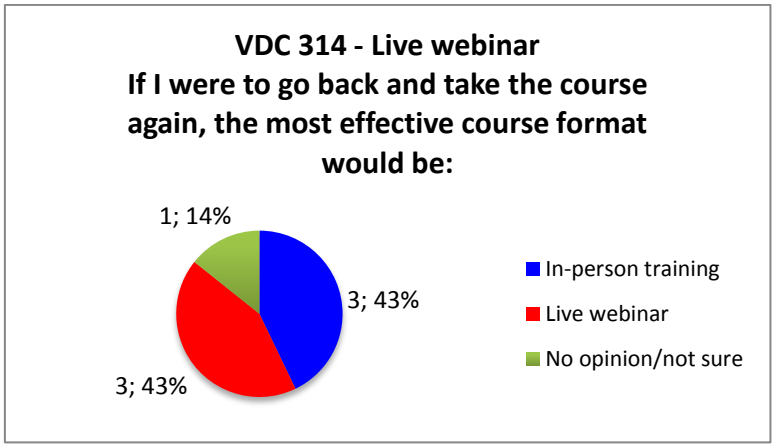


**FIGURE 13. STATISTICS ON THE PREFERRED TRAINING FORMAT AMONGST THE LIVE WEBINAR ATTENDANTS FOR VDC 314**

The chart in Figure 13 illustrates that there is an even split between course attendants preferring the in-person training and the live webinar format, implying that there is a demand for online live webinar formats as well. For non-hands-on courses, such as VDC 314, the live webinar format could be a suitable alternative and a less costly training format. However, combining the need for the live webinar format and the need for more hands-on courses, the live webinar format could be developed to have a more hands-on content as well. In this case, the live webinar format would be used as a complement for those who cannot attend the in-person training and still provide access to the same amount of hands-on exercises.

## 5.4 ASSUMPTIONS

The results and analysis described above contributed to a few assumptions that were investigated further. The assumptions were elaborated upon together with the internal employees involved in the study. Since course attendants had highlighted a need for more hands-on examples and exercises in the courses, it was decided to compare a hands-on course with a non-hands-on course and relate the average course scores to the amount of hands-on training offered in class. In addition to this, the level of perceived applicability for the course attendants was compared to the attendant's position. Therefore, the applicability-related questions were investigated and consider the expectations met regarding their learning experience, their ability to apply what was learnt to their current role and that what was learnt may be applicable in a future project. The specific formulation of the applicability-related questions can be seen in Figure 4. The following three assumptions were made:

**Assumption 1:** The more hands-on training content in a course, the higher the course score.

**Assumption 2:** The more hands-on training content in a course, the more knowledge you feel you lack since there is much more to learn, resulting in a lower course score.

**Assumption 3:** The scores of the applicability-related questions depend on the course attendant's position.

The first and second assumptions were investigated by examining the correlation between the time spent on working in models, i.e. spending time on hands-on examples versus no time spent on working in models, and the average course scores, see Table 2.

**TABLE 2. THE RESULTS OF ASSUMPTION 1 AND 2.**

| Course | Number of hours | Model Demonstrations | Hands-on Exercises | # Exercises | %Hands-on | Course average score |
|---|---|---|---|---|---|---|
| VDC 101 | 2 | Y | Y | 1 | 25% | 3,8 |
| VDC 201 | 3,5 | N | N | 0 | 0% | 3,8 |
| VDC 202 | 4 | Y | Y | 3 | 60% | 4,0 |
| VDC 203 | 8 | Y | Y | 3 | 80% | 3,9 |
| VDC 301 | 2 | Y | Y | 1 | 75% | 3,8 |
| VDC 303 | 4 | Y | Y | 2 | 80% | 3,6 |
| VDC 304 | 8 | Y | Y | 4 | 95% | 3,8 |
| VDC 311 | 8 | Y | Y | 4 | 60% | 3,7 |
| VDC 312 | 8 | Y | Y | 3 | 90% | 4,1 |
| VDC 313 | 4 | Y | Y | 2 | 90% | 4,6 |
| VDC 314 | 4 | Y | N | 0 | 0% | 3,9 |
| | | | | | | |
| | | | | | | |
| | | | | | Score > 4,0 | |
| | | | | | Score = 4,0 | |
| | | | | | Score = 3,9 | |
| | | | | | Score = 3,8 | |

The results in Table 2 indicate that, generally, the more hands-on training in class, the higher the score of the class. For example VDC 312 and VDC 313 have the highest average course scores and a very high percentage of hands-on training in class. The percentage reflects the amount of time spent on working in models during class, irrespective of training format. Although, there is an indication of the confirmation of assumption 1, however, the VDC 304 course shows somewhat different results. The VDC 304 course, which is the most hands-on class offered, has a significantly lower score than for example VDC 312 and VDC 313. This phenomenon could be indicating a diminishing return, where after a certain point, the level of hands-on training in class has a negative effect on the course scores. Consequently, the second assumption can be confirmed as well.

The third assumption was investigated by analyzing the scores of the applicability-related questions mentioned above. The work position of the survey respondents who gave the highest score, a score of 5, to these questions was identified and compared to the position of those who gave a lower score, a 1 or a 2, see Figure 14 and Figure 15.

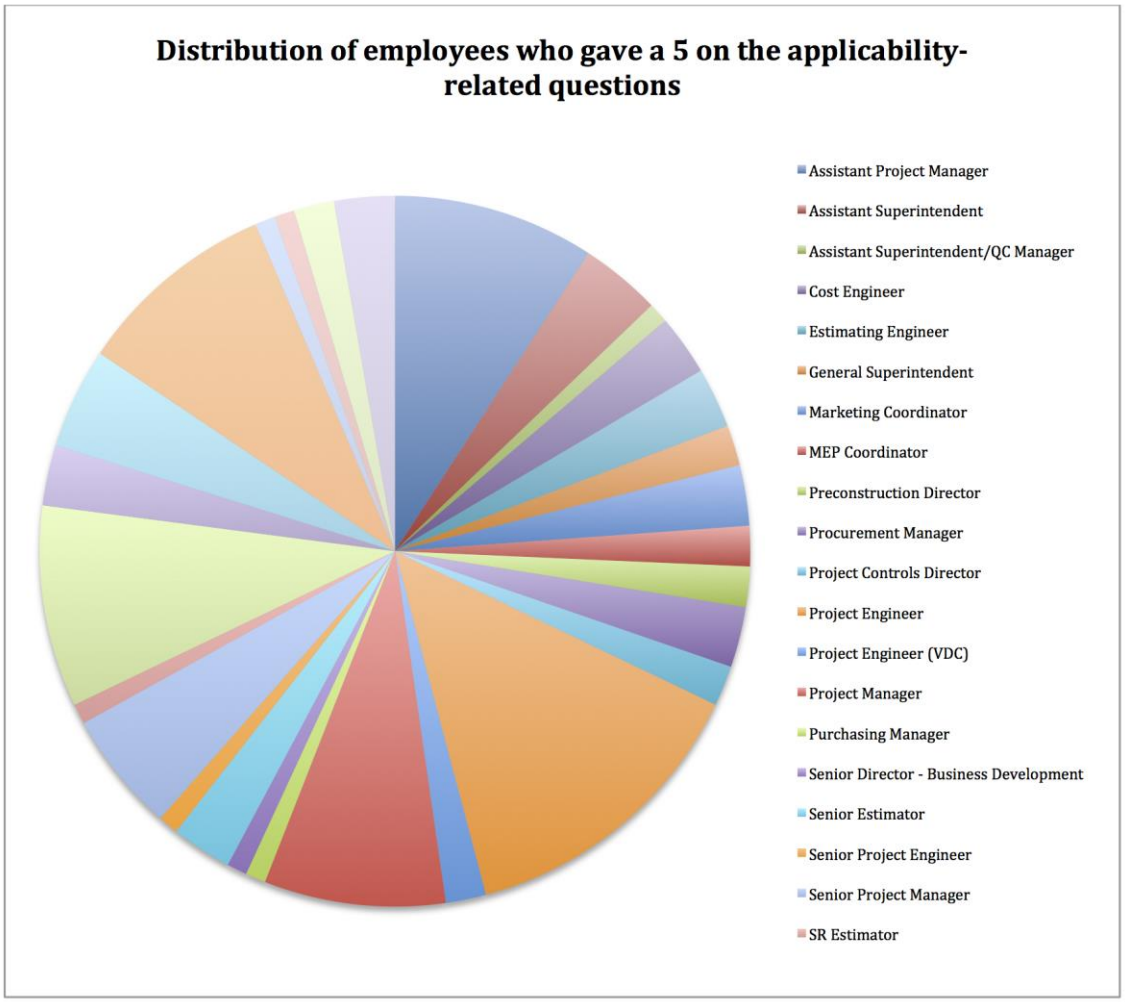


**FIGURE 14. THE DISTRIBUTION OF THE SURVEY RESPONDENTS WHO GAVE A 5 ON THE APPLICABILITY-RELATED QUESTIONS**

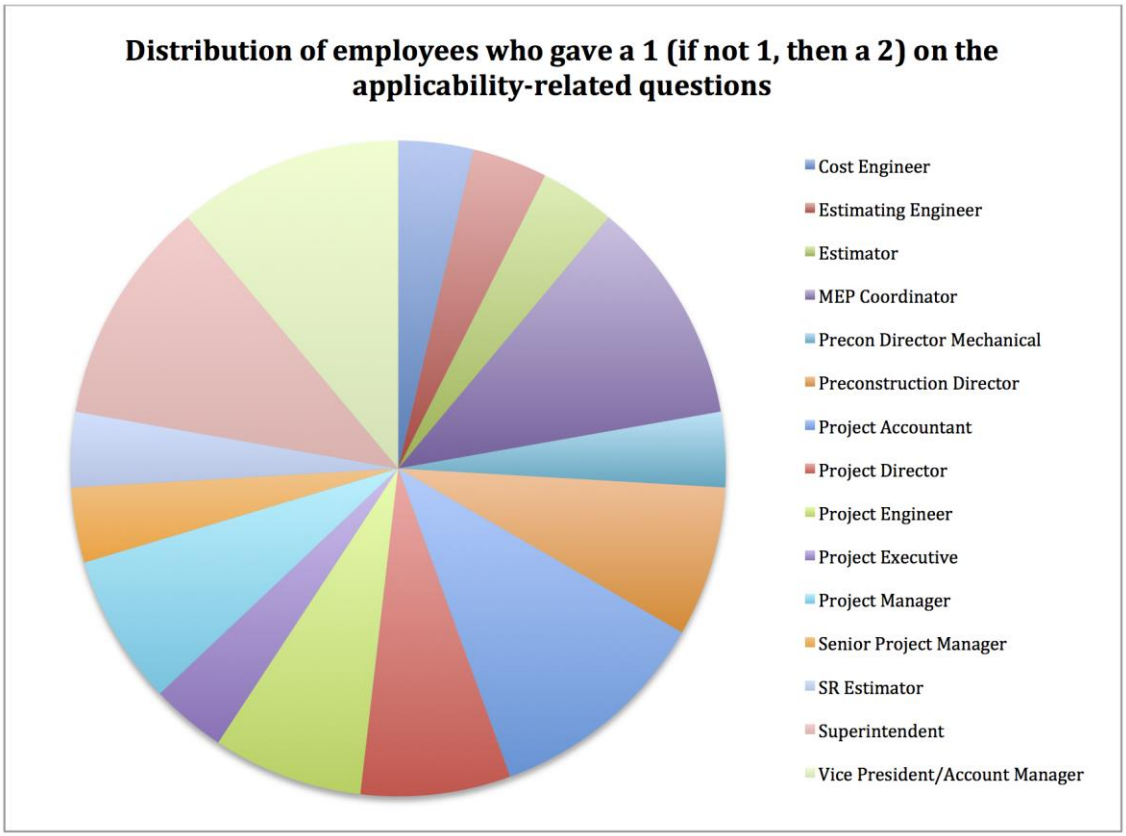


**FIGURE 15. THE DISTRIBUTION OF THE SURVEY RESPONDENTS WHO GAVE A 1 OR A 2 ON THE APPLICABILITY-RELATED QUESTIONS**

As illustrated in Figure 14 and Figure 15 above, the distribution of the course attendants' different positions is too varied to confirm the third assumption. Since there was no clear correlation between the position of the course attendants and the scores given by them in the applicability-related questions, assumption 3 was not analyzed further.

# 6 DISCUSSION

*This chapter presents a discussion regarding knowledge management through learning platforms as well as a comparison of the results to the research field with respect to tacit and explicit knowledge methods. Lastly, the contribution of this study to the research field will be discussed and suggestions will be given for future research.*

## 6.1 KNOWLEDGE MANAGEMENT THROUGH LEARNING PLATFORMS

The fact that USB utilizes BIM in their projects could be seen as a bridge between the two knowledge groups that Hartmann and Fischer (2007) mention; product (design) knowledge and process (sequencing and scheduling) knowledge. According to Straus and McGrath (1994), these knowledge groups need information-rich tools to coordinate and communicate between them and this need can be fulfilled by merging the parties through the utilization of BIM. Furthermore, utilizing BIM in projects requires a staff that has knowledge on how to navigate and withdraw relevant information from the models. Thus, continuous knowledge development in BIM is important, wherefore the VDC-learning platform plays a major role in the employees' learning process at the firm. This is also supported by theory, where Nonaka (1994) highlights the organization as the key player in helping the individuals to acquire new knowledge. Jones and Hughes (2004) highlight the importance of ensuring that applicable competences are being taught by continuously reviewing and improving the educational system.

As stated in the literature review, Sheehan et al. (2008) present two options to manage knowledge, where one is the explicit knowledge approach by using e.g. documents and the other is the tacit knowledge approach under which people can share experiences. By using the VDC-learning platform, USB incorporates both of these options. The VDC-learning platform is used to combine tacit knowledge sharing with explicit knowledge sharing due to its nature as an interacting tool for practice and learning as well as for information handling and learning material through for example documents. Furthermore, this implies that the learning platform can be considered to fulfill the four modes of knowledge creation, as stated by Nonaka (1994), since it is managed organizationally. Moreover, the VDC-learning platform is a digital visual representation tool that plays a major role in mediating knowledge, and in accordance with Whyte and Lobo (2010), it is beneficial for communicating, learning and capturing knowledge. Therefore, the VDC-learning platform can be seen as a strategic effort to assist the exchange of information and knowledge flow needed in an organization, which is consistent with research made by for example Egbu and Robinson (2008).

The results of this study will be discussed in the following section, where the implications of the outcome will be discussed related to tacit and explicit knowledge development. However, it is noteworthy that the results derive from an empirical study based on perceived experiences, and hence, knowledge is measured differently by different instances and in different contexts.

## 6.2 Knowledge Creation through Tacit and Explicit Knowledge Methods

There are several results in this study that strongly support previous research in the field. The results indicating a higher demand for more hands-on exercises with examples from real-life projects, as well as more training and frequent practice, and more in-depth and advanced training are all supported by theory. For example, Nonaka (1994) has elaborated upon the different ways of gaining tacit knowledge, e.g. acquiring experience through observation, imitation and practice. Comparably, Al-Ghassani et al. (2008) stated that training can help to improve staff skills and therefore increase knowledge. The results are also supported by Quintas (2008) in the sence that tacit knowledge is personal and cannot be codified. Similarly, the highest request for change was to increase the level of hands-on training in order to boost personal knowledge development. Moreover, results indicated that further hands-on training could increase the applicability of the learning experience. Furthermore, one of the four modes of knowledge creation – internalization, or the conversion of explicit to tacit knowledge – mentioned in research is conducted by the method of learning-by-doing.

Although the fact that the above-mentioned tacit methods can boost knowledge creation, further analysis demonstrated a different result; namely that there could be a diminishing return, where after a certain point, the level of hands-on training in class has a negative effect on the course scores. This could be explained by the fact that hands-on and advanced training in model building as such is challenging in its nature, wherefore an eight-hour class might not be sufficient enough.

Analyses did not show any correlations between the position of the course attendants and the scores given by them in the applicability-related questions. However, this could imply that no particular group is feeling left out, and hence, the vision of The College of VDC, i.e. to increase the knowledge of how to use information models in the employees' daily work, can be considered as fulfilled.

The possibility to utilize BIM and the software (Revis/Navisworks) on the actual projects was one of five main outcomes of the applicability issue at the firm. Prominently, research suggests that knowledge is increasingly developed by users in the context of its application (e.g. Scarbrough & Swan 2001), which underscores the importance of making the utilization of BIM possible on actual projects.

Another result showed that there was a clear demand for having the courses held through the in-person training format. Perhaps this format is preferred due to the ability of more interactions and discussions in class, which is closely linked to tacit knowledge methods such as shared experience or socialization. Hence, it could be interpreted that this training format is preferred because it simplifies the perceived learning experience among course attendants.

Explicit knowledge methods are equally as important for knowledge creation and development as tacit knowledge methods. Results from the surveys indicated a demand for access to the teaching material in different ways, which is a way of gaining explicit knowledge (Quintas 2008). Having access to the teaching material after the courses can contribute to further assurance of knowledge gained because one can repeatedly use the material as support in the learning process. Explicit possibilities to go back and access teaching material in this way are in line with research, such as for example Nonaka (1994) who presents one of the four modes of knowledge creation - externalization - or the conversion of tacit into explicit knowledge. Teaching material can also induce tacit knowledge creation, because such redundant information or necessary information can promote the sharing of redundant knowledge between individuals, which according to Nonaka (1994) fosters the sharing of individual tacit knowledge. Similarly, this is also supported by Numagami et al. (1996), who state that it is a practical requirement that everyone in an organization is given access to necessary information, since efficient knowledge creation requires quick inquiry and information processing.

## 6.3 Contributions and Future Research

This study shows that a higher level of hands-on training can foster higher satisfactions regarding internal corporate education programs. The empirical results provide insights on how a firm can enhance knowledge within a particular field, here VDC in BIM. The theoretical field regarding knowledge creation is strengthed through this study with respect to the need for learning-by-doing acitivities such as hands-on training.

Although the results of this study indicate a demand for further hands-on training in order to boost the applicability of the courses, nevertheless, it would be interesting to study the actual outcome of such a change. Therefore, future research could investigate how the level of applicability changes with the level of additional hands-on training. While this study was a single case study performed at a firm, a longitudinal study on knowledge development could provide more validated implications. In addition to this, an industry-wide study of how companies use their internal learning platforms could be used as a benchmarking tool for future developments of performance enhancement through corporate education systems.

# 7 CONCLUSIONS AND RECOMMENDATIONS

*This chapter provides a concluding summary of the results generated from this thesis. The research questions are answered and recommendations are provided to the firm addressed in this case study.*

The purpose of this study was to investigate and analyze the applicability of an internal learning platform at a construction firm. Such a platform concerning BIM could be used to develop knowledge and enhance performance through corporate education. A single case study was conducted at a construction firm to answer the research questions.

**RQ1:** In what way does a learning platform support knowledge development internally?

A learning platform induces knowledge creation and knowledge development by its nature as a tool for learning and for information handling. Courses held through different types of training formats provide learning through training sessions. Tutoring in class enables direct communications that strongly support the hands-on learning experience. Access to teaching material after the sessions allows for repetitions and mind refresheners in order to support the learning process.

**RQ2:** How can the applicability of the learning experience be ensured?

This study suggests several methods to ensure the applicability of the learning experience derived from courses in the learning platform. Hands-on exercises with real-life examples and advanced training can boost the applicability. The possibility to utilize the knowledge gained from the courses on the actual projects will allow for further learning. Furthermore, frequent training and practice in the software could ensure that the knowledge is used and developed on a regular basis.

In order for USB to increase the applicability of the courses taught through the VDC-learning platform, i.e. The College of VDC, a few recommendations are addressed to the firm. Firstly, it is important to conduct similar surveys continuously on a regular basis in order to understand the current state and to enhance the performance of the firm. A clear plan for who should take what course should be developed and communicated to the firm to ensure that the right person is taking the right course. Some courses should be focused more towards the specific set of tasks it was intended to help. For example, the VDC 201 – VDC Planning for Account Management should address the aspects of understanding the client, since it is a marketing class. Allowing such a course to learn about the benefits of BIM for the clients could increase the applicability of BIM on a project-to-project basis.

Since there was a clear demand for hands-on training in the courses, it is of great importance to make sure that hands-on corresponds to using real-life examples previously made at the firm and not older, less relevant examples that do not reflect everyday, realistic situations. In order to meet the demand of more hands-on training as well as more in-depth and advanced training, the firm is recommended to use a workshop approach to the courses. This implies

that, instead of the regular lecture format with a lecturer explaining how to do things, there is a mutual communication between the course attendants and the instructor. The course attendants would be allowed to learn by working in the models themselves, thus enhancing the knowledge creation process.

Although the in-person training format was preferred, there was still a significant request for live webinars as well. Therefore, the firm is suggested to plan webinars and merge offices and employees in order to save capital and use resources optimally.

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# APPENDICES

## APPENDIX I – INTERVIEW TEMPLATES

**Interview template – Manager of The College of VDC**

What is the purpose of The College of VDC (the learning platform)?

In what ways does The College of VDC support knowledge development internally at Skanska?

How do you use feedback from class surveys?

How does the feedback help you in developing The College of VDC and its courses?

Do you feel like you are missing info in the feedback that you need in order to develop The College of VDC?

**Interview template – Instructor of The College of VDC**

Please describe how you teach College of VDC Classes. For example, do you work from behind a computer and project your screen on a wall? Do you use hands-on exercises, etc.?

In general what are you hoping to accomplish through your courses?

Do you teach different groups differently? Depending on what factors?

How do, or can you help ensure that your students are paying attention and learning during class? (E.g. learning-by-doing)

What do you, or can you do in class that will help ensure that your students apply what they have learned?

**Interview template – Course attendants of The College of VDC**

What course did you take and when?

Did you find the class helpful? If so, in what way?

What did you think of the instructor's teaching methods?

In general, what did you learn from the class?

Have you been able to apply what you learned to your current role at Skanska?

Are you using the software? How often? What do you use it for?

Do you feel this may be applicable for a future role or project? If so, how so?

Do you foresee using the software more in the future?

What would have made it more applicable or useful to you?

Where there any topics or materials that the class did not include that it should have?

Do you have any questions or inputs that you would like to make?

# APPENDIX II – SURVEY TEMPLATES

**Survey template – Long-term follow up survey**

**General information:**

What is your job title? (Open-ended)

**Course specific information:**

How did you take the course? (*In-person training, Live webinar, Self-paced online, I do not remember*)

I found the format to be an effective way to learn this material (*Strongly agree, Agree, Neutral, Disagree, Strongly disagree, Do not remember*)

Which of the training formats would be best suited for learning this material? (*In-person training, Live webinar, Self-paced online, No preference, Not sure*)

My background and/or prior training enabled me to get the most out of the course. (*Strongly agree, Agree, Neutral, Disagree, Strongly disagree, Do not remember*)

The course was relevant for my position. (*Strongly agree, Agree, Neutral, Disagree, Strongly disagree, Do not remember*)

The instructor's teaching methods (e.g. screen projections, power point slides, oral presentation) helped me in my learning. (*Strongly agree, Agree, Neutral, Disagree, Strongly disagree, Do not remember*)

The course met my expectations regarding my learning experience. (*Strongly agree, Agree, Neutral, Disagree, Strongly disagree, Do not remember*)

I have been able to apply what I learned to my current role at Skanska. (*Strongly agree, Agree, Neutral, Disagree, Strongly disagree, Do not remember*)

What I learned in this course may be applicable in a future role or on a future project. (*Strongly agree, Agree, Neutral, Disagree, Strongly disagree, Do not remember*)

**Software specific information**

After taking the course, I have more knowledge about how to use building information models in construction. (*Strongly agree, Agree, Neutral, Disagree, Strongly disagree, Do not remember*)

The course enhanced my knowledge of Autodesk Revit and/or Navisworks. (*Strongly agree, Agree, Neutral, Disagree, Strongly disagree, Do not remember*)

If you currently use these packages, what purposes do you use them for? (*Open-ended*)

Have you used the Skanska CADLearning portal? (*Yes/No*)

If yes, how and when? (*Open-ended*)

On average, how often do you use the software (Revit and/or Navisworks)? (*Daily, Weekly, Monthly, Less frequently, Never*)

**Concluding information**

Were there any topics or materials that the course did not include that could have been included? (*Open-ended*)

Could the course have been taught differently in order to be more effective? If so, how? (*Open-ended*)

What would have made the course more applicable or useful to you in your work? (*Open-ended*)

Would you be interested in the teaching material for future reference? If so, what type of material (online, power point slides, handouts etc.)? (*Open-ended*)

Do you have any other comments or suggestions? (*Open-ended*)

**Survey template – Specific VDC 314 (live webinar) survey**

I found the webinar format to be effective for learning the topic (*Strongly agree, Agree, Neutral, Disagree, Strongly disagree, Do not remember*)

How effective was your learning experience in a live, web-based format compared to in-person training you have taken? (*The webinar format was as or more effective than in-person training, Less effective, About the same, No opinion/Not sure*)

Why? (*Open-ended*)

If I were to go back and take the course again, the most effective course format would be: (*In-person training, Live webinar, Self-paced online, No opinion/Not sure*)

## APPENDIX III – QUALITATIVE RESPONSES

The following table presents the categorized qualitative responses to the open-ended question: *What would have made the course more applicable or useful to you in your work*? The responses shown in the table are the most relevant ones with respect to patterns in the course attendants' responses.

| **The possibility to utilize BIM and the software on the actual projects** | **More hands on activities and real life examples from specific projects** | **Learning about the benefits for the clients** | **More training and frequent practice of the program** | **More in-depth and advanced training for the 300-level courses** |
|---|---|---|---|---|
| Actually be able to use BIM on my project | Examples of scenarios that actually occur on projects. When and why Project Managment and Superintendents actually go into a model | What do clients expect to see? benefits to clients using BIM? | Training | Since I already have in-depth knowledge of these programs, it would have been the most useful for me if it was more advanced and got into great detail. However, I know the course is structured towards beginners |
| If I was on a different project which allowed us to utilize Navisworks & Revit | I would like to see a superintendent teach the class and show how he uses this information in the field | Understanding the software so that when we are in front of a potential client, we can better explain the benefits | To use the software after i took the course | More advanced big picture workflows and less about the technical skills to complete the work |
| If this type of program was used at the project I work at then I could see many ways to use the program | More hands on | More emphasis on how to pitch VDC to specific client needs. Also, how to manage client expectations | I need to practice | As I had pretty good insight into clash detection prior to taking this course, some more advanced tips would have been great |
| Use models more on the jobsite | Perhaps more hands on/interactive | | I need to work in the program more frequently | Longer / more in-depth |
| …using the new tools in Revit and Navisworks | More hands on activities | | | If we had more time in the training to develop the schedule links to the modeling software |

| | | | | |
|---|---|---|---|---|
| | More specific training | | | |
| | More examples from specific projects | | | |
| | Use real life examples of how the information has been used by someone in my position | | | |
| | Would like to have tried a few more things to get more hands on experience | | | |
| | Use one of our current projects as an example | | | |
| | If the trainer/local office could somehow fit this in at a relevant time for a project. For example the day we recieve a model and a few weeks prior to the next deadline for that project | | | |
| | More hands on learning. This is a hard skill to develop only reviewing hand out materials | | | |
| | More examples from actual projects | | | |