ADOPTING NEW TECHNOLOGIES IN THE DESIGN AND CONSTRUCTION INDUSTRY: BEST PRACTICES FOR ORGANIZATIONAL CHANGE MANAGEMENT

By

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Submitted to the graduate degree program in Civil, Environmental and Architectural Engineering and the Graduate Faculty of the University of Kansas in partial fulfillment of the requirements for the degree of Master of Science.

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Date Defended: 19 July 2019

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ABSTRACT

The application of new technologies continues to grow in the architecture, engineering, and construction (AEC) industry. Adopting a new technology can require substantial effort for the company's staff to learn new skills and adapt operational norms, and therefore should be treated as an organizational change initiative. Organizational change is challenging, and many organizational change initiatives fail to achieve their intended outcomes. Companies who are better equipped to manage organizational change have a competitive advantage because they have a greater chance of successful change adoption, which then allows them to reap the benefits of the new technology in their operations.

The current literature in the field of AEC technology adoption has primarily investigated the technological functionality and benefits of the adoption, with limited focus on the organizational change management context. Research designs in the literature are often limited to an individual type of adopted technology and capture a limited number of organizational change cases in their data samples. To address these gaps, this study aimed to identify the organizational change management practices most associated with successful change adoption for a variety of technology-based organizational change cases collected across the AEC industry.

A survey questionnaire was used to collect a data sample of 167 cases of technology adoption. The questionnaire's unit of measure was designed such that each data point represented an entire organizational change case that occurred within a separate organization. Results found seven organizational change management practices that have statistically significant positive relationships with successful change adoption. The study also found differences in reported levels of change adoption between different groups of organization types and hierarchical positions of

respondents; whereas other parameters did not, such as technology function, new vs. upgrade situations, organizational sector, employee years of experience, and generational affiliation. This study contributes to the body of knowledge by identifying seven organizational change management practices associated with successful technology adoption across the AEC industry. These organizational change management practices may assist practitioners better understand and manage the technology adoption process in their companies.

ACKNOWLEDGMENT

I would like to express my gratitude to the greatest advisor and committee chair, Professor Brian Lines, for the tremendous support and guidance he provided me from the first day of my degree till the completion of my thesis. He sets the bar for the supreme advisor that anyone could ever have, he assisted me in all possible ways, academically and personally. I will be forever grateful to him.

I would like also to thank my committee members, Professor Daniel Tran, and Professor Michael Panethiere, for their time, valuable suggestions and patience they have offered me to complete this thesis.

I would like to thank the University of Kansas and the Civil, Environmental, and Architectural Engineering department for this opportunity to pursue my academics.

I would like to thank my wonderful parents, Dr. Nazih Bajis Maali and Dr. Rawda Qaruti, my siblings, Dr. Laith, Dr. Rawan, Dr. Read and my life partner “the wife” Sara, for their support, encouragement and believing in me throughout my degree.

Finally, I would like to thank my family members, friends, colleagues, and well-wishers for their unconditional love and support.

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CHAPTER 1: INTRODUCTION AND LITERATURE REVIEW

1.1 Introduction

The architecture, engineering, and construction (AEC) industry faces numerous obstacles to achieve goals such as reducing costs and increasing productivity. To achieve such goals, new practices and strategies—that is, 'innovations'—are needed. *Innovation* is defined as the adoption of ideas, systems, policies, programs, process, products, or services that are new to the adopting organization (Damanpour 1992). In the context of this study, the focus is on technology innovations in the AEC industry. In recent years, the use of new technologies in the AEC industry is increasing due to market pressure to improve productivity, reduce costs, enhance safety, and increase sustainability (Loosemore 2014). Examples of technology innovations that have been introduced in the AEC industry include building information modeling (BIM), mobile technology, scanning technology, sensor technology, virtual reality, augmented reality, safety monitoring, unmanned aerial vehicles (UAV; also known as drones), remote-controlled construction equipment, internet of things, and 3D printing. Technology innovations in the AEC industry will continue to be developed and to evolve because the benefits of technologies are well recognized. However the adoption of technologies in the industry is typically very slow compared to other industries (Edirisinghe 2019; Gholizadeh et al. 2018). Further, there is a large difference in the degree of adoption of technologies, such as BIM, at different companies because of different implementation processes (Chong et al. 2016; Lee and Yu 2016; Liu, Du, et al. 2017). Adopting a new technology is considered an organizational change since the adoption will affect the processes and protocols in the organization. In this context, *organizational change management* (OCM) is defined as the steps to implement practices that are different from the organization's current practices, with the intent to achieve organization-wide goals (Burnes 2009; Hallencreutz and

Turner 2011; Helms Mills et al. 2008). The AEC industry is not considered an industry that fosters innovations; some sources have asserted that the reluctance to adopt innovations a reason for the decline in the industry's productivity over 50 years (Crew 2017). Previous studies of technology adoption in the AEC industry – although primarily focused on investigating technological functionality and operational benefits – have consistently identified OCM elements (such as resistance to change, poor change-related communication, resource requirements for staff training, and lack of change leadership) as being major barriers to adopting technologies (Ahn et al. 2016; Ding et al. 2015; Gu and London 2010; Lee and Yu 2016; Lu et al. 2015; Ozorhon and Karahan 2017). The industry has an interest in establishing practices for managing technology adoption in the context of organizational change, so that implementation barriers can be overcome.

The current literature in the field of AEC technology adoption has primarily investigated the technological functionality and benefits of the adoption, with limited focus on the organizational change management context. Research designs in the literature are often limited to an individual type of adopted technology and capture a limited number of organizational change cases in their data samples. For example, the literature contains many case studies examining technical aspects of change initiatives, specific type of adopters, and a specific category or type of technology. To address this gap, the current study was conducted to examine OCM practices for adopting a variety of technologies broadly across the AEC industry. The study included survey data regarding 167 technology-adoption initiatives in the AEC industry in the United States and Canada.

1.2 Thesis Organization

This thesis comprises five chapters and one appendix:

- Chapter 1 presents a short background regarding best practices in adopting technologies in the AEC industry. the chapter contains a review of research on organizational change in general, organizational change in the AEC industry, and organizational change in terms of adopting technologies in the AEC industry. The literature review also discusses research on change-related trainings and employees' reactions to change implementation. The chapter also highlights this study's point of departure from other research and the study's main objective and approach.
- Chapter 2 contains the study's research questions and hypotheses. The hypotheses were used to scientifically answer the research questions, thereby enabling the research objectives to be achieved. The chapter also discusses the variables that were used to investigate the research questions for this study.
- Chapter 3 explains the steps used to design the data collection survey. The chapter explains how the web-based survey was distributed to potential participants. The end of this chapter summaries the survey responses, including the participants' demographic information. The chapter also lists the objectives and definitions of the statistical tests that were used to analyze the data and answer the research questions.
- Chapter 4 presents the results of the statistical tests. The chapter also contains interpretations of the test results and provides answers to the research questions.
- Chapter 5 presents conclusions based on the analysis results. The chapter also presents discussion of the research outcomes and objectives.
- Appendix contains a copy of the study survey.

1.3 Literature Collection Methodology

Previous studies on the topics of organizational change and the implementation of new technologies in the AEC industry were examined to identify common barriers to and drivers of successfully adopting new technologies. The following aspects of the studies were analyzed to identify gaps and limitations in the body of knowledge: data collection methods, data samples, data locations (i.e., countries the data were collected from), and type of organizational change initiatives.

Published articles from 2009 to 2019 were considered for the literature review. Articles were collected from various sources, including five leading journals (*Journal of Construction Engineering and Management*; *Journal of Management Engineering*; *International Journal of Project Management*; *Engineering, Construction, and Architecture Management*; and *Automation in Construction*), international databases (the American Society of Civil Engineers online library, Emerald Insight online library, and Elsevier online library), and the University of Kansas online libraries. The focus was on collecting articles focused on organizational change, technology diffusion, technology adoption, technology implementation, and adoption success factors in terms of organizational change and the AEC industry. Some of the main keywords used in online searches were *organizational change*, *change management*, *change adoption*, *successful change adoption*, *organizational change adoption*, *technologies in AEC industry*, *implementation of technology*, *adoption of new technology*, and *critical success factors for adopting technology*. The search process also involved identifying articles published from 2014 to 2019 on research designed to introduce or study the application of technologies in the AEC industry. The collected articles were reviewed and filtered so that the literature review included only articles with a focus on organizational change adoption and technology implementation in the AEC industry. More than 100 articles were included in the literature review for this study.

1.4 Literature Review

The collected literature of OCM were divided in to three areas as the following:

1.4.1 OCM in the Literature

Lewin (1947), an early researcher on OCM, proposed three phases of change implementation: unfreezing, moving, and refreezing. Lewin's research indicates that organizational change can be divided into steps to successfully adopt change. Several models of recommended OCM practices were proposed throughout the literature (Burnes 2009; Galpin 1996; Hunsucker and Loos 1989; Judson 1991; Kanter 2003; Kotter 1995; Luecke 2003; Price and Chahal 2006). According to these models, a well-planned process is needed in order to successfully implement change. These models commonly recommended practices such as using change agents to lead the change process, communicating the change vision, monitoring the change, obtaining the commitment of top management, and providing change-related training for employees. The use of these models in the AEC industry is limited because they were not designed for a specific industry (Lines and Smithwick 2019). Due to this limitation, studies on OCM practices in the AEC industry are needed.

1.4.2 OCM in the AEC Industry

OCM practices in the AEC industry are accompanied by several barriers to change adoption because of the nature of the industry (Lines, Sullivan and Wiezel 2015). Change implementation in the AEC industry has been extensively studied; many of the studies have focused on one type of change innovation, such as alternative project delivery methods. A framework for implementing an alternative project delivery method was proposed by Migliaccio et al. (2008). Other research has examined strategies to successfully adopt the design-build method in AEC firms located in the United States and Canada (Jergeas and Fahmy 2006) and in Korea (Park et al. 2009). Additional studies have examined drivers of and barriers to adopting public private partnerships in firms located in China and Hong Kong (Chan et al. 2009) and in Nigeria (Babatunde et al. 2015). Other types of change innovations that have been studied include the adoption of modern methods of construction, such as lean construction (Castillo et al. 2015; Ozorhon et al. 2014; Rahman 2014; Salem et al. 2006), Six Sigma (Pheng and Hui 2004; Siddiqui et al. 2016), front-end planning (Hwang and Ho 2012), safety innovations (Esmaeili and Hallowell 2012), human resources practices for safety management (Lai et al. 2011), total quality management (Maher Altayeb and Bashir Alhasanat 2014; Burati and Oswals 1993; Sui Pheng and Ke-Wei 1996), quality management programs (Sullivan 2011), alternate procurement approaches (Hurtado et al. 2018), risk management (Chileshe and Kikwasi 2014; Rostami et al. 2015; Zhao et al. 2015), and prefabrication (Wong et al. 2017).

Most of the literature has focused on the technical aspects of adopting change instead of management practices in the context of OCM (Lines and Smithwick 2019). Limited studies have investigated OCM practices in the AEC industry and provided a framework for managing the change process to achieve maximum benefits (Erdogan et al. 2014). One proposed framework consists of five stages: initiation of change, development of change vision, development of a plan for organizational change, implementation of change, and evaluation of change. Other research has focused on workplace relationships and attitudes toward organizational change in engineering asset-management organizations (Xerri et al. 2015), highlighting the important role of the change management team (change agents) in managing employees' resistance to change.

Other researchers have studied specific types of change in specific industry subsectors. For example, Said (2015) studied best practices for adopting prefabrication among electrical contractors, while Lines and Smithwick (2019) studied best OCM practices among electrical contractors. Lines and Vardireddy (2017) studied OCM practices in change innovation in the AEC industry. The researchers ranked OCM practices based on the relationship between OCM practices and successful change adoption, based on a global data sample of 237 organizational-level change initiatives. The researchers identified five categories of organizational change: software, technology application, supply chain reorganization, management and operations, and business strategy. Lines and Vardireddy's (2017) research provided a broad understanding of OCM practices throughout the AEC industry, not only for a specific change category (e.g., technology innovation).

1.4.3 OCM for Adopting Technologies in the AEC Industry

The literature contains numerous studies regarding technology innovation in the AEC industry. Researchers have investigated practices in technology innovation, diffusion, and implementation in various contexts, such as technology in general, specific types of technology, specific types of technology in specific industry subsectors, technology in specific countries, and technology in specific projects. Slaughter (2000) emphasized that to improve the technological capacity in the construction industry, an innovation management system is needed. Researchers have studied innovations to provide better innovation management models (Ercan 2019; Liu, Li, et al. 2017). Research has identified factors promoting and preventing the diffusion of technology in the AEC industry (Gan et al. 2019; Nikas et al. 2007) and the adoption of technologies (Peansupap and Walker 2006; Sepasgozar et al. 2018). Researchers have also studied technologies that aid a specific process in the AEC industry. Several types of technologies are used to improve safety at construction sites, such as sensor technologies and smart phones that detect near mess incidents (Lim et al. 2016; Park et al. 2016; Zhang, Cao, et al. 2019) and detect the use of hard hats (Zhang, Yan, et al. 2019), mobile software that improves safety inspection processes at construction sites (Zhang et al. 2017), machine learning software that analyzes videos to identify in real time whether workers are wearing hard hats at the construction site (Park et al. 2015), and eye-tracking technology that improves safety training for workers (Hasanzadeh et al. 2017). Most of the research on technologies related to construction-site safety have focused on technological benefits rather than the company process for adopting the technology. Some researchers have studied the feasibility and acceptance of wearable safety equipment (Awolusi et al. 2018; Choi et al. 2017; Ryu et al. 2019). Seo et al. (2018) examined the use of unmanned aerial vehicles, also known as drones, to improve the inspection process for a bridge located in South Dakota; the researchers found that drones can perform tasks at a lower cost than is possible through traditional methods.

Most of the of adopted technologies in the AEC industry are categorized as information communication technology (ICT) and smart systems software because of the technologies' potential ability to restructure and simplify work procedures, thereby enhancing productivity and safety (Liu et al. 2018). Delgado-Hernandez et al. (2017) highlighted that smart systems, such as planning software and design software, are the management tools that are most used and most important in helping the construction industry improve its quality. The use ICT can facilitate integrated project delivery (Ahmad et al. 2019; Azhar et al. 2015).

Smart systems that use virtual reality and augmented reality technology have been adopted in the AEC industry; examples include site monitoring (Zollmann et al. 2014), safety training for construction workers (Dawood et al. 2014; Froehlich and Azhar 2016), facilities management

(Carreira et al. 2018), and quality and progress management (Akinci et al. 2006). Other smart systems and programs have been researched, including optimized computer programs that plan the layout of material yard laydown (Alanjari et al. 2015) and programs that use advanced machine-learning and consider economic variables to estimate new-construction costs (Rafiei and Adeli 2018). One of the widely researched smart systems is BIM. Researchers have studied BIM's effectiveness and functions (Hwang et al. 2019, Liu, Du, et al. 2017); the diffusion of BIM (Gholizadeh et al. 2018); BIM's contractual and legal risks (Arshad et al. 2019; Chong et al. 2017); the impact of BIM implementation on the adoption of other changes, such as integrated project delivery (Chang et al. 2017); the impact of BIM adoption on lean construction (Ahuja et al. 2018; Koseoglu and Nurtan-Gunes 2018; Koseoglu et al. 2018); BIM-integrated functions and applications in other processes (Deng et al. 2019; Ma et al. 2018; Teo Ai Lin et al. 2017; Wang et al. 2019), such as safety monitoring using Bluetooth mobile tracking sensors integrated with BIM (Park et al. 2017) and the use of BIM in green buildings (GhaffarianHoseini et al. 2017; Murphy and Nahod 2017).

For this study, research on critical factors, risks, and obstacles related to implementing BIM were the most suitable for obtaining a better understanding of challenges that organizations face when implementing BIM. Critical success factors for BIM implementation have been clearly identified through studying the literature from 2005 to 2015 (Antwi-Afari et al. 2018), including the use of BIM in developing countries, where BIM is new to the construction industry (Ozorhon and Karahan 2017), and among architects in China (Ding et al. 2015). Researchers have examined BIM implementation risks and barriers among Chinese practitioners (Jin, Hancock, Tang, Chen, et al. 2017; Jin, Hancock, Tang and Wanatowski 2017; Zhao et al. 2018; Zhou et al. 2019). Some researchers have proposed frameworks for implementing BIM (Gu and London 2010; Hong et al.

2019; Jung and Joo 2011; Khosrowshahi and Arayici 2012). Other researchers have investigated the acceptance of BIM adoption (Lee and Yu 2016; Lee et al. 2015). Chong et al. (2016) compared BIM adopters to highlight the differences in maturity level of BIM implementation.

1.5 OCM Practices

Taking an interdisciplinary approach for the literature review provided the author with a better understanding of key practices in OCM regarding technological innovation in the AEC industry. The interdisciplinary approach was needed because of the previously mentioned limitations of the literature. The key OCM practices in the literature on technology adoption in the AEC industry align with practices used in two studies on the AEC industry (Lines and Smithwick 2019; Lines and Vardireddy 2017); both studies will be used as reference points. This alignment motivated the author to focus on seven key OCM practices for the current research. These practices are discussed in the following subsections.

1.5.1 Senior-Leadership Commitment

One of the most important drivers of successful change adoption identified in the literature is the involvement of senior leadership. Before the adoption of any change senior leaders should justify the purpose and appropriateness of the proposed change (Beer and Eiesentat 1996). Senior leaders should be committed throughout the entire change-adoption process (Armenakis et al. 1999) to support the progress of the change in the organization (Emiliani and Stec 2005). In the AEC industry, a lack of senior-level support is a critical hindrance to implementing enterprise risk management (Zhao et al. 2015). In a study that investigated critical success factors for BIM implementation in developing countries, effective leadership was found to be one of the most significant drivers of success in 96 construction firms (Wang et al. 2019). A study about obstacles to implementing ICT showed the importance of managers providing support (Peansupap and

Walker 2006). Liao et al. (2018) reported that the early involvement of key stakeholders and primary participants counters obstacles to implementing BIM and enhances the adoption of change in building projects. Other researchers have stated the crucial role that management support plays to the adoption of BIM (Cheng and Teizer 2013; Gu et al. 2010; Lu et al. 2015; Xu et al. 2014).

1.5.2 Training Resources

A major obstacle to successfully implementing change is not providing appropriate change-related training to employees (Alvesson 2002; Galpin 1996; Schneider et al. 1994). To implement and achieve the full potential of BIM, the AEC industry need to invest in training (Chang et al. 2017). Providing change-related training is one of the factors supporting successful adoption of ICT (Lu et al. 2015; Peansupap and Walker 2006) and BIM (Ahn et al. 2016; Ozorhon and Karahan 2017).

1.5.3 Communicating the Benefits of Change

To avoid resistance to change, the benefits of the change should be communicated to the employees (Bourne et al. 2002). The disadvantages of not implementing the change should also be communicated (Cameron and Quinn 1999). A study across the AEC industry was conducted to investigate potential causes of the digital divide in BIM adoption. The researchers found that when employees lack an understanding of the benefits of implementing BIM, they are more likely to resist the change (Ayinla and Adamu 2018). In another study on BIM implementation, one of the listed barriers was uncertainty about the benefits of BIM implementation (Zhou et al. 2019). Peansupap and Walker (2006) noted that one of the obstacles to change at the organizational level is the failure to identify clear benefits of using ICT. Arayici et al. (2011) and Peansupap and Walker (2006) stressed the importance of communicating the benefits of change to employees.

1.5.4 Establishment of a Realistic Timeframe for Change Adoption

The benefits of strategic long-term planning instead of short-term planning were highlighted by Garratt (1999) and Tatum (1989). Smollan (2011) noted that employees may resist change if they believe that managers are requiring the change at an impractical time. Hong et al. (2019) identified the absence of long-term BIM implementation plans as an organizational barrier to implementing BIM. Other researchers have reported that an obstacle to implementing change involves underestimating the resources and time required for employee to learn and accomplish the change (Loosemore and Cheung 2015; Li and Becerik-Gerber 2011; Peansupap and Walker 2006; Sullivan 2011; Tan et al. 2012).

1.5.5 Change Agent Effectiveness

Change agents are members of an internal team that guides the transition; change agents are known as the "internal champions of change" (Hunsucker and Loos 1989; Kanter 1983). Change agents have one of the most important roles during change implementation (Wolpert 2010). Organizations should assign individuals to be change agents, giving them responsibility to lead the change. Members of the change agent team should be available to provide support before and during the change (Covin and Kilmann 1990; Schweiger and DeNisi 1991). In a study comparing BIM acceptance in Korea and the United States, the researchers found that BIM acceptance can be increased in Korean companies by organizing a group of employees who are open to adopting new technologies (Lee and Yu 2016). Ahn et al. (2016) suggested that BIM adoption can be enhanced when a company creates a department with clear organizational goals related to BIM implementation. Gu and London (2010) stated that to facilitate BIM adoption in the AEC industry, companies need to have teams that have been trained and that are dedicated to supporting BIM implementation.

1.5.6 Establish Clear and Measured Benchmarks of Change Progress

Establishing clear bench marks of the required outcomes and measuring it thought the change process is an important strategy for building change momentum (Lines and Vardireddy 2017). Creating short-term millstones and celebrating it, will recognize and reward employees who been actively involved in the change (Kotter 1995). In BIM adoption, a proper list of benchmarks is very important to evaluate BIM performance and to point the future directions (Liu, Du, et al. 2017). Lack of immediate benefits and performance improvements are barriers for BIM implementation (Eadie et al. 2013; Lee et al. 2015). Lines and Smithwick (2019) stated that measuring performance benchmarks have several advantages, including measuring if the change is being successful and help in building change momentum.

1.5.7 Workload Adjustments to Support the Adoption

Learning and applying new practices and processes are inevitable aspects of change implementation. Employees involved in change implementation will typically have change-related trainings, meetings, and other activities added to their workloads. Smollan (2011) observed that employees resist change when they experience unfavorable outcomes, such as work overload. In the AEC industry, which is focused on cost and time, investment is required to successfully implement change (Chang et al. 2017). Employees’ time is one of the investments that should be considered when implementing change. Peansupap and Walker (2006) found that two of the obstacles to ICT implementation are the time available to learn information and the time available to share information. Also, the researchers mentioned that managers have little time to mentor employees and encourage them to implement the change. Peansupap and Walker (2006) added that employees may become frustrated about implementing the change because of the lack of time to learn about the change and how to solve problems that arise. To reduce employee resistance to change, organizations should provide enough time for employees to learn needed information and solutions (Peansupap and Walker 2006).

1.6 Successful Change Adoption

Successful adoption of change is the goal of any change initiative. It is clear throughout the literature that this goal can be measured in multiple ways, such as by using benchmarks and defining objectives of the change (e.g., lowering resource cost). The appropriate measurement depends heavily on the type of change. Three measurements of successful adoption of technology in the AEC industry have been identified in studies on electrical contractors in the United States (Lines and Smithwick 2019) and internationally (Lines and Vardireddy 2017). The measurements used in this study regard whether the organizational change was adopted as intended, whether the organizational change resulted in benefits, and whether the organizational change is sustainable with the organization's long-term operations.

1.7 Employee Reactions to Organizational Change

Researchers have agreed that employees' reactions to change affect whether organizational change is successfully implemented (Bovey and Hede 2001a; Piderit 2000). Lines (2005) categorized behaviors toward change into two dimensions: attitude strength (ranging from weak to strong) and attitude valence (ranging from negative to positive). Bovey and Hede (2001b) likewise identified two dimensions of behaviors toward change: from active to passive and from overt to covert. Employee reactions can be favorable or unfavorable (Herscovitch and Meyer 2002). Resistance to change implementation is one of the key barriers to successful change adoption (Bovey and Hede 2001b; Maurer 1997; Waldersee and Griffiths 1996). Resistance may be active or passive. In the AEC industry, resistance to change for multiple reasons is one of the challenges that may derail the change implementation process (Ahn et al. 2016; Chan et al. 2017; Lu et al. 2015; Zhou et al. 2019).

1.8 Change-Related Training for Employees

To implement any change throughout an organization, change-related training is needed. The training can help overcome resistance to change and can increase employees' abilities to successfully adopt the change (Alvesson, 2002; Galpin, 1996; Schneider et al. 1994). Researchers have highlighted the importance of change-related training in successfully implementing technologies in the AEC industry (Ahn et al. 2016; Chang et al. 2017; Lu et al. 2015; Ozorhon and Karahan 2017; Peansupap and Walker 2006).

1.9 Gaps in the Literature

The current literature has multiple gaps, most of the studies of adopting technology were primarily focusing on the technical barriers, benefits and applications of the adoption, with limited focus on organizational change management context even though organizational issues were listed as one of the important barriers (Ahn et al. 2016; Ahuja et al. 2018; Gu and London 2010; Khosrowshahi and Arayici 2012; Lee and Yu 2016; Liu, Du, et al. 2017; Ozorhon and Karahan 2017; Zhao et al. 2015; Zhou et al. 2019) . Also the literature is limited to specific types of adopted technology (e.g., BIM), with a small limited data sample of organizational change cases. In addition to studies that are limited to specific type of adopters (e.g., a specific sub-industry group or a specific geographical location).

Limited research exists on the adoption of technology in the context of OCM practices within the AEC industry. For example, Liao and Teo (2018) studied the critical factors that affect the implementation of BIM in terms of organizational change. The researchers collected data through a survey of 84 experts in Singapore and through follow-up interviews. The results of the study reveal 22 hindrances and 12 critical drivers related to people management that had a significant influence on BIM implementation. The researchers proposed an OCM framework containing 13 attributes. Though Liao and Teo's (2018) study led to a better understanding of OCM practices, but the results are limited only to the adoption of BIM and to a specific geographic location.

The gaps in the literature, including limited data sample sizes, specific types of organization, specific types of technology, and limited focus on OCM practices rather than technological aspects and benefits, generated the need for a study that analyzed OCM best practices for a variety of technologies adopted across the AEC industry as a whole.

CHAPTER 2: RESEARCH QUESTIONS, HYPOTHESIS STATEMENTS AND DEFINITIONS OF VARIABLES

2.1 Overview

Companies in the AEC industry are adopting more technologies to be part of the companies' operations; new technologies are implemented to either replace old technologies or to replace non-technological processes. Implementing technology requires organizational change. To obtain the maximum benefits of a technology, it needs to be implemented successfully and run smoothly throughout the organization. This research sought to provide a better understanding of the relationships between OCM practices and the successful adoption of technologies in the AEC industry, as well as to highlight critical OCM practices that drive the successful adoption of various types of technology.

2.2 Research Questions

The research attempted to answer the following questions:

1. What is the strength and direction of the relationships between effective use each of the seven OCM practices and the success of technology adoption?
2. What is the effect of different technology characteristics on the levels of reported change adoption of that technology?
3. What is the effect of different demographics of technology adopters on the levels of reported change adoption?

2.3 Hypothesis Statements

To answer the research questions, three hypotheses were developed. The focus of the hypotheses is on the relationships between OCM practices for adopting technologies and the success of the change adoption. Hypothesis 1 is a combination of seven sub-hypotheses, each of which examines the relationship between a dependent variable and one of seven independent variables. The dependent and independent variables are listed in Table 1. The dependent variable is the change-adoption construct (CAC), which encompasses three dependent variables measures successful change adoption: overall adoption achieved, the long-term sustainability, and the benefits achieved. The seven independent variables are senior-leadership commitment, sufficient training, communicated benefits, realistic timeframe, measured benchmarks, change-agent effectiveness, and workload adjustments. The seven sub-hypotheses ($H1_A$-$H1_G$) of hypothesis 1 are graphically shown in Figure 1.

Table 1. Summary of Hypothesis 1 Variables

Independent Variables	Dependent Variables
Senior-leadership commitment Training resources Communicated benefits Realistic timeframe Change-agent effectiveness Measured benchmarks Workload adjustments	Overall adoption achieved Long-term sustainability Benefits achieved Change Adoption Construct (CAC)

Hypothesis 1

- $H1_0$: The effective use of OCM practices is not related with successful change adoption.
- H1: The effective use of OCM practices is related with more successful change adoption.

The seven null sub-hypotheses are that use of the following OCM practices has no statistically significant positive association with successful change adoption measurements: senior-leadership commitment, sufficient training, communicated benefits, realistic timeframe, measured benchmarks, change-agent effectiveness, and workload adjustments.

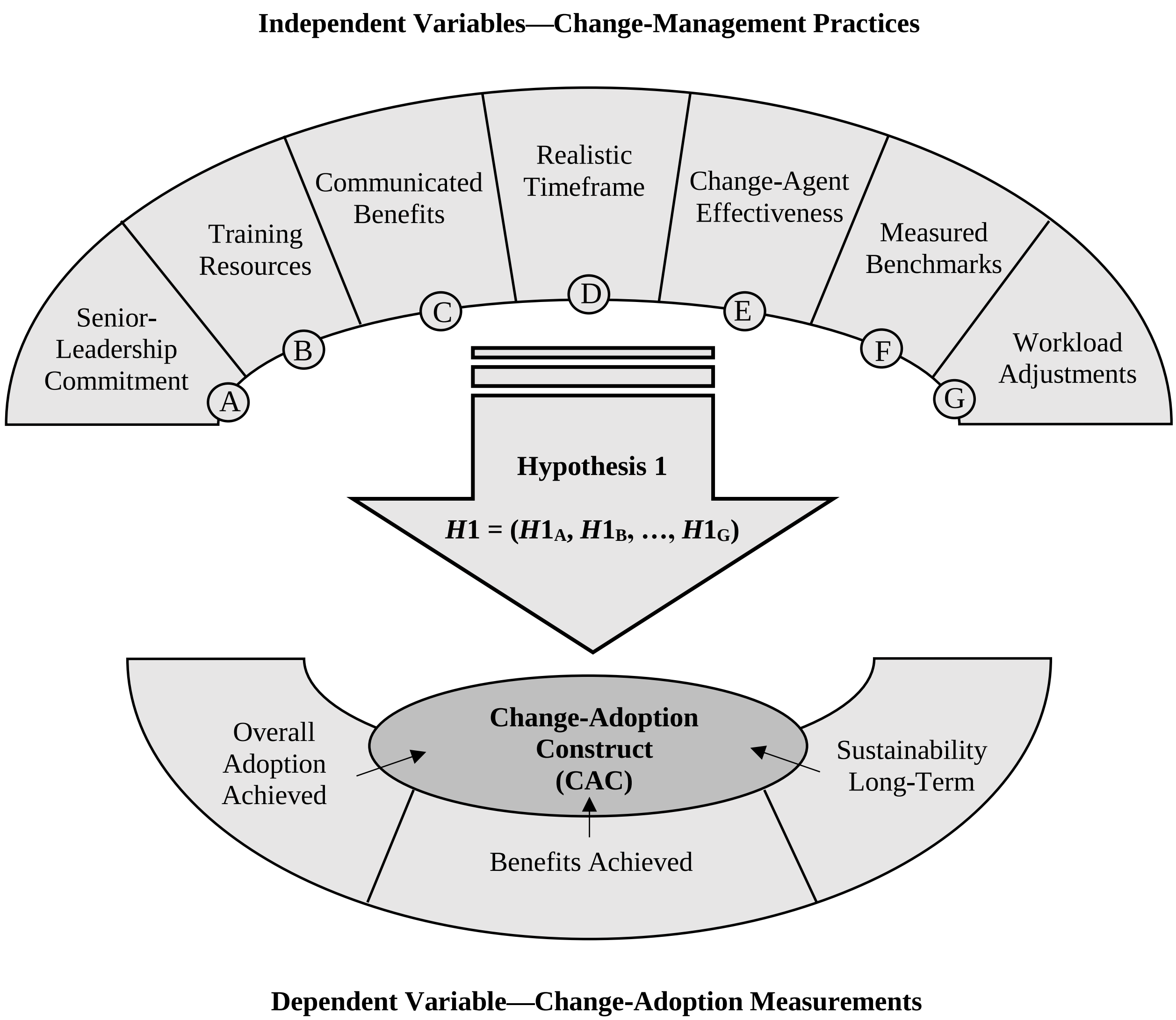


Figure 1. Graphical Summary of Hypothesis 1

Hypothesis 2

- $H2_0$: The levels of successful change adoption are consistent for different groups of adopted technology—that is, the distribution of adoption scores is consistent for all technology types.

- $H2_:$ The levels of successful change adoption are different for at least one group of adopted technology—that is, the distribution of adoption scores is not consistent for all technology types.

Hypothesis 2 contains two sub-hypotheses ($H2_A$ and $H2_B$), for the purpose of studying differences in successful change-adoption levels (CAC) between groups of adopted technology for two categories of adopted technology. $H2_A$ examines adopted technology functions (including business-related software, project-related software, and physical technology tools). $H2_B$ examines technology characteristics.

Hypothesis 3

- $H3_0$: The levels of successful change adoption are consistent among respondents in a demographic category—that is, the distribution of adoption scores is equal for all groups in a specific demographic category.

- $H3_:$ The levels of successful change adoption are different for at least one group in a demographic category—that is, the distribution of adoption scores is not consistent for all groups in a specific demographical category.

Hypothesis 3 is divided into five sub-hypotheses ($H3_A$ to $H3_E$), one for each demographic category, to study differences in successful change adoption levels (CAC) among groups in a category. $H3_A$ examines the organization sector category, $H3_B$ examines the organization type category, $H3_C$ examines the hierarchical position category, $H3_D$ examines the years of professional experience category, and $H3_E$ examines the generational affiliation category. The groups in each demographic category are listed in the next section.

2.4 Definitions of Variables

Based on the literature review, seven key OCM practices were selected for this study. These practices were selected because of their pervasiveness in the literature on organization change and technology adoption in the AEC industry. The selected OCM practices are directly connected to successful change-adoption measurements. The definitions of variables that were used in this study—including the seven OCM practices, change-adoption measurements, types of adopted technology, employee reactions during the change, change-related training, and respondent demographics—were modified from the industry-wide survey conducted by Lines and Vardireddy (2017), and for electrical contractors by Lines and Smithwick (2019)

2.4.1 Independent Variables (OCM Practices)

Definitions of the seven independent variables (OCM practices) are listed in Table 2. The definitions were used in the current study's survey questions to help ensure that the respondents understood the terms in the survey.

Table 2. Definitions of Independent Variables (OCM Practices)

Variable	Definition
Senior-leadership commitment	The organization's senior leaders were committed to making the change a success (i.e., they "walked the talk").
Training resources	Employees had a clear understanding of the action steps for how to implement the change in their job functions.
Communicated benefits	Employees had a clear understanding of how the change would benefit them in their job functions.
Realistic timeframe	The speed at which the organization implemented the change was appropriate.
Change-agent effectiveness	The change agents (transition team) responsible for managing the change in the organization were effective.
Measured benchmarks	The organization established clear benchmarks to measure the success of the change.
Adjusted workload	The organization's leaders appropriately adjusted staff members' workloads so they could focus on implementing the change.

2.4.2 Dependent Variables (Successful Change-Adoption Measurements)

Table 3 lists the definitions of the four dependent variables (successful change-adoption measurements). The definitions of overall adoption achieved, sustainability long-term, and benefits achieved were used in the survey to help ensure that the respondents understood the terms in the survey.

Table 3. Definitions of Dependent Variables (Successful Change-Adoption Measurements)

Change Adoption Abbreviation	Definition
Overall adoption achieved	The organizational change was successfully adopted in the organization's operations as intended.
Benefits achieved	The organization achieved benefits through implementing the change.
Sustainability Long-Term	The organization has sustained the change in its long-term operations (or is on track to sustain the change).
Change Adoption Construct (CAC)	The overall organizational change adoption is measured as the linear composite of the optimally weighted change adoption variables.

2.4.3 Adopted Technology Functions and Characteristics

The adopted technologies identified in the 167 cases reported in the survey were categorized into three groups: business-related software, project-related software and physical technology tools (i.e. hardware).

The characteristics of the adopted technology were categorized into two groups based on the main driver of technology adoption. The first group is technology that was introduced to replace manual, non-technological processes. The second group is technology that replaces other technology. Technology functions and characteristics are listed in Table 4.

Table 4. Definitions of Adopted Technology Categories

Technology Function	Example of Technology
Business-related software	The software affected employees and tasks at the business level of the organization (e.g., enterprise resource planning, asset management, data management, document management, data analysis, payroll automation, time management, operating platforms, communication).
Project-related software	The software affected employees and tasks at the project level of the organization (e.g., project management, facility management, cloud-based project documentation, design software, BIM, 4D, online takeoff, estimations, project planning).
Physical technology tools	Technology tools "Hardware", such as the use of (drones, Smartphones , tablets, tracking sensors, movements sensors, GPS sensors and scanning tools for virtual reality)
Technology Characteristic	**Definition**
Technology that replaces manual processes (New technology)	The company implemented a technology to replace a manual process (e.g., replaced a pencil-and-paper process with a technological process).
Technology that replaces other technology (Replacement or upgrade)	The company replaced or upgraded an existing technology (e.g., switched from one software program to a newer one).

2.4.4 Methods Used to Provide Change-Related Trainings

A study on the development of a web-based multimedia tool to support training about the change indicates that various methods are used to train employees to implement change (Lines et al. 2014). The methods of change-related training examined in this study are listed in Table 5.

Table 5. Method Used to Provide Change-Related Training

Training methods	
Speeches	On-the-project and on-the-job support
Informational presentations	Memos and emails
Interactive workshops and simulations	Instructional videos
Meetings and phone calls	Instructional manuals, checklists, and guidebooks

2.4.5 Employee Reactions to Change

Employee reactions during the change initiative were categorized as favorable reactions and unfavorable reactions. Reactions were measured along a continuum ranging from actively supporting to actively opposing the change. Reaction types and definitions are listed in Table 6;

the definitions were based on those in the literature (Bovey and Hede 2001a; Bovey and Hede, 2001b; Emiliani and Stec 2005; Fiedler 2010; Giangreco and Peccei 2005; Lines, Sullivan, Smithwick, et al. 2015).

Table 6. Types and Definitions of Employee Reactions During Change

Reaction Type	Spectrum of Employee Reactions	Definition of Observable Employee Reactions
Favorable reactions	Championing	Initiating and embracing the change
	Actively supporting	Supporting the change
	Passively supporting	Accepting the change
	Reluctantly complying	Just going with the change
Unfavorable reactions	Passively avoiding	Ignoring, withdrawing, or avoiding the change
	Openly not participating	Refraining, waiting, or observing the change
	Covertly opposing	Stalling, dismantling, or undermining the change
	Overtly opposing	Obstructing, opposing, or arguing against the change

2.4.6 Respondent Demographics

Respondents were categorized based on demographic characteristics, including sector type, organization type, hierarchical position, years of professional experience, and generational affiliation. These characteristics are summarized in Table 7.

Table 7. Respondent Demographics

Demographic Category	Examples
Sector type	The organization's sector is either public or private.
Organization type	The organization performs as an owner; engineering, procurement, and construction (EPC); subcontractor; architect/engineering consultant; or other type.
Hierarchical position	The respondent's job position in the organization is senior executive, vice president, regional manager, project lead, team member, or another position.
Years of professional experience	The respondent has been in the industry for less than 10 years, 10–19 years, 20–29 years, 30_39 years, or 40 or more years.
Generational affiliation	The respondent is a baby boomer (1946–1964), a member of generation X (1965–1978), or a member of generation Y (1979–1997).

CHAPTER 3: METHODOLOGY

3.1 Overview

An online survey was designed to collect data from members of the AEC industry about their experiences of implementing technologies. A wide range of architecture, engineering, construction, and owner representatives were targeted for participation in the survey. The collected data were screened and then analyzed in order to answer the research questions.

3.2 Survey Design

The survey was based on previous surveys used to collect data on OCM in the AEC industry. For example, Lines and Smithwick (2019) studied best practices for OCM among electrical contractors. Lines and Vardireddy (2017) studied drivers of OCM in the AEC industry and linked change management practices to successful change adoption.

The survey was designed using an online tool because the tool provided flexibility in building, editing, and testing the survey. The online tool also helped in reaching large numbers of participants via email distribution. A graphical representation of the survey design process is shown in Figure 2.

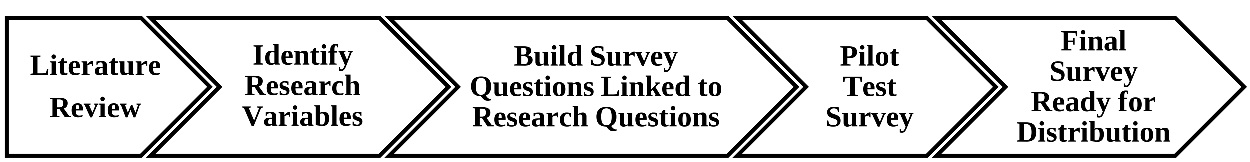


Figure 2. Graphical Representation of Survey Design

After completing an extensive literature review, the research variables were identified and then the survey questions were developed to collect data on all research variables in order to answer the research questions. After drafting the survey, it was tested by distributing it to 25 participants via email. The pilot survey participants recommended making minor changes, and these changes were incorporated into the final version of the survey.

The survey was designed to gather responses where the unit of measure was such that each response represented an organizational change initiative that was implemented by an organization in the AEC industry.

The survey had three sections. In the first section, participants were asked to identify a technology change that their firms had experienced. The first section also contained statements regarding the independent and dependent variables (seven change management practices and three change adoption measurements). The responses to these statements were based on a 7-point Likert-type scale (*strongly agree*, *agree*, *somewhat agree*, *neither agree nor disagree*, *somewhat disagree*, and *strongly disagree*). The Likert scale was developed to measure people's agreement or disagreement with a statement (Likert, 1932). Such ordinal scales use fixed responses to measure the opinions and attitudes of respondents (Bowling, 1997; Burns, & Grove, 1997). The second section of the survey was designed to collect information on the biggest barriers to change implementation and the greatest drivers of success. This section also asked participants to identify the most commonly observed employee reactions during the change and to identify the most commonly used methods of change-related training. The third section in the survey was designed to collect information about the respondents' demographics, including organization sector, organization type, respondent's job position, respondent's years of professional experience, and respondent's generational affiliation. The survey is included in the APPENDIX – SURVEY QUESTIONNAIRE.

3.3 Data Collection

A wide range of architecture, engineering, construction, and owner representatives were targeted for participation in the survey. Email addresses were gathered from private, public, and professional groups and organizations to obtain a nationwide list of individuals in the AEC industry and to gather data regarding all available types of adopted technology.

A summary of the organizations that were included in the survey distribution list are shown in Table 8. Four invitation email templates were created; the templates were customized for each targeted group of recipients (professional organizations with group-contact emails, professional organizations with individual-contact emails, AEC organizations with group-contact emails, and AEC organizations with individual-contact emails). Each email template contained information about the survey and the study’s objectives.

More responses were obtained by using a snowball technique similar to the one Lines and Vardireddy (2017) and Lines and Smithwick (2019) used. All email recipients were asked to forward the survey link to their colleagues or professional group members. Consequently, the exact number of distributed surveys and the survey response rate could not be calculated. Using an online survey tool eased the distribution process, enabling the survey to be sent to potential respondents in a short time. Two weeks after the survey was first distributed, a survey reminder was emailed to individuals who had not yet responded.

The collected data were screened, and if a participant’s responses were not complete or did not regard the adoption of a technology, then the participant’s data were not included in the final data set for the study. The survey was designed to collect data regarding a case of adopting a technology throughout an organization. The responses included in the final data set were coded in preparation for the analysis process.

Table 8. Summary of Organizations and Groups Included in the Survey Distribution List

ABC: Associated Builders and Contractors
ACEC: American Council of Engineering Companies
AGC: Associated General Contractor
AIA: American Institute of Architects
ARTBA: American Road & Transportation Builders Association.
CMAA: Construction Management Association of America.
COAA: Construction Owners Association of America
CSI: Construction Specifications Institute
CURT: Construction Users Roundtable
IFMA: International Facility Management Association
MCAA: Mechanical Contractors Association of America.
NAHB: National Association of Home Builders
NAWC: National Association of Women in Construction.
NECA: National Electrical Contractors Association.
NLC: National League of Cities
NSPE: National Society of Professional Engineers
SMACNA: Sheet Metal and Air Contractors National Association

3.4 Data Summary

In total, 167 individuals responded to the survey, representing a wide spectrum of organizations in the AEC industry. Each respondent provided information about a case of technology adoption. Table 9 provides a summary of the types of adopted technology the respondents reported on in the survey.

Table 9. Summary of Types of Adopted Technology (N = 167)

Technology Function	Frequency	Percentage
Business-related software	75	44.9%
Project-related software	60	35.9%
Hardware technology	15	9.0%
Unknown/no answer	17	10.3%
Technology Characteristics	**Frequency**	**Percentage**
New technology	55	33.5%
Replacement or upgrade	56	32.9%
Unknown/no answer	56	33.5%

Table 10 provides a summary of the respondents' demographics (organization sector, organization type, job position, years of professional experience, and generational affiliation).

Descriptive analysis was performed on the data regarding types of change-related training and employees' reactions to the change. This analysis resulted in a better understanding of the common types of change-related trainings and the commonly observed employee reactions during change initiatives.

Table 10. Summary of Survey Respondents' Demographics (N = 167)

Organizational Sector	**Frequency**	**Percentage**
Public	64	38.3%
Private	103	61.7%
Organization Type	**Frequency**	**Percentage**
Owner/operator	47	28.1%
EPC/general contractor	13	7.8%
Subcontractor/specialty contractor	54	32.3%
Architecture/engineering consultant	22	13.2%
Facilities management and operation	12	7.2%
Other/no answer	19	11.4%
Job Position	**Frequency**	**Percentage**
Senior executive/vice president	28	16.8%
Regional manager/director / local office supervisor	54	32.3%
Project members/crew members	38	22.8%
Other/no answer	47	28.1%
Years of Professional experience	**Frequency**	**Percentage**
Less than 10 years	12	7.2%
10–19 years	17	10.2%
20–29 years	60	35.9%
30–39 years	44	26.3%
40 or more years	22	13.2%
Unknown/no answer	12	7.2%
Generational Affiliation	**Frequency**	**Percentage**
Baby boomer (born 1946–1964)	31	18.6%
Generation X (born 1965–1978)	28	16.8%
Generation Y (born 1979–1997)	13	7.8%
Unknown/no answer	95	56.9%

Respondents were asked to select the top-three methods that the organization used to conduct change-related training. The responses are shown in Figure 3. The analysis results indicate that the most commonly used methods were informational presentations, memos and emails, and workshops. Less commonly used methods were guidebooks, manuals, and check lists; instructional videos; and speeches.

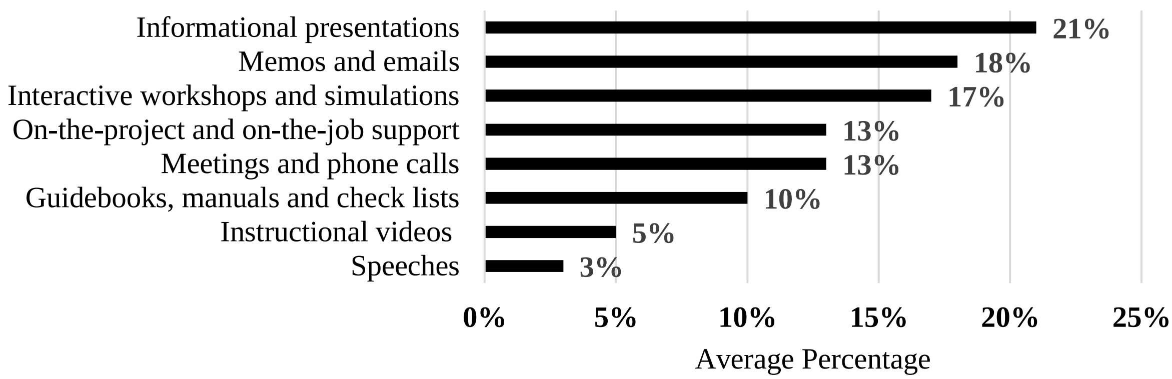


Figure 3. Common Methods Used in Change-Related Trainings

Respondents were also asked to identify the three most common reactions of employees during the change implementation. The results indicate that 73% of respondents mainly observed favorable reactions, whereas 27% of respondents mainly observed unfavorable reactions. The results are illustrated in Figure 4.

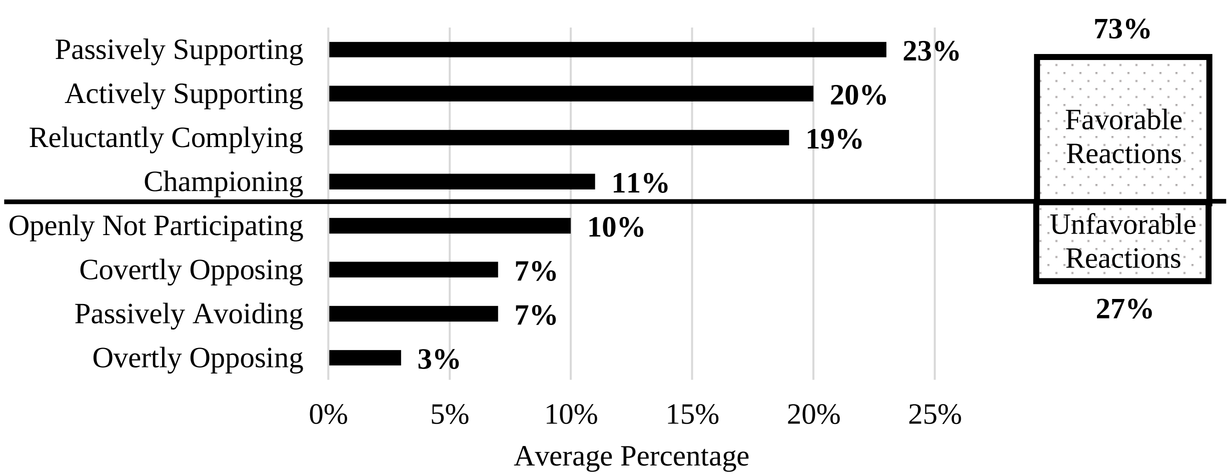


Figure 4. Employees' Reaction during Change Implementation

The finding that employees' responses were largely favorable may be the result of the fact that in the study, 80% of respondents provided data about successful change-adoption cases, whereas only 8% of respondents reported on unsuccessful change-adoption cases. The average percentage of successful versus unsuccessful change initiatives was determined by calculating the CAC. The percentages of successful, neutral, and unsuccessful change-adoption cases are shown in Figure 5.

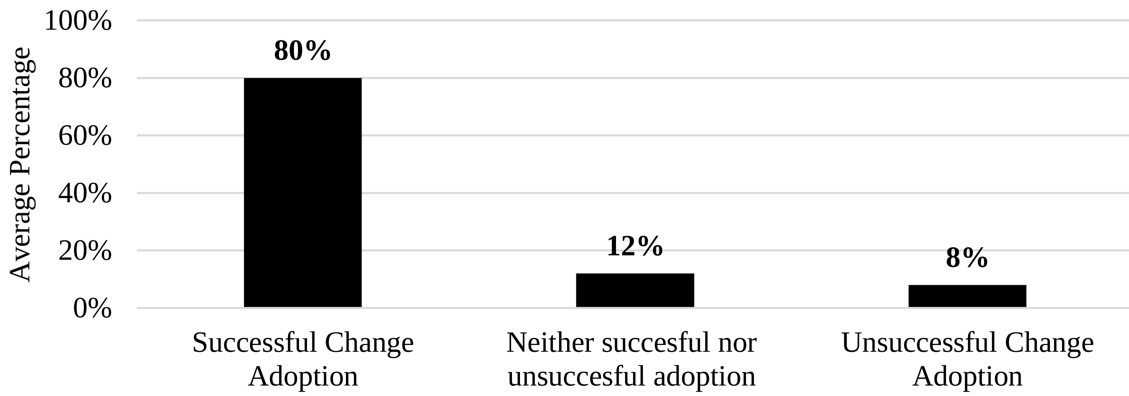


Figure 5. Percentage of Successful, Neutral, and Unsuccessful Change-Adoption Cases

3.5 Method of Analysis

The survey data were analyzed using various methods to answer the research questions. A graphical representation of the data analysis process is shown in Figure 6.

3.5.1 Reliability Test: Cronbach's Alpha

Cronbach's alpha was used to measure the underlying construct of the three dependent variables (overall adoption achieved, sustainability long-term, and benefits achieved). The survey was designed to obtain data regarding all study variables. The survey included three questions designed to measures adoption success. Cronbach's alpha was used to confirm that the three survey questions measured the underlying construct of successful adoption of change. Cronbach's alpha (α) is used to measure the reliability or internal consistency for a set of multiple test items (DeVillis 2003; Kline 2005).

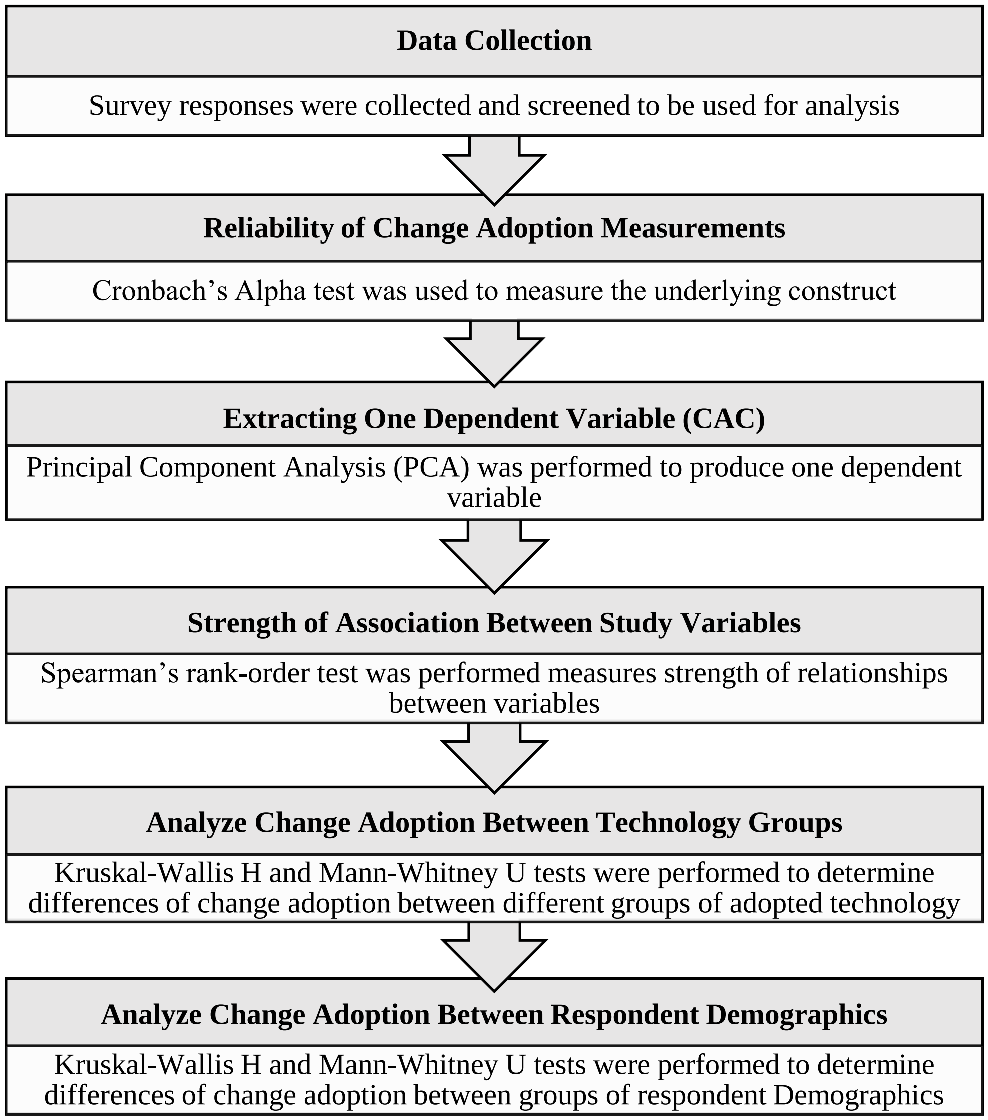


Figure 6. Graphical Representation of the Analysis Process

3.5.2 Component Extraction: Principal Component Analysis (PCA)

PCA was performed to produce one dependent variable that represents the three change-adoption variables. The resulting dependent variable, the CAC, was used in addition to the three individual dependent variables.

3.5.3 Bivariate Correlation: Spearman's Rank-Order Correlation

Spearman's rank-order test was performed to measure the bivariate relationship between the independent variables (the seven change management practices) and the dependent variables (the four change-adoption measurements, including the CAC). Spearman's rank-order correlation is a nonparametric test that is used to measure the degree of association between two variables and to determine the direction of the relationship by calculating a coefficient (r_s, or rho). The test includes assumptions about the distribution of the data.

The test was appropriate for this study because ordinal data (based on a Likert-type scale) were collected to measure the variables. This test was appropriate for testing Hypothesis 1 and answering Research Question 1: What is the strength and direction of the relationships between effective use each of the seven OCM practices and the success of technology adoption?

3.5.4 Grouped Spearman's Rank-Order Correlation

The results of Spearman's rank-order test were categorized into groups regarding respondents' demographics in order to examine differences in change-adoption scores based on respondents' sector types, organization types, job positions, years of professional experience, and generational affiliations.

3.5.5 Group Differences: Kruskal-Wallis H Test and Mann-Whitney U Test

The Kruskal-Wallis H test and the Mann-Whitney U test were used to obtain answers to Research Questions 2 and 3. The Kruskal-Wallis H test was performed to determine whether there were any differences in the levels of change-adoption success based on technology function, organization type, hierarchical position, years of professional experience, or generational affiliation. The Kruskal-Wallis H test is a nonparametric test that can be used instead of the one-way ANOVA. The Kruskal-Wallis H test uses the ranks of data values instead of the actual data points to determine whether there is a significant difference between test groups. This test was used to determine whether to accept sub-hypotheses $H2_A$, $H3_B$, $H3_C$, $H3_D$, and $H3_E$.

The Mann-Whitney U test is similar to the Kruskal-Wallis H test, but it can only be used for a maximum of two groups. (It is more common to use the Mann-Whitney U test for two groups than to use the Kruskal-Wallis H test.) The test was used to determine whether there were any differences in the level of change-adoption success between the two categories of technology characteristics and organization sector. This test was used to determine whether to accept the sub-hypotheses $H2_A$ and $H3_B$.

CHAPTER 4: RESULTS

4.1 Overview

The results are divided into seven sections. The sequence of the seven sections reflects the sequence of the data analysis. First, the reliability of change-adoption measurements was confirmed by using Cronbach's alpha test. Second, one component was extracted from the three adoption measurements and was named the CAC. Third, bivariate relationships between change-management practices and change-adoption measurements (including the CAC) were investigated to determine any differences in the level of change-adoption success and then to rank order the practices. Also, the correlations between change-management practices and the CAC were grouped based on respondent demographics. Fourth, the Kruskal-Wallis H test and Mann-Whitney U test were performed to study whether levels of change-adoption success differed between groups for each category of respondent demographics and technology type.

4.2 Cronbach's Alpha Test for Change Adoption Variables

The results of Cronbach's alpha test indicate there was high internal consistency among the three individual dependent variables (see Table 11). The Cronbach's alpha value of 0.876 is above the acceptable threshold of 0.7 (DeVillis 2003; Kline 2005; Nunnally 1978), indicating a high level of internal reliability.

Table 11. Reliability Test for Successful-Adoption Measurements (Overall Adoption Achieved, Sustainability Long-Term, and Benefits Achieved)

Number of items	Cronbach's alpha	Cronbach's alpha based on standardized items
3	0.876	0.875

4.3 Principle Component Analysis (PCA) for Change Adoption Variables

PCA resulted in one component (CAC) that combined the three individual dependent variables and was used to measure the success of adopting a technology change. The suitability of PCA was assessed prior to the analysis. Inspection of the correlation matrix showed that all variables had a correlation coefficient greater than 0.3. The overall Kaiser-Meyer-Olkin (KMO) measure was 0.729, with all individual KMO measures greater than 0.6. A KMO value of 0.729 is classified as good, according to Kaiser's (1974) classification of measure values. Bartlett's test of sphericity was statistically significant ($p < .0005$), indicating that the data was likely factorizable.

PCA revealed one component that had an eigenvalue greater than 1, explaining 80% of the total variance. Visual inspection of Figure 7, a scree plot, indicated that one component should be retained (Cattell 1966). In addition, the one-component solution met the interpretability criterion. As such, one component was retained.

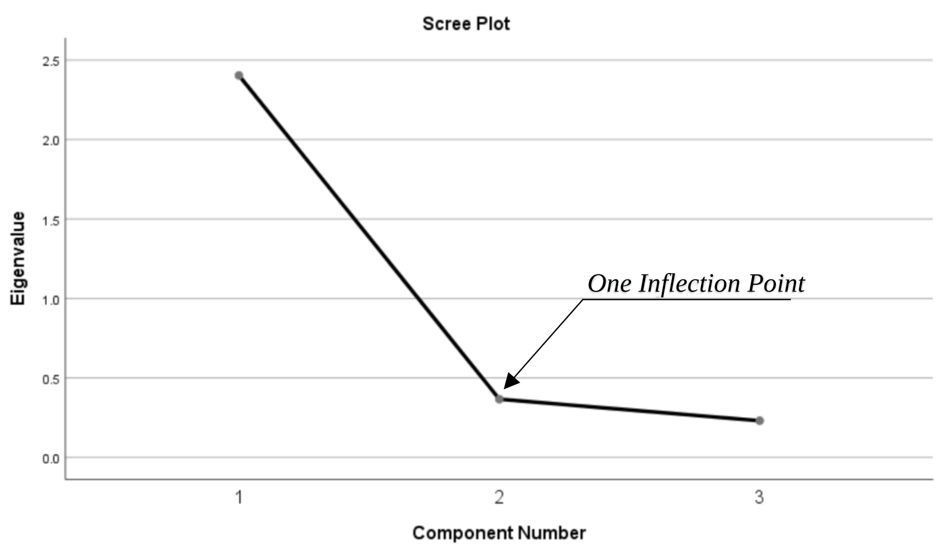


Figure 7. Scree Plot (Cattell 1966) with an Inflection Point for PCA

The one-component solution explained 80% of the total variance. Varimax orthogonal rotation was employed to aid interpretability. The rotated solution exhibited a simple structure

(Thurstone, 1947). Component loadings and commonalities of the extracted solution are presented in Table 12.

Table 12. Commonalities of the Extracted Component Solution

Variable	Initial	Extraction	Extracted component [a] (CAC)
Overall adoption achieved	1.000	0.827	0.909
Benefits achieved	1.000	0.828	0.910
Sustainability Long-Term	1.000	0.748	0.865

Note: The extraction method was PCA.
a. One component was extracted.

The extracted CAC scores were interpreted as the following: scores ranging from -3.388 to -1.352 represents unsuccessful reported change of adoption. While scores ranging from 0.834 to 1.207 represents successful reported change of adoption. Scores ranging between -1.352 to 0.834 represent neutral levels of reported adoption (neither successful nor unsuccessful).

4.4 Spearman's Rank-Order Correlation

Preliminary analysis (involving visual inspection of scatterplots) showed the relationships to be monotonic. The results of Spearman's rank-order test regarding nonparametric correlation are presented in Table 13. All correlations between the independent variables (i.e., change-management practices) and the dependent variables (i.e., change-adoption metrics and the CAC) were statistically significant, with a positive correlation varying from $r_s = 0.354$ to $r_s = 0.664$, $p < 0.0005$). Based on the results of Spearman's test, the seven null sub-hypotheses for Hypothesis 1 ($H1_A$–$H1_G$) were rejected. Statistically significant correlations between the OCM practices and the change-adoption measurements were found at the 99% confidence interval.

To interpret the strength of associations based on correlation coefficients for Spearman's r_s, Field's (2009) guidelines were used: coefficients between 0.10 and 0.29 represent a small

Table 13. Spearman's Correlation of Independent and Dependent Variables

Abbr.	Variable	A	B	C	D	E	F	G	1	2	3	4
A	Senior-leadership commitment	1.000										
B	Training resources	0.436	1.000									
C	Communicated benefits	0.376	0.621	1.000								
D	Realistic timeframe	0.431	0.546	0.548	1.000							
E	Measured benchmarks	0.476	0.612	0.510	0.510	1.000						
F	Change-agent effectiveness	0.498	0.592	0.534	0.625	0.657	1.000					
G	Workload adjustments	0.530	0.52	0.425	0.414	0.529	0.495	1.000				
1	Overall adoption achieved	0.388	0.455	0.493	0.617	0.583	0.664	0.422	1.000			
2	Benefits achieved	0.358	0.410	0.464	0.514	0.584	0.578	0.378	0.737	1.000		
3	Sustainability long-term	0.456	0.424	0.391	0.438	0.461	0.419	0.354	0.565	0.599	1.000	
4	CAC	0.435[1A]	0.485[1B]	0.523[1C]	0.618[1D]	0.626[1E]	0.653[1F]	0.419[1G]	0.915	0.910	0.743	1.000

Notes: Correlation is significant at the 0.01 (2-tailed) level for all variables.
[1A, 1B, 1C, 1D, 1E, 1F, 1G] Bivariate association with the seven sub-hypotheses of H1. 1a, 1b, 1c, 1d, 1e, 1f, and 1g.

correlation effect, coefficients between 0.30 and 0.49 represent a medium correlation effect, and coefficients between 0.5 and 0.99 represent a large correlation effect. Based on Field's scale, all OCM practices have a medium to large effect on successful change adoption.

Focusing on the CAC, four of the seven correlations were large and positive, while the other three correlations were medium and positive. The OCM practice with the strongest correlation is change-agent effectiveness ($r_s = 0.653$, $p < 0.0005$), the practice with the second strongest correction is measured benchmarks ($r_s = 0.626$, $p < 0.0005$), the practice with the third strongest correlation is realistic timeframe ($r_s = 0.618$, $p < 0.0005$). The practice with the fourth strongest correlation is communicated benefits ($r_s = 0.523$, $p < 0.0005$). The practices with the fifth, sixth, and seventh strongest correlations, which are modest, are change-related training ($r_s = 0.485$, $p < 0.0005$), senior-leadership commitment ($r_s = 0.435$, $p < 0.0005$), and workload adjustments ($r_s = 0.419$, $p < 0.0005$). The correlations between practices and the three change-adoption measurements (overall adoption achieved, benefits achieved, and sustainability long-term) were consistent with the correlation results for the CAC. The practices of senior-leadership commitment and workload adjustments had the weakest correlations with the benefits achieved.

Table 14. Summary of Correlations Between OCM Practices and CAC Based on Adopted Technology

Variable	Sr. leader. commit.	Train. resour.	Comm. benefits	Realis. time.	Meas. bench.	Change-agent effect.	Work load adjust.
Technology function							
Business-related software	0.460**	0.498**	0.637**	0.700**	0.570**	0.657**	0.438**
Project-related software	0.386**	0.491**	0.330*	0.521**	0.764**	0.687**	0.247
Physical technology tools	0.673**	0.206	0.450	0.615*	0.320	0.674**	0.414
Technology characteristic							
New technology	0.367**	0.434**	0.453**	0.622**	0.435**	0.690**	0.235
Replacement technology	0.422**	0.493**	0.552**	0.589**	0.699**	0.674**	0.535**

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

The correlations between OCM practices and the CAC in terms of adopted technology functions and characteristics are shown in Table 14, and the correlations between OCM practices and OCM practices and respondent demographics are shown in Table 15.

Table 15. Summary of Correlations Between OCM Practices and CAC Based on Respondent Demographics

Category	Sr. leader. commit.	Train. resour.	Comm. benefits	Realis. time.	Meas. bench.	Change-agent effect.	Work load adjust.
Organizational sector							
Public	0.523**	0.538**	0.627**	0.618**	0.747**	0.718**	0.449**
Private	0.361**	0.440**	0.465**	0.611**	0.550**	0.613**	0.315**
Organization type							
Owner/operator	0.302*	0.447**	0.614**	0.619**	0.644**	0.629**	0.133
EPC/general contractor	0.412	0.481	0.690**	0.757**	0.625*	0.438	NA
Sub cont./specialty cont.	0.480**	0.492**	0.408**	0.582**	0.517**	0.687**	0.532
A/E consultant	0.259	0.541*	0.530*	0.686**	0.637**	0.681**	0.551*
Facilities manag. & opera.	0.654*	0.419	0.686*	0.646*	0.686*	0.613*	0.562
Hierarchical position							
Senior executive/VP	0.231	0.537**	0.435*	0.627**	0.609**	0.685**	0.248
Regional manager	0.487**	0.479**	0.586**	0.639**	0.621**	0.660**	0.628**
Project members	0.295	0.475**	0.622**	0.622**	0.765**	0.604**	0.086
Years of prof. experience							
Less than 10 years	-0.139	0.395	0.440	0.374	0.598*	0.608*	0.241
10–19 years	0.415	0.543*	0.639**	0.722**	0.666**	0.738**	0.686**
20–29 years	0.331*	0.498**	0.600**	0.648**	0.597**	0.596**	0.260
30–39 years	0.487**	0.377*	0.421**	0.622**	0.459**	0.552**	0.288
40 or more years	0.665**	0.584**	0.771**	0.525*	0.809**	0.830**	0.721
Generational affiliation							
Baby boomer (1946–1964)	0.530**	0.227	0.508**	0.613**	0.515**	0.613**	0.402*
Generation X (1965–1978)	0.187	0.637**	0.462*	0.666**	0.681**	0.621**	0.430*
Generation Y (1979–1997)	0.541	0.613*	0.562*	0.537	0.854**	0.906**	0.406

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

4.5 Group Differences Regarding Technology Functions and Characteristics

Kruskal-Wallis H test was conducted to examine correlations between independent groups and the CAC. The interpretations of the boxplot graphs of CAC scores for test groups are subjective; there is currently no standard practice for determining whether the distributions are similar (Vargha and Delaney 1998).

4.5.1 Group Differences within the Technology Function

Kruskal-Wallis H test was conducted to determine whether there are differences in the levels of the CAC based on it's the technology function: business-related software (n = 75), project-related software (n = 57), and hardware technology (n = 15). The CAC scores for all groups were similar, as assessed by visual inspection of the boxplot shown in Figure 8. The median CAC scores ranged from -0.0659 for business software to 0.439 for project software to 0.188 for hardware technology, but the differences were not statistically significant between those groups, $\chi2(3) = 1.673$, $p = 0.433$. Since the results of the Kruskal-Wallis H test were not statistically significant ($p > .05$), a post hoc test was not conducted and the null hypothesis for $H2_A$ was not rejected; the CAC is statistically the same across types of technology functions.

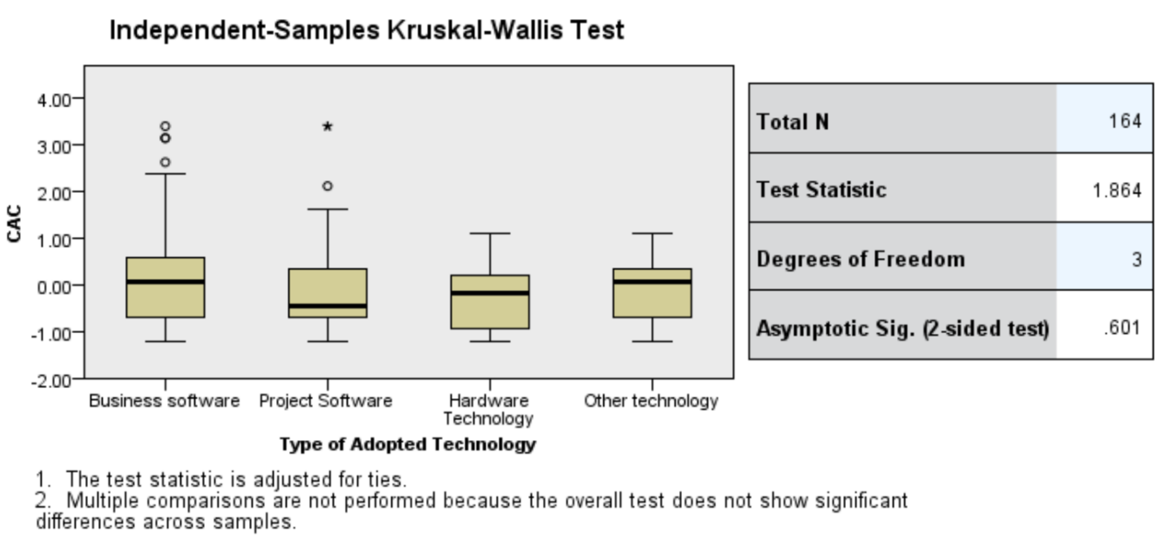


Figure 8. Boxplot of Kruskal-Wallis Test for Technology Function Groups

4.5.2 Group Differences in Technology Characteristics

Mann-Whitney U test was conducted to determine whether there were differences in the levels of the CAC based on technology characteristics: new ($n = 54$) and replacement or upgrade ($n = 54$). The CAC scores for both groups were similar, as assessed by visual inspection. The median CAC score for new technology was 0.068, with a mean rank of 57.4, and the median CAC score for replacement/upgrade technology was 0.068, with a mean rank of 51.6. These scores are not different to a statistically significant degree, $p > 0.05$, $U = 1303$, $z = -0.954$, $p = 0.340$. Consequently, the null hypothesis for $H2_B$ was not rejected; the CAC scores are statistically the same for new technology and replacement/upgrade technology.

4.6 Group Differences regarding Respondents Demographics

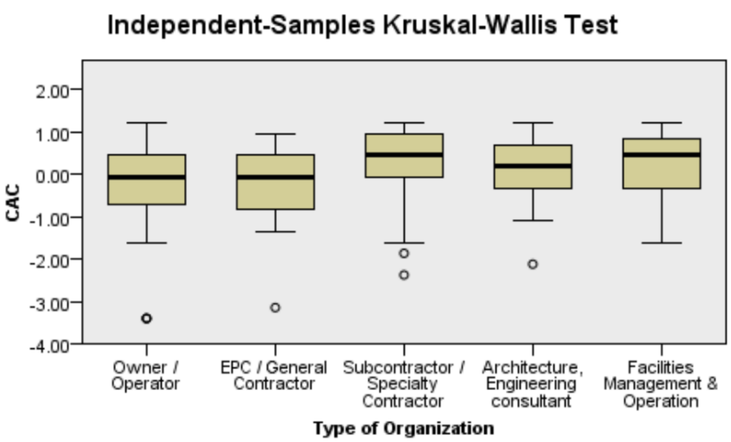
4.6.1 Group Differences Regarding Organization Sector

Mann-Whitney U test was conducted to determine whether there were differences in the CAC based on organization sector: public ($n = 63$) and private ($n = 101$). The CAC scores for public and private organizations were not similar, as assessed by visual inspection. The CAC score for public organizations was a mean rank of 78.3, compared to private organizations' mean rank CAC score of 85.1. However, the scores were not different to a statistically significantly degree, $p > 0.05$), $U = 3447$, $z = -0.901$, $p = 0.368$. Consequently, the null hypothesis for $H3_A$ was not rejected.

4.6.2 Group Differences Regarding Organization Type

Kruskal-Wallis H test was conducted to determine whether there were differences in the CAC based on organization type: owner/operator ($n = 47$), EPC/general contractor ($n = 13$), subcontractor/specialty contractor ($n = 54$), architecture/engineering consultant ($n = 21$), and facilities management and operations ($n = 11$). The CAC scores for all groups were similar, as assessed by visual inspection of the boxplot shown in Figure 9. The median CAC scores based on organization type were different to a statistically significant degree, $\chi2(4) = 9.878$, $p = 0.043$.

Pairwise comparisons were performed using Dunn's (1964) procedure with a Bonferroni correction for multiple comparisons (p = 0.05, before adjustment). With this calculation, the median CAC scores increased: EPC/general contractor (-0.0738, mean rank = 52.3), owner/operator (-0.0685, mean rank = 64.1), architecture/engineering consultant (0.1876, mean rank = 74.6), facilities management and operations (0.441, mean rank = 80.36), and subcontractor/specialty contractor (0.441, mean rank = 85). The post hoc analysis did not reveal any statistically significant differences in CAC scores for any two group combinations. The nonsignificant post hoc results can be explained by the weak significance level, p = 0.043, which is very close to the significance level of 0.05. Because of the results, the null hypothesis for $H3_B$ was rejected; the CAC is not the same across different organization types.



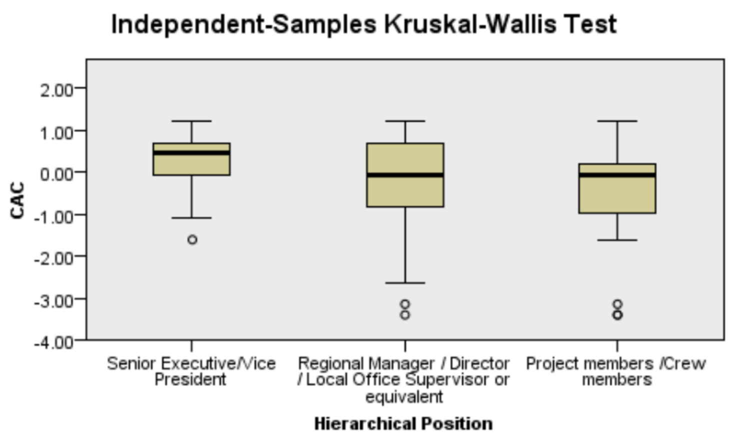
Total N	146
Test Statistic	9.878
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	.043

1. The test statistic is adjusted for ties.

Figure 9. Boxplot of Kruskal-Wallis Test for Organization Types

4.6.3 Group Differences Regarding Job Position

Kruskal-Wallis H test was conducted to determine whether there were differences in the CAC based on job position: senior executive (n = 27), regional manager (n = 54), and project member (n = 36). The CAC scores were similar for all groups, as assessed by visual inspection of the boxplot shown in Figure 10. The median CAC scores were different to a statistically significant degree based on job position, $\chi2(2) = 7.885$, p = 0.019. Pairwise comparisons were performed using Dunn's (1964) procedure with A Bonferroni correction for multiple comparisons. Statistical significance was accepted at $p < .0166$. This post hoc analysis revealed statistically significant differences in median CAC scores for senior executives (0.44, mean rank = 73.1) and project members (0.072, mean rank = 48.9), $p = 0.005$, but not between any other group combinations. The median scores and mean ranks were higher for senior executives than for project members, which means that senior executives reported higher levels of successful adoption than did project members. Based on the analysis results, the null hypothesis for $H3_C$ was rejected; the CAC is not the same across different jobs.



Total N	117
Test Statistic	7.885
Degrees of Freedom	2
Asymptotic Sig. (2-sided test)	.019

1. The test statistic is adjusted for ties.

Figure 10. Boxplot of Kruskal-Wallis Test for Job Positions

4.6.4 Group Differences Regarding Years of Professional Experience

Kruskal-Wallis H test was conducted to determine whether there were differences in the CAC based on years of professional experience: less than 10 years (n = 12), 10–19 years (n = 17), 20–29 years (n = 59), 30–39 years (n = 43), and 40 or more years (n = 21). The CAC scores were similar for all groups, as assessed by visual inspection of the boxplot shown in Figure 11. The median CAC score was lowest for less than 10 years (-0.073, mean rank = 57.3), then 20–29 years (-0.709, mean rank = 72.8), then 10–19 years (0.185, mean rank = 76.8), then 30–39 years (0.185, mean rank = 81.1), and then and 40 or more years (0.441, mean rank = 88.2). However, the differences were not statistically significant, $\chi 2(4) = 4.692$, $p = 0.320$. Since the results of the Kruskal-Wallis H test were not statistically significant ($p > .05$), a post hoc test was not conducted. The null hypothesis for $H3_D$ was not rejected.

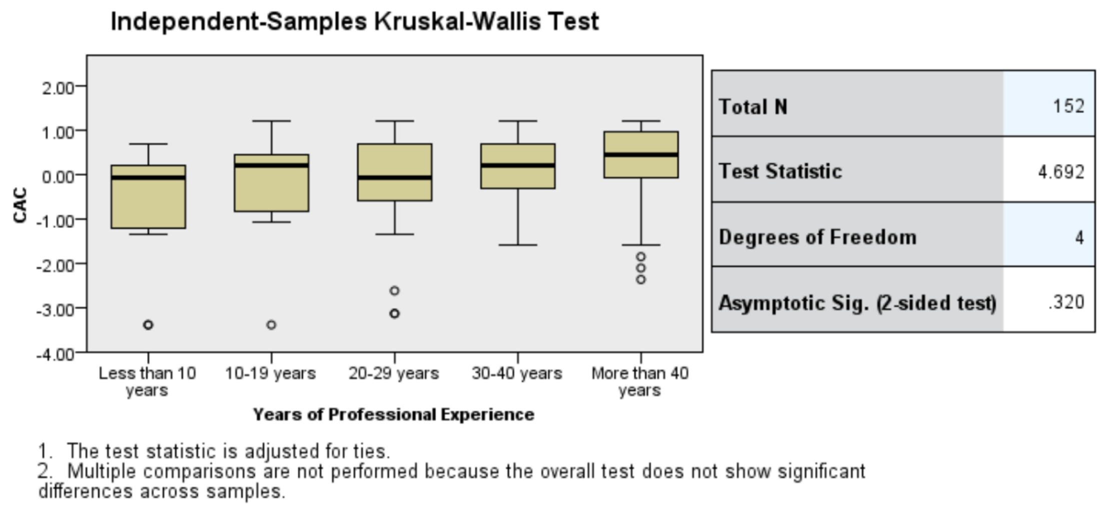


Figure 11. Boxplot of Kruskal-Wallis Test for Years of Professional Experience

4.6.5 Group Differences Regarding Generational Affiliation

Kruskal-Wallis H test was conducted to determine whether there were differences in the CAC regarding generational affiliation: baby boomer, born 1946–1964 (n = 29); generation X, born 1965–1978 (n = 28); and generation Y (born 1979–1997) (n = 13). The CAC scores were similar for all groups, as assessed by visual inspection of the boxplot shown in Figure 12.

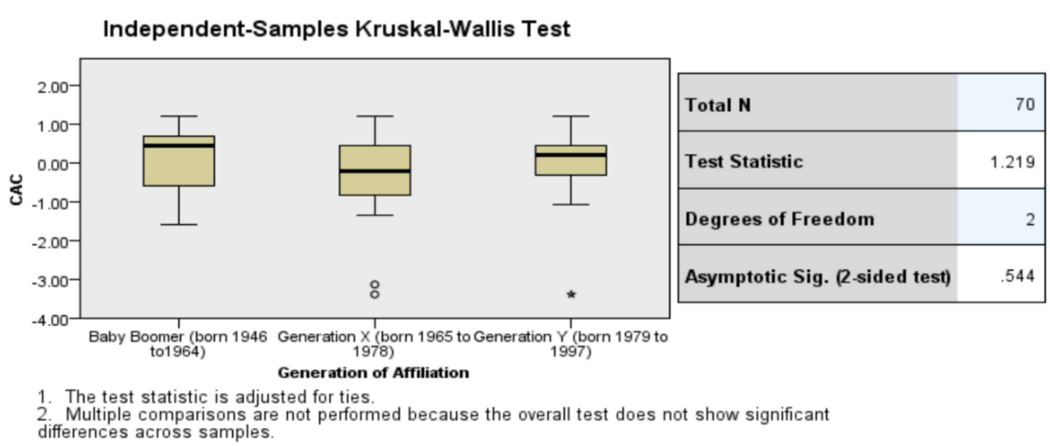


Figure 12. Boxplot of Kruskal-Wallis Test for Generational Affiliation Groups

CAC median scores were the highest for baby boomers (0.439, mean rank = 38.3), followed by Generation Y (0.185, mean rank = 36) and then Generation X (0.198, mean rank = 32.4). However, the differences were not statistically significant, $\chi2(2) = 1.219$, $p = 0.544$. Since the results of the Kruskal-Wallis H test were not statistically significant ($p > .05$), a post hoc test was not conducted. The null hypothesis for $H3_E$ was not rejected.

CHAPTER 5: DISCUSSION AND CONCLUSION

5.1 Overview

The overall objective of this study was to understand the relationships between OCM practices and the adoption of technologies in the AEC industry. To achieve the study objectives, a survey questionnaire was used to collect 167 cases organizational change within the context of technology adoption. The questionnaire's unit of measure was designed such that each data point represented an entire organizational change case that occurred within a separate organization.

5.2 Discussion

The Collected data from the survey questionnaire provided a good set of data for analysis to answer research questions and hypothesis mentioned in chapter 2. After performing statistical tests, decisions were made with reference to each proposed hypothesis, summary list of hypotheses with key findings and decisions are listed in Table 16.

Table 16. Summary of Results for Research Hypotheses

Hypothesis	Findings	Test Performed	Result
H1a to H1g	There are moderate to strong positive correlations between OCM practices and the level of change-adoption success.	Spearman's rank-order test	Reject the null hypothesis
H2a and H2b	There are no significant differences in the level of change adoption based on the characteristics of the adopted technology.	Kruskal-Wallis H and Mann-Whitney U tests	Retain the null hypothesis
H3a, H3d, and H3e	There are no significant differences in the level of change-adoption success based on respondents' sector types, years of professional experience, and generational affiliation.	Kruskal-Wallis H and Mann-Whitney U tests	Retain the null hypothesis
H3b	There are significant differences in the level of change-adoption success based on organization type.	Kruskal-Wallis H test	Reject the null hypothesis
H3c	There are significant differences in the level of change-adoption success based on respondents' job positions. Senior executives reported higher levels of successful adoption than did project members.	Kruskal-Wallis H test	Reject the null hypothesis

5.2.1 Relationships between OCM Practices and Successful Change Adoption

The positive bivariate correlations between the seven OCM practices and the four change-adoption measurements (including CAC) are consistent with the findings in organizational behavior literature. The findings are also consistent with two recent studies on organizational change adoption in the AEC industry. One study examined the relationship between OCM practices and change adoption (any type of change) using industry-wide, international survey data regarding 237 change-adoption cases (Lines and Vardireddy 2017). The second study examined the relationship between OCM practices and change adoption (any type of change) among electrical contractors; the nationwide survey data regarded 94 change-adoption (Lines and Smithwick 2019). The findings of these two studies will be compared to the findings of the current study.

The OCM practice that had the strongest positive correlation with change adoption was having effective change agents. This practice was ranked as the most important practice in the studies by Lines and Smithwick (2019) and Lines and Vardireddy (2017). Similarly, studies on organizational change indicate that change agents are one of the most important elements of change adoption (Wolpert 2010) because the change-agent team leads the change and provide essential support during the change (Covin and Kilmann 1990; Schweiger and DeNisi 1991). Additionally, previous studies have emphasized the high importance of change agents in successfully adopting BIM in the AEC industry (Ahn et al. 2016; Gu and London 2010; Lee and Yu 2016).

The OCM practices with the second, third and fourth practices with the strongest correlations were measured benchmarks, realistic timeframe, and communicated benefits, and they were also listed among the top-four OCM practices by Lines and Vardireddy (2017). Previous studies have emphasized the importance of such practices in successfully adopting change throughout organizations; these studies have focused on organizational change (Bourne et al. 2002; Cameron and Quinn 1999; Garratt 1999; Kotter 1995; Tatum 1989) and the adoption of technology in the AEC industry (Ayinla and Adamu 2018; Loosemore and Cheung 2015; Eadie et al. 2013; Lee et al. 2015; Li and Becerik-Gerber 2011; Lines and Smithwick 2019; Liu, Du, et al. 2017; Peansupap and Walker 2006; Sullivan 2011; Tan et al. 2012; Zhou et al. 2019).

The remaining three OCM practices (training resources, senior-leadership commitment and adjusted workload) had moderately strong correlations with successful change adoption. This finding aligns with Lines and Vardireddy's (2017) finding that change-related training and senior-leadership commitment are less significant than other OCM practices. On the other hand, Lines and Smithwick (2019) found that senior-leadership commitment and sufficient resources are among the top-four practices with the strongest correlations with successful change adoption. One explanation for the difference in findings is that Lines and Smithwick's (2019) study data was limited to electrical contractors.

5.2.2 Relationships between Respondent Demographics and OCM Practices

The correlations between OCM practices and successful change adoption were generally consistent in a category of respondents' demographics, but there were minor differences. The CAC scores for the public and private sectors were consistent; all OCM practices had significant correlations with the CAC, and the four OCM practices with the strongest correlations were the same for both groups. However, in the organization-type category, the only OCM practices that had strong correlations with successful change adoption for the EPC and general contractor groups were realistic timeframe, training resources, and communicated benefits. One possible explanation for this finding is that because EPC and general contractor organizations are oriented toward cost, time, and productivity, the change is treated as a project and the variables of cost, time, and productivity are their main focuses during the change.

Overall, workload adjustment had the weakest correlation with successful change adoption in this study, but it had one of the three strongest correlations for architecture and engineering consultants, regional managers, and respondents with 10–19 years of professional experience. A potential reason that workload adjustments are more important for these individuals is that they may already be overwhelmed by high workloads or may suffer more in performing their jobs when technology changes are made.

One interesting finding regards the correlation between senior-leadership commitment and successful change adoption. There was no significant correlation between senior-leadership commitment and successful change adoption for respondents with 19 or fewer years of professional experience. In contrast, there was a significant correlation between these two variables for groups with 20 or more years of professional experience; the strength of the correlation increased with each increase in years of experience. This finding contradicts one of the findings of Lines and Vardireddy (2017). A potential reason for this contradiction is that this study focused on the adoption of only technology, whereas Lines and Vardireddy did not focus on technology adoption but, rather, examined all types of change. One possible explanation for the finding of the current study is the poor technological skills of senior leaders compared to early-career employees (less than 20 years of experience); early-career employees might perceive senior leaders' commitment as generating barriers to implementing the change. Another possible explanation is that early-career employees may perceive that high levels of senior-leadership commitment result in micromanagement approach, thereby causing the early-career employees more stress.

Another interesting observation regarding the reported relationship between OCM practices and the three adoption measurements (Overall Adoption Achieved, Sustainability Long-Term, and Benefits Achieved). Between all OCM practices senior leadership commitment had the only strongest effect on sustainability long-term of change adoption when compared to other two adoption measurements, while other OCM practices reported low effect on sustainability with respect to adoption measurements. Which may indicate that the effective commitment of senior leaders throughout the implementation of technology change will improve the long-term use of the adopted technology throughout the organization.

5.2.3 Relationships between Functions/Characteristics of Adopted Technologies and Change Adoption Success

The function of the adopted technology (business-related software, project-related software, or physical technology tool) was not correlated with change-adoption success. Likewise, the characteristics of the adopted technology (new technology or replacement/upgrade technology) was not correlated with change-adoption success. In other words, the use of organizational-change practices is important in successfully adopting technology, whereas focusing only the technical aspects of the adopted technology is not related to the success of the adoption.

5.2.4 Relationships between Respondent Demographics and Change Adoption Success

The levels of successful change adoption were statistically different for different groups of organization types and job positions. Though initial analysis indicated that different organization types had different levels of correlation with change-adoption success, further analysis failed to identify which groups combination are statistically different. However, based on the medians and mean ranks of all organization-type groups, it can be ranked as follows, from low to high: EPC/general contractor, owner/operator, architecture/engineering consultant, facilities management and operations, and subcontractor/specialty contractor. A possible explanation of the biggest ranking difference is that specialized organizations (roofing contractors, plumbing contractors, etc.) have more expertise in a specific area than do wide-focused organizations nations (General building contractors, EPC organizations, etc.); specialization in an area eases the process of implementing technologies that are related to the area of expertise. It could be assumed that specialized organizations have a higher likelihood of successfully adopting technology than do unspecialized/wide-focused organizations, although such assumption in based on non-significant difference between any group pairs.

Different groups of job positions reported significantly different levels of change-adoption success. Specifically, senior executives reported higher levels of change-adoption success than did project members. This finding can possibly be explained in three ways. First, senior executives typically observe the implementation of technology on a high level, without low-level details; therefore, their judgment of change-management success may not be as accurate as that of project members. Second, project members typically see the project level of change adoption and therefore will measure success at only a project level. Third, senior executives are better able to observe change adoption throughout the organization and therefore can see how the change affects different areas of the organization and the organization overall; thus, senior executives can determine whether the results align with the objectives of the technology change and whether the adoption is successful overall. All three explanations indicate that the benefits of the change are poorly communicated to lower-level personnel.

5.3 Conclusion

Results found seven organizational change management practices that have statistically significant positive relationships with successful change adoption. The study also found differences in reported levels of change adoption between different groups of organization types and hierarchical positions of respondents; whereas other parameters did not, such as technology function, new vs. upgrade situations, organizational sector, employee years of experience, and generational affiliation. This study contributes to the body of knowledge by identifying seven organizational change management practices associated with successful technology adoption across the AEC industry. These organizational change management practices may assist practitioners better understand and manage the technology adoption process in their companies.

5.3.1 Contributions

The study provides several contributions to the literature on organizational change and to practitioners in the AEC industry. This study is the first to focus on OCM practices in relation to adopting technology in the broadly across the AEC industry as a whole. Previous studies that examined OCM practices in the AEC industry focusing on specific types of organizations, specific changes (e.g., project delivery methods), or specific technologies (e.g., BIM). Previous studies were also limited in terms of data collection methods and sample sizes.

The study includes four main findings that contribute to the industry and the organizational change literature. First, the results indicate that OCM practices are consistent throughout the industry, in the sense that the OCM practices were found to have a positive, statistically significant relationship with successful change adoption throughout the AEC industry. Second, the correlations between OCM practices and the success of adopting technology were positive and similar to the correlations identified in previous studies. Third, the ranking of OCM practices in terms of the strength of the correlation with change-adoption success were mostly similar to the rankings in previous studies (i.e. change agent effectiveness having the strongest association with change adoption and other OCM practices with statistically significant relationships). However, relative to other organizational change initiatives common in the AEC industry (such as managerial changes, business process realignment, leadership transitions, new market entry, and mergers and acquisitions), successful adoption of new technologies was more strongly associated with the OCM practices of measured benchmarks and realistic timeframe. Fourth, only organization type and job position were correlated with levels of change-adoption success; the other five factors (technology function, technology characteristics, sector type, years of professional experience, and generational affiliation) did not have a significant correlation with the level of adoption.

The study results provide practical, evidence-based guidelines for professionals in the AEC industry to use in order to achieve higher levels of success in adopting technologies. This study reveals that there are certain OCM practices that are consistently effective at assisting companies achieve their change adoption objectives for new technologies. These OCM practices all appear to be learnable and repeatable managerial approaches that can become part of a company's skillset. AEC-industry professionals should focus on applying OCM principles, particularly the ones with the highest ranks in Table 17, which represent the strongest correlations with successful change adoption.

5.3.2 Limitations and Recommendations for Future Research

This section contains discussion of the study's limitations and areas for future research. The first limitation is that the number of OCM practices that were studied was limited; the practices were identified through reviewing the literature on OCM and the AEC industry. Future research could be conducted to investigate and propose practices similar to workload adjustment or practices that are unique to technology adoption in the AEC industry and that have not been studied previously.

Table 17. Recommended OCM Practices for Successfully Adopting Technologies

Rank*	OCM practice	Recommendations
1	Change-agent effectiveness	The organization should select change agents and provide them with adequate resources and support to manage the change in the organization.
2	Measured benchmarks	The organization should establish clear benchmarks to measure the success of the change adoption. The organization should celebrate when each benchmark is achieved.
3	Realistic timeframe	The organization should establish an achievable timeframe for implementing the change, focusing on long-term adoption rather than on short-term results.
4	Communicated benefits	The organization should communicate how the change will benefit the organization overall and employees personally in their specific job functions.
5	Training resources	The organization should provide required training, so employees have a clear understanding of the action required to implement the change in their job functions.
6	Senior-leadership commitment	The organization's senior leaders should be visibly committed to implementing the change.
7	Adjusted workload	The organization should appropriately adjust the workloads of employees involved in the change, so they can focus on implementing the change.

Note: The order was based on the correlational strengths resulting from using Spearman's rank-order test.

The second limitation is that the factors studied, including technology characteristics and respondent demographics, do not completely explain the differences in change-adoption success; many additional factors could also be correlated with change-adoption success, such as global economics and industry trends. Similarly, the background and driving motivations behind each organization's decision for embarking on their respective change initiatives was not considered in this study as it was beyond the scope of the research objectives. Therefore, several important factors may be excluded from consideration, such as the level of initial investment and the decision-making process to approve the change. Future research may identify and include more factors to be analyzed.

In terms of the third limitation, 80% of the respondents provided data regarding cases of successful change adoption; only 8% of the respondents provided data regarding unsuccessful change adoption. The results, including employees' reactions and the methods of training may have been skewed by this uneven ratio (positive bias). Future research could focus on obtaining data on a more equal number of successful or unsuccessful adoption cases.

The fourth limitation is that the demographic groups were unevenly distributed, which limited the findings about the differences between groups. Future research could involve collecting data from a sample that is more balanced in terms of the demographic groups.

As the fifth limitation, each adoption case was presented from a single point of view; therefore, the data may have been influenced by respondent bias or inaccurate recall of the change adoption. Future research could involve collecting responses from multiple employees about the same technology change; this data could provide a more accurate and precise picture of the level of success in adopting a change.

The sixth limitation is that the data were collected from members of the AEC industry in only the United States and Canada and only involved 167 technology-adoption cases. Future research could involve collecting data from more countries and about more technology-adoption cases.

One important recommendation for future research is that this research has found that four OCM practices are highly effective in achieving successful change adoption (change agents, measured benchmarks, realistic time-scale, and communicated benefits) which is supported by previous study (Lines and Vardireddy 2017). In order to provide the industry with more details and recommendations to manage the change, future research should investigate:

1. Characteristics of change agents (What does a change agent looks like? Who could be assigned as a change agent?)
2. Determination of benchmarks (How to effectively designate benchmarks?)
3. Determination of realistic timeframe (How to allocate a realistic timeframe?)
4. Study the communication process of change benefits (How to better communicate change benefits? What benefits to communicate?)

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APPENDIX – SURVEY QUESTIONNAIRE

STUDY OF BEST PRACTICES OF ORGANIZATIONAL CHANGE FOR NEW TECHNOLOGIES

This study is being conducted to capture how organizations have adopted a new technology, including software (such as financial, accounting, ERP, project management, work order systems, information systems, databases etc.), IT platforms, hardware (paperless, mobile), etc.

The survey takes approximately **4-8 minutes** to complete. If you are unsure of a particular question, please leave it blank.

Your participation in this study is voluntary and very much appreciated. All individual responses are anonymous and will not be shared. Only response averages will be shared in the final research study. This survey can be completed more than once if you have had multiple experiences in implementing new technologies within an organization.

Thank you for taking the time to share your insights and experience with our research team.

Do you agree to participate in this study?

○ Yes, I agree

Answer the following questions based on any **ONE** specific organizational change to adopt new software/technology that you participated in. You may choose a change that was either **successful** OR **unsuccessful** – both are equally valuable to the research!

1) Very briefly, describe the organizational change that you participated in and what new technology your organization adopted:

____

____

2) Which of the following describes the change most accurately?

- ○ Replacement or upgrade to an existing technology (i.e. switching from an existing software to a newer one).
- ○ Completely new technology (i.e. something the company had not used before, for example, moving from manual or pencil-and-paper process to a new technology).

Section 1: Change Management Practices
Please answer the following questions about the change management practices during implementation of the change in your organization.

3) Your organization's **senior leadership** was committed to making the change a success ("walked the talk").

- ○ Strongly agree
- ○ Agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Disagree
- ○ Strongly disagree

4) You had a clear understanding of the **action steps for how to implement** the change within your job function.

- ○ Strongly agree
- ○ Agree
- ○ Somewhat agree

- Neither agree nor disagree
- Somewhat disagree
- Disagree
- Strongly disagree

5) You had a clear idea of how the change would **benefit** you personally (within your job function).

- Strongly agree
- Agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Disagree
- Strongly disagree

6) The **timescale/speed** that your organization implemented the change was **realistic** and achievable.

- Strongly agree
- Agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Disagree
- Strongly disagree

7) Your organization established clear **benchmarks** to measure success compared to previous performance.

- Strongly agree
- Agree
- Somewhat agree

- Neither agree nor disagree
- Somewhat disagree
- Disagree
- Strongly disagree

8) The "**change agents**" (or transition team) responsible managing the change within your organization were effective.

- Strongly agree
- Agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Disagree
- Strongly disagree

9) Your organization leadership appropriately **adjusted the workloads** for staff to focus on the implementation of the new change.

- Strongly agree
- Agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Disagree
- Strongly disagree

10) Did your organization hire an **external organizational change management consultant** to assist with implementation of the change?

- Yes
- No

11) What formal **organizational change methodology** did your organization use to implement the change? <u>(Select all that apply)</u>

- ☐ Prosci ADKAR
- ☐ Association of Change Management Professionals (ACMP) Standard for Change Management
- ☐ Change Management Institute (CMI) CMBoK
- ☐ Other: ____
- ☐ None – no formal organizational change methodology was utilized

Section 2: Change Adoption
Please answer the following questions about adoption of the change in your organization.

12) The organizational change was successfully **adopted** as intended.

- ○ Strongly agree
- ○ Agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Disagree
- ○ Strongly disagree

13) Your organization achieved the beneficial impacts and performance **gains** that were desired from the change initiative.

- ○ Strongly agree
- ○ Agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Disagree

○ Strongly disagree

14) Your organization **sustained** the change into its long-term operations (or is currently on track to sustain the change).

○ Strongly agree

○ Agree

○ Somewhat agree

○ Neither agree nor disagree

○ Somewhat disagree

○ Disagree

○ Strongly disagree

15) Approximately how long did it take to **implement the change** from when the change started to when it became fully adopted into the organization's operations as the normal business practice?

○ Less than 1 year

○ 1-2 years

○ 2-3 years

○ 3-4 years

○ 4-5 years

○ More than 5 years

16) Please describe the biggest **barriers** to the change implementation.

____

____

17) Please describe the greatest **drivers of success**.

____

____

18) During the change, what were the three main ways your organization provided **change-related training** to employees? (Please select **at most 3** answers)

- ☐ Speeches
- ☐ Informational presentation
- ☐ Memos and emails
- ☐ Instructional videos
- ☐ Instructional manuals, checklists and/or guidebooks
- ☐ Interactive workshops & simulations
- ☐ Meetings and phone calls
- ☐ On-the-project or on-the-job support
- ☐ Other: ____

19) During the change, which reactions were most common among the organization's personnel? (Please select **at most 3** answers)

- ☐ Initiating, Embracing, Championing the change
- ☐ Actively Supporting and Cooperating with the change
- ☐ Passively Agreeing with and Accepting the change
- ☐ Reluctantly Complying with the change
- ☐ Ignoring, Withdrawing, Avoiding the change (covertly not participating)
- ☐ Refraining, Waiting, Observing the change (openly not participating)
- ☐ Stalling, Dismantling, Undermining (covertly opposing the change)
- ☐ Obstructing, Opposing, Arguing (openly opposing the change)
- ☐ Other: ____

Section 3: General
Please answer the following questions to provide some additional information about your organization.

20) Is your organization **public** or **private** sector?

- ◯ Public
- ◯ Private

21) What kind of organization do you work for?

- ◯ Owner / Operator
- ◯ EPC / General Contractor
- ◯ Subcontractor / Specialty Contractor
- ◯ Material / Equipment Supplier
- ◯ Architecture
- ◯ Engineering Consultant
- ◯ Facilities Management & Operation
- ◯ Other: ____

22) Which of the following describes your **work group**?

- ◯ Design & Planning
- ◯ Construction - Field
- ◯ Construction - Office/Admin/Management
- ◯ Facilities Operation and Maintenance
- ◯ Contracts, Procurement, Supply Chain
- ◯ IT / Technology
- ◯ Business Unit - Specify: ____
- ◯ Other industry sector: ____

23) Please indicate the **role** that best describes your current job position:

- ◯ Senior Executive (CEO, CFO, COO, CIO, etc.) or equivalent
- ◯ Vice President or Assistant Vice President or equivalent

- ◯ Regional Manager / Director / Local Office Supervisor or equivalent
- ◯ Team Lead / Crew Lead or equivalent
- ◯ Team Member / Crew Member or equivalent
- ◯ Other : ____

24) How many years of **professional experience** do you personally have?

- ◯ Less than 5 years
- ◯ 5 – 9 years
- ◯ 10 – 19 years
- ◯ 20 – 29 years
- ◯ 30 – 39 years
- ◯ 40 – 49 years
- ◯ More than 50 years

25) What is your generational affiliation?

- ◯ Traditionalist (born prior to 1946)
- ◯ Baby Boomer (born 1946–1964)
- ◯ Generation X (born 1965–1978)
- ◯ Generation Y (born 1979–1997)
- ◯ Generation Z (born 1998–present)

26) (Optional) What is the name of your organization?

____

27) Please let us know how you heard about this survey:

☐ AGC	☐ CCA
☐ CMA	☐ NAWIC
☐ ABC	☐ ACEC
☐ CURT	☐ NSPE
☐ NECA	☐ AIA
☐ SMACNA	☐ CSI
☐ MCAA	☐ NLC
☐ COAA	☐ ARTBA
☐ NAHB	☐ KCPRT
☐ IFMA	☐ Other: ______________

28) Can you refer us to someone else in your organization who might be willing to share your organization’s change implementation?

Name: ____

Email address: ____

<u>End of Survey</u>