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Safety Design Management Processes to Mitigate Design Errors

Hernan Guadalupe
Walden University

Walden University

College of Management and Technology

This is to certify that the doctoral study by

Hernán Guadalupe

has been found to be complete and satisfactory in all respects,
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Review Committee
Dr. David Blum, Committee Chairperson, Doctor of Business Administration Faculty

Dr. Marilyn Simon, Committee Member, Doctor of Business Administration Faculty

Dr. Kenneth Gossett, University Reviewer, Doctor of Business Administration Faculty

Chief Academic Officer and Provost
Sue Subocz, Ph.D.

Walden University
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Abstract

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MEng, University of Maryland, College Park, 2017

BEng, Stevens Institute of Technology, 2003

Doctoral Study Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Abstract

Some organizations lack processes to mitigate design errors that may result in potential accidents or loss of life during building construction. Managers are concerned about preventing injuries and accidents~~,~~ which may promote safer working conditions during construction. Grounded in the transformation-flow-value theory of production, the purpose of this qualitative single case study was to explore safety design management processes that managers use to mitigate errors. The participants included 7 members from 1 design firm with business operations in the United States northeastern region. Data were collected from semistructured interviews and company document reviews. Data were analyzed using Yin’s 5-phase, where 5 themes emerged: developing standardized processes and procedures, collaboration and information sharing, active senior management involvement, allocating technical design experts, and leveraging technology implementation. The key recommendation for building design managers is to develop and implement a systemic and systematic approach to establish detailed communication protocols to improve the design management processes to mitigate design errors. The implications for positive social change include promoting safer and healthier working environments to protect workers' well-being and increase community residents' living standards.

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Dedication

First and foremost, all thanks and praises are due to Allah, alone; without Him, nothing is possible. I thank Him for giving me the courage, strength, and patience to complete my study. I dedicate this study to my family. To my beautiful and supportive wife, Wendy, thank you for your unconditional love, patience, understanding, and motivation. I love you with all my heart and soul. To my children, Uthman, Muhammad, Mariam, Aasia, Ali, and Omar, thank you for being my *why*. I did this with the hopes of being an excellent example to follow and inspire you all to reach your dreams. Papi did this for you. To my loving parents and beloved brother, Walter, Martha, and Diego, thank you for your love and support; I am who I am because of you all. Finally, to my late grandmother, María Rebecca, my goal was to finish and have you with me as I walked across the stage, but God had another plan. Nonetheless, I will carry on your legacy forever. I hope I made you proud of me once more. Te quiero con todo mi corazon, Abuelita.

Acknowledgments

I would like to express my utmost gratitude to my committee members, classmates, and the Walden community for their selflessness and support throughout my DBA journey. I would like to especially thank my chair, Dr. David Blum, for his patience, honesty, guidance, insight, and support during my doctoral study. Without your help, I would indeed have been lost. I also thank my second committee member, Dr. Marilyn Simon, and URR, Dr. Ken Gossett, for their valuable contributions and guidance on my study.

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Section 1: Foundation of the Study

The design phase of a construction project is a complex process (Knotten et al., 2015) involving numerous decisions by key project stakeholders to complete a design (Herrera et al., 2020). However, the design process oversight by design managers may result in design errors (Knotten et al., 2015). These design errors may affect the design quality and have negative implications during the construction phase (Peansupap & Ly, 2015), which may result in accidents or loss of life (Karakhan, 2016).

Background of the Problem

The construction industry continues to be one of the most dangerous industries in the United States (Karakhan, 2016). According to the U.S. Department of Labor (2019), 5,250 work-related fatal injuries occurred in the United States in 2018, with the construction industry representing 19.2% of the total injuries. The construction industry ranks as the highest in accident rates among all industries (Yuan et al., 2019). Researchers have stated that design errors are a significant cause of building construction injuries and fatalities (Mohammadi et al., 2018).

Design errors refer to design flaws, omissions, and discrepancies (Peansupap & Ly, 2015) and indicate poor management during the design phase (Knotten et al., 2015). However, design professionals have given limited attention to design error control (Mohammadi et al., 2018) and have traditionally focused on end-user safety during the design phase (Mroszczyk, 2015). More effective design management processes and tools are necessary to improve design quality and reduce design errors, resulting in fewer construction hazards (Al Hattab & Hamzeh, 2015; Mohammadi et al., 2018). Scant research exists to identify effective safety design management processes to mitigate design errors during the design phase to improve safety performance.

Problem Statement

Design errors are a cause of potential accidents or loss of life during building construction (Yap et al., 2018). Design errors are associated with 36.1% of construction-related incidents and fatalities (Xiahou et al., 2018). The general business problem was that ineffective safety design management decreases safety performance during building construction. The specific business problem was that some building design managers lack safety design management processes to mitigate design errors during the design phase to improve safety performance during building construction.

Purpose Statement

The purpose of this qualitative single case study was to explore the safety design management process that building design managers use to mitigate design errors during the design phase to improve safety performance during building construction. The population consisted of seven building design managers from one design firm located in the northeast region of the United States who have successfully implemented safety design management processes during the design phase to improve safety performance during building construction. The implications for positive social change might include safer working conditions for building construction employees, leading to employment longevity, satisfaction, and maintaining healthy social relationships. Positive social change might include benefiting residents through enhanced stability of communities with increased employment opportunities that enable residents to increase their contributions to community betterment.

Nature of the Study

The methods for conducting research are qualitative, quantitative, and mixed methods (Thamhain, 2014). Qualitative researchers explore a phenomenon through the underlying meanings and motivations of participants (Park & Park, 2016). Researchers use a qualitative approach to obtain an in-depth understanding of *how* and *why* a phenomenon exists (Barnham, 2015; Fusch et al., 2018). I chose the qualitative research method for this study. Quantitative researchers focus on numerical data and statistical measurements to test a theory by identifying, comparing, and testing relationships of examined variables (Dasgupta, 2015). Mixed method researchers integrate qualitative and quantitative methods in the same study to provide empirical support to match the intricacies of the phenomenon (Molina-Azorin et al., 2017). Quantitative and mixed methods research were not appropriate for this study as both methods depend on analyzing numerical data and hypotheses testing to examine relationships between measured variables associated with the phenomenon and did not align with my research question.

The qualitative designs that I considered were case study, phenomenological, and ethnographic. A case study consists of a comprehensive and systematic analysis of a particular phenomenon, which may include a person, a group of people, or an organization (Karim Jallow et al., 2014; Yin, 2018). Using a case study design allows researchers to explore real-life, bounded systems by place and time (Yazan, 2015) and identify specific themes or patterns to extend the understanding of the phenomenon (Nguyen et al., 2019). A phenomenological design is used to understand the personal meanings and lived experiences of the participants (Davidsen, 2013). Researchers use the ethnographic design to explore intact cultures or social constructs of participants, which requires a level of immersion into the environment of the participants to understand the phenomenon (Oswald et al., 2015). Phenomenological and ethnographic design did not align with my research question and were unsuitable for this study as I did not explore individual lives, shared lived experiences, or cultural constructs over a period of time. I chose the case study design to investigate a phenomenon bounded by place and time to explore an analysis of events, groups, and people.

Research Question

What safety design management processes do building design managers use to mitigate design errors during the design phase to improve safety performance during building construction?

Interview Questions

1. What design management processes do you implement during the design phase to mitigate design errors to improve safety performance during building construction?
2. What key barriers exist, if any, to implement effective safety design management processes to mitigate design errors to improve safety performance?
3. What tools do you use to implement effective safety design management processes to mitigate design errors?

4. What challenges exist to mitigate design errors to improve safety design management processes?
5. How do you measure the effectiveness of the design management process to mitigate design errors to improve safety performance during building construction?
6. What additional information would you like to add about the processes you use to mitigate design errors to improve safety performance during building construction?

Conceptual Framework

I used the transformation-flow-value (TFV) theory of production for the conceptual framework of the study. Koskela (1999) introduced TFV to interpret the process of value production for construction. Koskela characterized construction as a flow process coupled with transformation activities (as cited in Bajjou et al., 2017b). The concepts of TFV are (a) transformation, (b) flow, and (c) value generation. Researchers consider TFV as a baseline to understand the process of generating design value (Mota et al., 2019). The conceptual framework provided a context to enable me to understand the safety design management process used by design managers to mitigate design errors during the design phase to improve safety performance during building construction.

Operational Definitions

Architecture, engineering, and construction (AEC): AEC is an industry composed of architectural, engineering, and construction organizations and professionals that integrate and collaborate through a series of activities to efficiently complete the desired outcome (Jacobsson et al., 2017)

Building information modeling (BIM): BIM is a design process that involves geometric and nongeometric properties and data to develop a digital representation of the physical and functional characteristics of a building through the design phase (Marzouk et al., 2019).

Design management (DM): DM is a business approach that integrates project management and design capabilities, processes, and strategies as part of an organization's overall mission and strategic initiatives to create and control effectively designed products or services (Wolff & Amaral, 2016).

Flow: Flow refers to the process of composing, inspecting, moving, and waiting for information to eliminate nonvalue adding activities (Koskela, 1999).

Lean design: Lean design is a design methodology to generate value and reduce or eliminate waste during the design phase (Franco & Picchi, 2016).

Prevention through design (PtD): PtD is a concept to facilitate the inclusion of safety management during the design phase process (Yuan et al., 2019).

Project management (PM): PM is the application of knowledge, skills, tools, and techniques to a project's planning, organization, monitoring, and controlling activities to meet the project performance criteria (Radujković & Sjekavica, 2017).

Assumptions, Limitations, and Delimitations

Assumptions

Assumptions are presumable facts researchers consider to be true or plausible, but researchers have not verified (Grant, 2014). My first assumption was that participant selection criteria were inclusive to ensure all the participants were qualified in safety design management processes to mitigate design errors to improve safety performance during building construction. My second assumption was that participants would respond to the interview questions truthfully and accurately. My final assumption was that the findings may be a valuable source of information to design firms to mitigate design errors during the design phase to improve safety performance during construction.

Limitations

Limitations are potential weaknesses that a researcher has no control of and may negatively influence the results of the study (Munthe-Kaas et al., 2019). The first limitation was that interview participants might have misrepresented or misinterpreted concepts and provided misleading comments intentionally or unintentionally. A second limitation was that findings may not be generalizable for other types of construction projects and or other organizations. A third limitation was that the company document review process depends on the documents provided by the design firm participants, which may have been subjective and contained bias.

Delimitations

Delimitations refer to the characteristics that limit the scope and define the boundaries of the study (Theofanidis & Fountouki, 2019). The delimitation of the study may be (a) sample population and size, (b) industry, and (c) geographical location. The selected participants included seven design managers who had experience in safety design management processes within the building construction industry. I restricted the geographical location of the study to the northeast region of the United States.

Significance of the Study

Contribution to Business Practice

The results of the study may be of value to businesses that seek to maintain consistent labor productivity, reduce insurance premiums and opportunity costs as a result of workplace injuries and accidents, and increase the company's ability to compete in the building construction market. The results of the study could contribute to effective business practices of design management processes by mitigating design errors during the design phase to improve safety performance during construction. Mitigating design errors and implementing safety considerations during the design phase may limit the number of workplace injuries and accidents during the construction phase. Companies may not require significant monetary or human capital investments in incident prevention programs during the construction phase nor encounter excessive costs associated with worker's compensation, medical expenses, and opportunity costs, which may improve a company's operational effectiveness, profitability, and competitive advantage.

Implications for Social Change

The results of the study may contribute to positive social change by reducing the adverse effects that workplace safety incidents have on a worker's psychological and behavioral responses, employment, economic stability, social relationships, and community betterment. Safer working conditions during construction may lead to psychological and behavioral stability, employment longevity, economic stability, and maintaining healthy social relationships with family and friends. Local communities may benefit from social change through an increase of construction labor employment opportunities, which might enable residents to contribute to the local community economy through the purchasing of locally produced goods and services, thus increasing the standard of living and well-being of community residents.

A Review of the Professional and Academic Literature

The purpose of this qualitative single case study was to explore the safety design management process that building design managers use to mitigate design errors during the design phase to improve safety performance during building construction. Researchers have given considerable attention in the literature on the importance of formulating strategies and effective project management practices for the construction phase (Mpofu et al., 2017). However, the processes identified, developed, and implemented within the realm of engineering design projects have received less research attention than strategies related to construction projects. Researchers have described design processes as ad hoc approaches that cause inefficient design iterations and value loss (Nøklebye et al., 2018). Additionally, there is limited objective research on design processes to reduce or eliminate potential safety risks during the design lifecycle (Hardison & Hallowell, 2019). To achieve this objective, I conducted a comprehensive literature review of existing research. I researched key words and a combination of key words connected with Boolean operators that were relevant to the intended study concerning as *engineering, construction, design management, project management, TFV theory, transformation, flow, value, value generation, prevention through design, safety, safety in design, building construction, lean design, lean construction,* and *BIM* with an emphasis on design management processes.

The literature review contains 136 references, with 119 of the references published within 5 years of the chief academic officer's approval anticipated by February 2021, representing 87.50%. In addition, the literature review contains 113 out of 136 references from scholarly peer-reviewed articles, representing 83.09%. The remaining 16.91% consists of published conference proceedings. The primary source of the professional and academic literature was the Walden University Library using databases, including ScienceDirect, SAGE Premier, Emerald Management Journals, and EBSCOhost. I also used Google Scholar to search key words to identify relevant articles and then researched through the Walden University Library to gain access to the literature. The literature review begins with an overview of the TFV theory of production, which I used as a conceptual framework for this study.

Transformation-Flow-Value Theory of Production

Koskela (1999) introduced the TFV theory of production to address the gaps in the theory of production and its application to the construction industry. Koskela opined that production primarily focuses on the process of transforming inputs to outputs based on principles applied from the manufacturing industry; however, researchers do not consider the architectural, engineering, and construction (AEC) processes to a simple conversion model (Freire & Alarcón, 2002). The design process in the AEC industry requires the management of task interdependencies, complexity, uncertainty, innovation, and decision-making (Mota et al., 2019). The challenges in the design process require the need for participation and collaboration between stakeholders (Naar et al., 2016), which is not considered a conversion model. A more applicable theory for design and construction is necessary, which should consider the flow of information and the value generation dynamic in addition to transformation (Koskela, 1999); thus, the development of the TFV theory of production integrates the concepts of transformation, flow, and value simultaneously.

TFV Theory Concepts

Transformation

Researchers have considered the transformation concept as the traditional element of production (Al Hattab & Hamzeh, 2018). The general tenet of the transformation concept in the TFV theory is to transform a set of determined inputs into a set of acceptable outputs (Nowotarski & Pasławski, 2016). Besklubova and Zhang (2019) identified transformation as a physical change, which includes material, labor, and energy. In the context of the building construction industry, transformation refers to the conversion of conceptual design requirements into visual model elements (Abou-Ibrahim & Hamzeh, 2016a). However, researchers have characterized transformation as a black box (Malaeb & Hamzeh, 2018; Orgut et al., 2018) and have criticized the lack systemic approach that makes up the complexities of the actual transformation process (Munir et al., 2019). Al Hattab and Hamzeh (2018) stated that the transformation concept is an unclear understanding of the internal conversion process.

The transformation view process equates to the efficient breakdown of the primary transformation elements into subelements. The categorization of the transformation elements is part of production management (Koskela, 2003). The transformation concept is useful to identify what tasks are necessary to complete the production process (Koskela, 1999). The main principles of the transformation concept include the methodical breakdown and control of designated activities during the design phase (Pikas et al., 2020). However, control implies plannable actions, which contradicts the traditional perspective of transformation by Orgut et al. (2018) and Malaeb and Hamzeh (2018). Researchers have relied on the concept of flow and value to further define the transformation process (Malaeb & Hamzeh, 2018).

The transformation view is a fundamental principle of design within the AEC industry (Munir et al., 2019). According to Kärnä and Junnonen (2017), the purpose of the design phase is to transform initial concepts into spatial manifestation that satisfies the client's requirements optimally and economically. The design process is dependent on mapping the process and sequencing in a manner that allows the transformation of perceptible and imperceptible inputs (Wolff & Amaral, 2016). Munir et al. (2019) noted that improving the subprocess of the transformation view improves the production performance of the design.

Design managers may use the transformation view as a performance metric. The focus of the transformation view is to identify the needs of the end-user (Shou et al., 2019). The transformation view is dependent on goals and targets set forth at the front-end briefing with the client (Pikas et al., 2020). A successful design process depends on the client's clear input more than on the designer's ability to design (Knotten et al., 2017). Decisions made during the earlier stages of the design process have the most significant influence on project success (Surlan et al., 2015). The realization or attainment of the goals or targets is an indication of successful performance (Rezvani & Khosravi, 2018). However, researchers have argued that the transformation view is a traditional and inflexible concept (Besklubova & Zhang, 2019) without consideration of the means and methods for managing, monitoring, and controlling the hierarchical components (Savolainen et al., 2018). Also, the transformation view does not provide managers the necessary information for problem-solving (Orgut et al., 2018), thus lacking the opportunity to optimize the design management process to improve performance.

Transformation impacts the value of the end-user. The principle of transformation is directly related to value due to its dependency on capturing the client's requirements and production completeness (Munir et al., 2019). Inefficient transformation of the design requirements decreases the value of the design (Uusitalo et al., 2019b). Designers may confront challenges during the transformation process if the design requirements are not captured adequately (Uusitalo et al., 2019b). Herrera et al. (2020) attributed methodical consideration of the client's requirements as the primary consequence for increased output value, not the merit of transformation, which supports Uusitalo's et al. position. Thus, the completeness of the design process requires consideration of additional elements to improve the entire design system (Uusitalo et al., 2019b).

Flow

The transformation of design inputs to outputs is contingent on sufficient flow.

AEC firms depend on the flow of information to organize, operate, and produce a final product to the end-user (Segarra et al., 2017). The flow concept refers to the processes of transformation between inputs and outputs consisting of inspection, evaluation, and waiting to optimize the design value through waste reduction and elimination (Bajjou et al., 2017b). Sacks (2016) described flow as the path progression of a product from raw material to finished product. The inputs and outputs of the design during the flow stage depend on critical decision-making and performance, which influence subsequent activities and stages of the design (Pandit et al., 2015).

Researchers have considered the flow of information as an iterative process over a set period where the most significant level of engineering and design details occur (Jacob & Varghese, 2018). Abou-Ibrahim and Hamzeh (2016b) argued that iterations during the design phase are vital to creating value. Conceptualizing the design process as a flow of information allows for the time efficiency of critical activities between design contributors (Freire & Alarcón, 2002). The flow of information involves a multitude of specialists and stakeholders working cohesively to determine design and construction feasibility (Swinson et al., 2016). Savolainen et al. (2018) described the design process as the flow of drafting intangible targets into designing a buildable concept. According to Liu et al. (2018), as the design evolves through the flow of information, so will the validation and refinement of the final design concept. Thus, the flow process establishes the methodology to obtain the final output or value.

The flow of information during the design phase is critical toward addressing design complexities. The design workflow increases in complexity as further design specifications advance, client requirements become extensive, and time limitations increase (Al Hattab & Hamzeh, 2018). The designers often perform a design under time restrictions requiring effective planning with a focus on information flow among stakeholders (Mota et al., 2019). Knotten et al. (2015) argued that the complexity and iterative characteristics of the design project requires managers to flow with change rather than attempting to plan and control.

The flow of information is essential as it impacts other aspects of the flow process (Dave et al., 2016). Design managers may use the flow concept to identify design dynamics that to streamline the production of design elements in addition to optimizing the design workflow (Abou-Ibrahim & Hamzeh, 2016a). Researchers often refer to flow as workflow emphasizing waste reduction, improving operation production, and improving overall project performance (Zhang et al., 2017). The success of design management in the AEC industry depends on accurate and timely information flow (Emmitt, 2016).

Design managers may find it difficult to measure efficient flow. Sacks (2016) argued that it is difficult to measure flow due to the various perspectives of understanding the spatial and temporal process of flow. Sacks noted that engineers focus on determining the end-product rather than the process itself; thus, there is an emphasis on a quantitative perspective of production and neglecting the qualitative perspective of flow. From a construction perspective, researchers have suggested a new process-oriented metric towards emphasizing the flow aspect of productivity (Sacks et al., 2017). Orgut et al. (2018) argued that a lack of measuring the flow process is a common cause of low production. Sacks et al. (2017) introduced the construction flow index as a method for measuring flow during construction. However, the metric lacks empirical evidence to substantiate the metric's effectiveness towards measuring flow (Orgut et al., 2018), especially during the design phase. Zhang et al. (2017) argued that the lack of a flow metric to measure volume, rate, and effectiveness of information flow impedes future research.

The flow concept may help reduce wastage during design and construction. The design phase within the AEC industry is known for its problems and challenges (Mota et al., 2019). Design errors and rework from inefficiency during design increase the complexity and variability of the overall project (Mota et al., 2019). There is an inherent need to improve the flow of information through effective collaboration and communication to manage complexity and variability during design (Naar et al., 2016). Nowotarski and Pasławski (2016) posited that the purpose of the flow concept is to reduce activities that do not add value through the reduction of time and variability and to increase process flexibility. Reducing variations in work activities generates an efficient workflow (Marzouk et al., 2019). Sacks et al. (2017) considered the significance of flow on waste reduction products and operations perspective.

The design managers should consider the design process from the flow perspective to address the inefficiencies of the design activities (Pikas et al., 2020). Wastage may be a result of design errors (Ajayi & Oyedele, 2018). Researchers have stated that approximately 33% of waste during construction is a result of ineffective flow during the design phase (Michaud et al., 2019). However, researchers have viewed waste reduction primarily from a construction perspective in the literature (Ashika, 2019; Besklubova & Zhang, 2019).

Enhancing the design system may reduce waste and improve information flow (Uusitalo et al., 2019b). Pikas et al. (2020) identified that the uncertainty of information flow is one of the sources of underperformance during the design phase. Michaud et al. (2019) argued that researchers should emphasize on improving the information flow through standardization and management development. Michaud et al. (2019) also stated that interactions are dependent on each other; thus, the flow of one interaction may negatively affect the flow of the subsequent interaction producing waste.

Design managers may use various methods during the flow of information to reduce wastage. Design managers may improve flow and reduce waste by using a design structure matrix (DSM), tool integration, and partnering during the design process (Pikas et al., 2020). Designers use DSM to communicate the required information flow from one activity to the next using visual representation (Ma et al., 2019). Tool integration, such as the use of project intranets, may provide design teams access to design information, which may improve the information flow process (Svalestuen et al., 2017). Cohesive relationships among stakeholders using partnering may improve collaboration and increase the flow of information during the design (Yap et al., 2018). By implementing design methods and practices, design managers may shift their focus towards value-adding activities and mitigate time loss on unnecessary activities.

The flow of information improves communication during the design phase. Zadeh et al. (2016) argued that the extensiveness of the flow of information might contribute to the design changes during the construction phase. Al Hattab and Hamzeh (2018) argued that deficient workflow continues to affect the design process negatively. Al Hattab and Hamzeh attributed poor workflow to ineffective communication. Korb and Sacks' (2018) research on lean production systems of apartment building identified that poor information flow contributes to the inefficiency in the production system, which supports Al Hattab and Hamzeh's (2018) position. Orgut et al. (2018) stated that the inability to measure the effectiveness of the process activities and their interrelationships might be cause for low production.

Like transformation, the flow may affect the value generation of the design process. Bajjou et al. (2017b) argued the importance of synthesizing flow with transformation and value, specifically within lean construction. Bajjou et al. (2017b) also stated that it is essential to consider the lean operation as the optimal flow of sequential steps (i.e., transformation) to create value for the end-user. Sacks (2016) referred to the flow path as the value stream. Avelar et al. (2019) equated efficient flow as the minimizing of nonvalue adding activities and waste within the value stream.

Value

The final concept of the engineering and design process is value generation (Koskela et al., 2002). The traditional concept of the value generation refers to the fulfillment of the client's requirements and expectations (Khalife & Hamzeh, 2019). The quality of the value generation process is dependent on the engineering and design professionals' ability to align the client's needs and objectives with the project's execution and deliverables (Kärnä & Junnonen, 2017; Knotten et al., 2017). According to

Korb et al. (2017), value refers to observing the production activities through the client's perspective. Value is the result of the stakeholder assessment or evaluation of the end-product (Khalife & Hamzeh, 2019).

The needs of the client are at the forefront of the design process. Koskela (1999) opined that the practical contribution of value with the TFV theory may help design managers achieve client requirements in the most optimal manner. Nowotarski and Pasławski (2016) expanded on Koskela's definition of practical contribution into five associated principles that ensure the (a) capturing of requirements, (b) flow down of client requirements, (c) deliverables are accounted for, (d) capability of the production system, and (e) value metric. The principles are methods and practices to obtain value generation through a systematic and rigorous approach (Bajjou et al., 2017b).

Researchers and AEC professionals have relied on comprehensive studies conducted within the manufacturing and business industries to understand value and value generation during design and construction (Khalife & Hamzeh, 2019). The general understanding of the design process concerning value is to ensure that the final design product corresponds with the client's requirements (Boton & Forgues, 2017). Researchers have also added the elimination of value loss as a leading principle during the production process (Nowotarski & Pasławski, 2016), which includes design (Koskela et al., 2002). However, researchers have debated the objective, subjective, and relative nature of value (Salvatierra-Garrido & Pasquire, 2011).

From an objective perspective, researchers have understood value through measurable attributes or physical features (Salvatierra-Garrido & Pasquire, 2011). Target value design (TVD) is an objective method of determining design value (Alves et al., 2017). Alves et al. (2017) stated that the TVD process establishes allowable cost as the main driver for the feasibility of the design. The extent of labor, innovation, and value of the design is contingent on the allowable cost (Alves et al., 2017). Meijon Morêda Neto et al. (2019) stated that TVD might increase the probability of project performance improvement. Oliva et al. (2016) included schedule and product delivery in addition to cost improvement. The emphasis on time and budget in the literature as criteria to generate value suggests that value is explicit; thus, TVD is viable if all stakeholders on the project share the same perspective of value.

Subjectivity is a complex feature that may impact the meaning of product value. The inclusion of individual perspectives, ideas, emotions, and feelings of the product contributes to the subjective nature of value (Salvatierra-Garrido & Pasquire, 2011). Khalife and Hamzeh (2019) argued that value is ambiguous and difficult to understand due to the interference of human interest. Korb et al. (2017) stated that value is difficult to internalize due to conflicting interests between project stakeholders. Drevland et al. (2017) stated that value is a result of simultaneous critical assessments with unshared consequences. Thus, value may not always be a linear concept due to the varying experiences and expectations of stakeholders.

Value may also be relative. Haddadi et al. (2016) stated that the determination of value is relative to the needs of the client. Salvatierra-Garrido and Pasquire (2011) referred to relativity as situational, citing that something that is not always considered valuable may still be appreciated given a specific situation or opportunity. Wandahl and

Bejder (2003) stated that the value of a product might be comparative to the value of another. Wandahl and Bejder (2003) further added that goods or products deemed invaluable might increase in value when combined with another good or product. Concerning the design process, the determination of value is relative to the expected and unexpected issues that shift the intended value creation (Çıdık, & Boyd, 2019). Value, from a relative perspective, is scant in the existing literature. Researchers have primarily leaned towards the subjective nature of value (Giménez et al., 2020; Khalife & Hamzeh, 2019).

Building design managers may perceive value through the process of waste reduction and the creation of the design model. Waste during the design phase may negatively affect value. Bølviken and Koskela (2016) opined that waste is a form of value loss from the value perspective. Design managers may implement lean methodologies to minimize waste and maximize value during the design process (Haarr & Drevland, 2016). The purpose of a lean methodology concerning value is to enable clients to work alongside designers and contractors to determine better solutions (Alves et al., 2017). The waste reduction or elimination process improves the quality of the design model and buildability of the design (Ajayi & Oyedele, 2018).

Researchers have considered the design documentation the value generated from the design process (Ajayi & Oyedele, 2018). The design documentation is also referred to as the construction plans and specifications (Yap & Skitmore, 2017) in the literature. At this stage of the design process, the design is ready for implementation in the construction phase (Savolainen et al., 2018). The design documentation impacts the constructability and waste generation of a construction project (Ajayi & Oyedele, 2018). Although researchers have focused on the relationship between client's requirements and value generation, design professionals should also consider fiduciary requirements to safety, welfare, and health of the public during the design phase (Breakey & Sampford, 2017; Eveleth, 2017). The obligatory considerations as a result of regulatory standardization during design and social impacts support the subjective nature of value during the design phase.

Contrasting and Complementary Theories

Yin (2018) discussed the significance of theoretical considerations and aligning the research design with the conceptual framework to gain a richer understanding of the research problem. Researchers have presented contrasting and complementary theories that design managers may apply to the AEC industry, such as the theory of constraints (Trojanowska & Dostatni, 2017) and lean theory (Goh & Goh, 2019). Researchers have considered the relevance and application of the theory of constraints and the lean theory in the context of design and construction management in previous studies (Trojanowska & Dostatni, 2017; Uusitalo et al., 2019a). Per Yin's recommendations, I considered both theories for the study; however, neither theory aligned with the exploration of the research problem.

Theory of Constraints

Goldratt and Cox (1984) proposed the theory of constraints (TOC) as an approach to address production system improvement through understanding dependencies or constraints. TOC is frequently used in supply chain management, evaluating the process efficiency of a system as a whole and not limited to a single process (Wu et al., 2019). The principles of TOC consist of five steps, which include (a) identifying the system's constraints, (b) deciding how to exploit the system's constraints, (c) subordinate and adjust other activities to the decided constraints, (d) elevate the system's constraints, and (e) if a constraint is interrupted, then repeat from step one (Munir et al., 2019; Wu et al., 2019). Modi et al. (2018) stated that a characteristic of TOC is the consideration of problems as symptoms that managers may eliminate through addressing system constraints. Modi et al. (2018) posited that this unique approach may improve production and profitability.

Concerning the AEC industry, managers have considered TOC through the application of critical chain project management (CCPM; Trojanowska & Dostatni, 2017). Goldratt (1997) proposed CCPM based on the principle of TOC to address inefficiencies with traditional project management practices. The principle of CCPM is the monitoring and control of critical project activity durations to meeting schedule constraints (Ordoñez et al., 2019). Researchers posited that efficient time management might yield scope and cost benefits (Luiz et al., 2019). The considerations of time, cost, and scope are known as the triple constraint principle in traditional project management (Turner & Xue, 2018). However, researchers have argued that the triple constraint does not provide an inclusive and explicit measurement of overall performance or project value (Williams, 2016).

The quantitative nature of TOC may not appeal to the subjective nature of the design value found in TFV. Gomes and Romão (2016) stated that many projects might successfully fulfill the triple constraints; yet, have fruitless business experiences. Pollack et al. (2018) stated that too much emphasis on the triple constraints might result in organizational limitations and ineffective realization of overall benefits. Albert et al. (2017) determined that the triple constraints criteria are performance dimensions that customers have come to expect from a project but may not necessarily result in project success or customer satisfaction.

The application of TOC includes a dependency on supplementary decision-making methods or models for the flow of information. Trojanowska and Dostatni (2017) suggested that design managers implementing CCPM should consider additional decision-making tools and methods to monitor and control key influencing factors on the project. According to Fokwa Soh et al. (2018), 88% of decisions impacting costs arise during the design phase. A significant component of the design management process is the management of decisions through efficient information workflows between the design team and stakeholders (Al Hattab & Hamzeh, 2018), which may not be found exclusively in TOC.

Lean Theory

Krafcik introduced the term lean manufacturing in the late 1980s, which Krafcik derived from Ohno and Shingo's Toyota Production System popularized by the Japanese manufacturing industry (Yamamoto et al., 2019). Although researchers have often referred to lean in terms of manufacturing or production industry in the literature, researchers opined that the principles and philosophy of lean might apply to any industry (Ansah et al., 2016). For this section, I referred to lean as understood through the design process approach in the AEC industry using Besklubova and Zhang's (2019) terminology of lean theory and Jørgensen and Emmitt's (2009) terminology of lean design. Besklubova and Zhang (2019) stated that the general objective of the lean theory is to eliminate waste from a process. Lean design refers to the integration of lean principles to optimize value and minimize waste during the production of a design (Jørgensen, & Emmitt, 2009). Managers may use lean principles to reduce waste, increase productivity, and improve health and safety while satisfying the client's requirements (Ansah et al., 2016). According to Ansah et al. (2016), there are five principles of the lean theory, which are (a) value specification, (b) value stream, (c) flow, (d) pull, and (e) perfection.

Lean design correlates with the TFV theory of production. Tzortzopoulos et al. (2020) stated that lean design is a production process to convert and transfer information to add value. Researchers have examined and developed lean design and lean design management through considerations of the TFV theory of production (Bajjou et al., 2017b; Besklubova & Zhang, 2019; Moaveni et al., 2019). Lean design management includes strategic development and decision-making to create and innovate products and services that may improve organizational success and quality of life (Tzortzopoulos et al., 2020), which denotes the concepts of flow and value in TFV. According to Pikas et al. (2018), there are three functions of lean design management, which are (a) design system design, (b) design system operation, and (c) design system improvement. Design system design in lean theory includes initial decisions on project framework, information and communication platforms, development of project specifications, and project vision (Pikas et al., 2020). Researchers posited that the lean community should approach design system design from the three TFV theory of production perspectives (a) transformation (what), (b) flow (how), and value generation (why; Pikas et al., 2018; Pikas et al., 2020).

There is a greater emphasis on flow and value in lean theory, as transformation is typical of most AEC management practices (Sarhan et al., 2019). The efficient management of flow processes is necessary for project success (Daniel & Pasquire, 2019). Lean design managers may approach the flow of information from a social and technical perspective of lean design, which includes goal setting, project alignment, continuous advancement, and integration (Pikas et al., 2018). Deficient interactions and information flow by the design team and stakeholders may result in poor performance, which may lead to value loss (Herrera et al., 2020). Design managers may maintain smooth flow processes through implementing a pull approach to execute tasks effectively, limit sources of waste, reduce congestion, and rework during the production of the design model (Michaud et al., 2019). Considerations of the pull approach in lean theory support the flow concept of TFV (Daniel & Pasquire, 2019).

A lean approach is a continuous process that carries through from design to construction (Jørgensen & Emmitt, 2009). Managers use lean thinking to identify the design processes necessary to eliminate waste and improve value and information flow (Uusitalo et al., 2019b). Researchers have considered value a critical starting point for lean theory (Lekan & Segunfumni, 2018). The concept of perfection in lean theory embodies the value generation concept in the TFV theory by continually removing nonvalue adding activities or waste to reduce value loss (Lekan & Segunfumni, 2018).

Although researchers have considered lean theory principles as an approach to the design phase (Jørgensen & Emmitt, 2009), there is scant research on the application of lean theory principles to mitigate design errors during the design process. Lean theory as a delivery system may improve production (Ansah et al., 2016), yet researchers still rely on the TFV theory to examine safety improvements on projects (Moaveni et al., 2019). Tzortzopoulos et al. (2020) argued that lean thinking in design is still in its preliminary phases of development. Researchers have not studied the effects of implementing the principles of lean theory to prevention through design (PtD) and safety improvements (Moaveni et al., 2019); thus, the TFV theory may have greater relevance to the current study similar to Moaveni's et al. (2019) approach.

Transformation-Flow-Value Theory and Mitigating Design Errors

The primary focus of this study is that some building design managers lack safety design management processes to mitigate design errors during the design phase to improve safety performance during building construction. The traditional consideration of design and construction production is the transformation and processing of inputs to outputs. The principle of transformation is to optimize subprocesses to improve production performance (Munir et al., 2019); however, it lacks principles to mitigate design errors or waste, which researchers commonly discuss through the understanding of flow and value (Pikas et al., 2020). Koskela et al. (2007) stated that the conceptualization of transformation as a metaphysical assumption implies that transformation is linear. The integration of flow and value to a linear model is problematic as flow and value are nonlinear (Koskela et al., 2007). Researchers have relied on a process-based framework of the TFV theory of production to address challenges in design and construction processes (Koskela et al., 2007; Munir et al., 2019; Pikas et al., 2020). However, Bølviken and Koskela (2016) opined that the AEC industry may not always be considered a production-like process. While the outcome of both the AEC industry and manufacturing industry is to ensure the quality of the production, the variability, complexity, and uniqueness of AEC projects may cause particularities that create challenges to the implementation of a production theory (Bajjou et al., 2017a).

Design errors are a significant problem in the AEC industry (Peansupap & Ly, 2015). Design errors are a cause of injuries and accidents (Hallowell et al., 2017) and designers may contribute up to 40% of the errors on a construction project (Baiburin, 2017). Design errors are a significant source for project variation (Dosumu & Aigbavboa, 2017; Khalifa & Mahamid, 2019). Koskela et al. (2002) argued that poor design practices stem from a lack of a fundamental theory of design and design management. The common challenges in the design process include a lack of flow of information management (Al Hattab & Hamzeh, 2018), ineffective value loss (Jylhä & Junnila, 2013), and an increase of complexity and variability (Shou et al., 2019) during design. Design managers could maintain the design activities and components through TFV to produce increase project value (Abou-Ibrahim & Hamzeh, 2016a).

Researchers have interpreted design errors as waste (Tzortzopoulos et al., 2020). The AEC industry continues to be afflicted by waste generation on projects, which suggest imperfect design and construction systems (Sarhan et al., 2018). Design errors and rework are a result of poor design flow, which may reduce the quality of a project and decrease the value to the end-user (Al Hattab & Hamzeh, 2018). Sarhan et al. (2018) proposed that elevating the flow concept of TFV as a production driver may help alter the classification of waste to improve design processes. Lekan and Segunfumni (2018) suggested that design managers use TFV to guide lean thinking to identify parameters to correct waste that include design errors. Michaud et al. (2019) posited that the use of TFV to standardize design processes might decrease project variability, thus reduce waste. Kärnä and Junnonen (2017) suggested that challenges in design management practices stem from a lack of standardization and collaborative efforts between design disciplines. However, Bølviken and Koskela (2016) argued that the nature of projects as temporary endeavors or organizations creates limitations to production stability and standardization to reduce waste in workflow and minimize value loss. According to Bølviken and Koskela (2016), the observation of waste in AEC production flow may not occur over time due to a lack of production repetitiveness, which may hinder improvements in mitigating design errors.

Managing flow improves communication between stakeholders during design. Poor design performance may be a result of poor communication and interactions between project teams (Herrera et al., 2020). The design process consists of a continuous reciprocal process between stakeholders, thus requiring a higher level of control and management (Knotten et al., 2015). Zanni et al. (2016) stated the design team integration and communication with stakeholders is essential to the design process. Participation and collaboration of technical specialists and project owners are necessary to fulfill the project objectives (Herrera et al., 2018). The application of TFV may improve communication and collaboration between project stakeholders to support flow (Sarhan et al., 2018), which may resolve challenges in the AEC industry. Although the flow of information may improve inconsistencies in operations, successful implementation of flow may require acceptance from stakeholders involved in the process (Kęsek et al., 2019). Successful implementation of flow processes depends on human behavior through the creation of collaborative culture and transparency as opposed to an exclusive focus on production process integration (Dinesh et al., 2017). Al Hattab and Hamzeh (2018) posited that increasing the understanding of workflows based on TFV may provide managers the opportunity to make better decisions and improve design processes.

Michaud et al. (2019) identified that design errors are a result of a lack of coordination between design engineers and stakeholders. Freire and Alarcón (2002) argued that the design process should integrate conversion (i.e., transformation), flow, and value models to enable identification and analysis of design aspects that design managers may overlook during the process. Conceptualizing the flow of information may improve coordination between interdependent flows and integration of design and construction (Freire & Alarcón, 2002). However, some researchers have contended that intercepting design errors should include considerations for people and psychological safety in addition to process improvements (Moaveni et al., 2019). Design managers should consider improvements to communication workflow with cognizant safety design method integration to reduce design errors that may result in safety hazards during construction.

Value generation is an essential factor in mitigating waste on a project. Understanding value and value loss on a project may reduce the complexity that causes design iterations and affects production (Tzortzopoulos et al., 2020). Nowotarski and Pasławski (2016) stated that TFV provides a standardized theoretical basis to define lean management by limiting losses and maximizing value. Savolainen et al. (2018) posited the information creation and determination of alternative solutions during the design process may be achieved through interim value creation at individual phases of the design process. The value perspective is essential to reduce uncertainty, eliminate nonvalue adding activities, improve production quality, reduce production time, and improve working client relationships (Savolainen et al., 2018). Avelar et al. (2019) relied on the value concept to evaluate customer required value-adding functions effectively. Researchers have referred to value through the understanding of TFV to focus on the external outputs of the production process and reduce value loss that results from a lack of quality or defective products (Besklubova & Zhang, 2019). However, Dlouhy et al. (2018) argued that researchers might not give enough attention to value determination. The lack of understanding of the nature of customer value is the greatest weakness of the TFV (Dlouhy et al., 2018).

Managers have traditionally viewed project success based on time, cost, and quality (Pollack et al., 2018); however, researchers have included stakeholder satisfaction as an additional dimension of project success (Kärnä & Junnonen, 2017; Khlaifat et al., 2017). Satisfaction refers to the proper alignment of customer and organization needs with project output to produce value (Badewi, 2016). Project success may include the success of managing the delivery of output, success of stakeholder communication and understanding, and success of realizing project benefits (Badewi, 2016), which are consistent with principles of transformation, flow, and value.

Researchers have highlighted the significance of value generation on projects (Osuizugbo, 2020). The design phase is an essential component of overall building construction success (Knotten et al., 2017). The consequences of unstructured design processes include unnecessary design iterations and value loss (Nøklebye et al., 2018). Michaud et al. (2019) suggested that value inaccuracy may influence the quality and reliability of information flow. A greater focus on increasing efficiency and improving quality is necessary to create value within the AEC industry (Knotten et al., 2017).

Effective design management practices may reduce complexity and variability. Variability hinders the predictability of the design output and may affect value (Herrera et al., 2020). A design has several variables that may or may not depend on others or have impacts with other variables (da Rocha & Kemmer, 2018). The variability during the design project may result in substandard design cycles, increase costs, and rework (Tzortzopoulos et al., 2020). The complexity of design requires a level of control to ensure that the necessary information is captured and addressed as not to affect subsequent variables or processes that need to take place to produce a final desired product.

Technology that adds value to the end-user is essential to the design process (Marzouk et al., 2019). There has been significant development of tools and technologies to help improve design management; however, the most significant challenge lies in the adoption of such tools and technologies by designers and engineers (Xiaer et al., 2017). Also, design managers in the AEC industry continue to use traditional methods to deliver the design product (Aguilar et al., 2019). Designers continue to rely on 2D plans and drawings to perform design reviews to identify design errors and possible construction risks (Aguilar et al., 2019). The lack of adoption by designers and engineers may be due to a lack of knowledge and motivation to adjust to changing trends in the AEC industry (Moaveni et al., 2019).

Nonetheless, numerous researchers have presented studies linking the TFV framework and design tools and technologies to improve the design process (Michaud et al., 2019; Rischmoller et al., 2018). The available design tools and technologies may include BIM (Teo et al., 2016), value stream mapping (VSM; Michaud et al., 2019), the Last Planner System (LPS; Wernicke et al., 2019), or computer advanced visualization tools (CAVT; Rischmoller et al., 2006). Designers use these tools to assist in recognizing potential hazards during the design phase and allow designers to make better design recommendations related to safety during the construction phase (Poghosyan et al., 2018).

Michaud et al. (2019) suggested that BIM may help designers reduce design errors and facilitate collaboration and communication during the project lifecycle. The TFV theory helps designers further the understanding of BIM and introduce a new level of development framework to improve design management (Abou-Ibrahim & Hamzeh, 2016b). Integrating BIM into the design process allows designers to create virtual models to facilitate the design and identify potential conflicts during the early stages of the process, improve information sharing, improve workflows, and increase value to the end-user (Al Hattab & Hamzeh, 2018). BIM is a popular method to ensure design collaboration that may help designers avoid design errors (Trani et al., 2016). Researchers have suggested the use of BIM to improve safety in the AEC industry through the development of automated safety checks during the modeling phase (Teo et al., 2016). However, limitations to the use of BIM exist due to a lack of time available to optimize design solutions (Tauriainen et al., 2016), lack of proficient BIM users (Vass & Gustavsson, 2017), lack of demand and cost (Ghaffarianhoseini et al., 2017), and lack of interoperability between various BIM-based design platforms and applications (Lewis et al., 2019).

Michaud et al. (2019) proposed that VSM may provide a visualization of the flow of information to help identify waste and improve workflows. Freire and Alarcón (2002) proposed seven tools that may improve the flow of resources and information during the design phase to mitigate design errors. The seven improvement tools include (a) interactive coordination, (b) intranet development, (c) development of checklists before design, (d) development of checklists after design, (e) quality function deployment, (f) VSM, and (g) training (Freire & Alarcón, 2002). According to Freire and Alarcón (2002), design errors could decrease by up to 44% through the implementation of proposed improvement tools, which indicate stabilization in the design workflow.

Design managers use LPS as a production control method based on the flow view of TFV to provide systematic and transparent design management (Koskela et al., 2002). Tzortzopoulos et al. (2020) stated that LPS might improve design transparency and workflows through effective planning, progress control metrics, and benchmarking promoting, which may translate to improvements in the production process and the minimization of waste. Rischmoller et al. (2006) used TFV theory as the theoretical foundation for studying improvements in value generation of the design process to propose CAVT. Rischmoller et al. (2006) argued that 3D modeling during the early phase of the design process could help automate interference detection and improve material quantity estimation to minimize design errors. The application of CAVT during the design phase may help reduce uncertainty and variability that lead to design errors, rework, and waste through the implementation of flow and value concepts (Rischmoller et al., 2006). The results indicate an improvement in the efficiency and effectiveness of the design process through consideration of tools based on TFV.

An Overview of Building Construction

Significance of the Design Phase on Building Construction

The design process is critical to the overall success of the construction project (Kärnä & Junnonen, 2017; Knotten et al., 2017). Engineering and design professionals develop a conceptual visualization based on the client's expectations that establish the definitions, parameters, and specifications of the construction project (Mroszczyk, 2015; Swinson et al., 2016; Tsiga et al., 2016). The design phase transforms the preliminary concept of the client into a visual form, reflective of optimization and economic considerations for project success (Kärnä & Junnonen, 2017). Critical design decisions and implementation made during the design phase have a significant impact on the overall outcome of construction projects (Orihuela et al., 2017; Segarra et al., 2017). Design managers should understand the significance of the design process and the implications for construction project success.

Engineering and design professionals act as faithful agents to clients and the public (Starrett, 2017), utilizing specialized skills, technical knowledge, and applications to develop the design plans and specifications (Swinson et al., 2016). Engineering and design professionals may exercise good judgment and perform at the highest level of industry standards (Tsiga et al., 2016). The technical performance of the engineers and designers contribute to quality designs that are free of errors and promote efficiency to minimize wastage due to rework during the design and construction phases (Ajayi & Oyedele, 2018; Knotten et al., 2017). Engineering and design professionals are traditionally responsible for adhering to regulatory codes and standards set forth by the governing agencies in the interest of the intermediary and end-users (Mroszczyk, 2015). The construction industry is a dangerous, complex, and uncertain industry (Dosumu & Aigbavboa, 2017). Engineering and design professionals have a mandatory and inflexible responsibility to fulfill their obligations to public safety (Kobielak et al., 2015). Mroszczyk (2015) posited that the design phase is the time to influence quality and safety on a construction project.

Impacts of Design Errors on Building Construction

The engineering and design phase require the highest level of detail to reduce design errors and omissions that may lead to negative impacts on project success. Engineering and design errors may cause deviations to the original construction plan causing significant schedule delays and cost overruns as a result of rework and changes

(Ajayi & Oyedele, 2018; Choudhry et al., 2017). Pandit et al. (2015) stated that the design phase is a critical process associated with overall project performance; however, design deficiencies resulting in rework can disrupt the continuum and performance on a project. Forcada et al. (2017) defined rework as the unnecessary effort to redo a process or task as a result of erroneous execution or poor performance the first time, which could increase project costs by up to 52%.

According to Yap and Skitmore (2017), design changes during construction are negatively perceived by stakeholders and influence construction cost and time. Ajayi and Oyedele (2018) and Yap and Skitmore (2017) agreed that design errors result in wastage and the use of additional resources. Yap and Skitmore (2017) noted that the duration of a project delay due to design errors might incur up to 69% of the original project duration and increase costs up to 25% of the original construction cost. Dosumu and Aigbavboa (2017) stated that 65% of the variation from the original construction plan is a result of design errors. Han et al. (2013) noted that 79% of rework costs are a result of design errors and omissions and account for over 50% of the project cost overrun. Design errors and deficiencies have a link with variances in project cost and time as well as contractor profit. Therefore, engineering and design firms should play a significant role in proactively managing the design and mitigating errors to achieve both project and financial goals.

Importance of Safety in Building Construction

Factoring in quality and safety is critical, given the gravity of fatalities within the construction industry. Construction-related injuries and fatalities are a global challenge

(Kasirossafar & Shahbodaghlou, 2015). Researchers posited that design deficiencies during the engineering and design phase are a leading contributor to construction-related injuries and fatalities (Hallowell et al., 2017; Karakhan, 2016). Implementing safety considerations during the design phase may help eliminate construction hazards associated with design deficiencies (Karakhan, 2016).

Design errors on construction projects is a worldwide phenomenon. Design deficiencies contributed to 42% of fatal injuries between 1993 to 2003 in the United States (Behm, 2005). Design deficiencies led to 63% of construction-related injuries and fatalities between 1986 and 1989 in the United Kingdom (Mroszczyk, 2015). In 2004, a collapsed air terminal in Paris, France, resulted in the death of four people and three injured as a result of design deficiencies (Kobielak et al., 2015). Similarly, 42% of construction-related fatalities in Australia from 1997 through 2002 were a result of poor design (Mroszczyk, 2015). In Iran, 37% of construction accidents were a result of a lack of safety considerations during the design phase (Kasirossafar & Shahbodaghlou, 2015). Engineering and design professionals are responsible for achieving client expectations but, more importantly, ensuring the quality of life and safety of the public during and after the construction phase.

Prevention Through Design (PtD)

The focus of PtD is to factor the safety of construction workers during the design phase (Yuan et al., 2019). PtD is also known in the AEC industry as safety through design (StD), design for safety (DFS), and construction hazard prevent through design (CHPtD; Teo et al., 2016). According to researchers, the concept of PtD began in the

1970s with process engineers due to new U.S. Occupational Safety and Health Administration (OSHA) safety regulations to address noise reduction during production (Taubitz, 2018). By the 1990s, the AEC industry began to incorporate PtD principles into design projects (Teo et al., 2016). In 2007, the National Institute for Occupational Safety and Health (NIOSH) adopted the concept of PtD as a national initiative to prevent and reduce workplace injuries, illnesses, or fatalities through prevention considerations during the design phase (Ho et al., 2020).

PtD ties the hierarchy of controls and the Szymberski curve together to mitigate design errors and safety concerns through (a) elimination, (b) substitution, and (c) engineering controls during the design phase (Yuan et al., 2019). The Szymberski curve is a time and safety influence curve, which implies that the ability to influence safety is most significant during the conceptual and design phases (Karakhan et al., 2018). Designers may use the PtD concept to develop safety design management processes that promote the implementation of safety decisions and incorporate design alternatives and solutions to improve safety performance during building construction (Moaveni et al., 2019). The concept of PtD in design practices requires designers to attempt to reduce or eliminate hazards during the project lifecycle (Lyon & Popov, 2019). While the elimination of hazards may not be feasible, the PtD concept requires designers to perform exhaustive considerations (Lyon & Popov, 2019).

The construction industry is one of the most dangerous industries in the United States. Researchers stated that 19% of industrial fatalities are a result of construction accidents (Yuan et al., 2019). The construction industry fatality rate is 3x than the average rate among all industries (Hallowell et al., 201~~6~~7). Construction companies have made significant efforts to improve safety management processes during construction and implement zero-accident initiatives (Yuan et al., 2019); yet, the rate of injuries, accidents, and fatalities in construction continue to be a significant phenomenon (Poghosyan et al., 2018). Researchers have argued that poor design processes, management, and design products are the major causes of fatal accidents and injuries during building construction (Pikas et al., 2020).

PtD is a proactive approach to reducing safety accidents and fatalities during construction. Researchers have suggested that more considerable efforts to produce viable approaches to reduce safety implications during construction need to occur at the front-end of a construction project (Yuan et al., 2019). Behm (2005) and Kasirossafar and Shahbodaghlou (2015) associated 33% to 42% of construction fatalities to design-related issues. Moaveni et al. (2019) opined that the implementation of PtD might help decrease construction-related accidents by 40%. Also, the implementation of PtD during the design phase could improve construction productivity, reduce schedule delays, and cost overruns (Moaveni et al., 2019).

PtD has become a nationally driven initiative due to the continual danger of the construction industry (Golabchi et al., 2018). NIOSH and OSHA have depended on previous research to postulate a relationship between PtD and construction injuries and accidents (Hardison & Hallowell, 2019). OSHA has developed industrial regulations as a result of seminal PtD research (Hardison & Hallowell, 2019). However, researchers have argued that PtD is a general presumption that lacks experimental observations to support the relationship between design and safety (Gambatese et al., 2017). Nonetheless, there is a consensus among researchers that a greater focus of construction injury and accident prevention initiatives during the design should be part of the process (Hardison & Hallowell, 2019; Poghosyan et al., 2018).

While the consensus that favors PtD during the design phase, there are several limitations. Researchers have identified several obstacles that limit the implementation of PtD in the design, such as traditional construction delivery methods, lack of designer integration during construction, limited implementation of new design methods, tools and technologies, and liability exposure (Yuan et al., 2019). The integration of construction professionals and design specialists during the early stages of the design phases can help improve safety performance (Moaveni et al., 2019). However, traditional contract delivery methods, such as Design-Bid-Build (DBB), do not allow designer-contractor integration during design (Park & Kwak, 2017), which might be necessary to identify and reduce safety risks during the design phase. Alternative contract delivery methods, such as Design-Build (DB), may allow the designer and contractor to work closely together from the onset of design, which helps devise more efficient safety plans (Moaveni et al., 2019). Xiaer et al. (2017) posited that the involvement and collaboration efforts by the contractors found in DB type contracts are essential to the success of PtD. Thus, the potential of implementing PtD may rely on the flexibility of the contract types that promote greater stakeholder collaboration during design.

A frequently cited limitation for implementing PtD in the literature is liability exposure linked with construction injuries or accidents. Designers are reluctant to provide direction on construction means and methods (Karakhan, 2016), which includes safety planning and execution. Traditional AEC industry practice shifts the liability to enforce and uphold safety protocols and efforts solely to the contractor (Sacks et al., 2015). Researchers have associated increases in insurance premiums on general liability and errors and omissions insurance as the reason for designer reluctancy (Toole & Carpenter, 2013). The litigious nature in the United States in which designers may find themselves having to defend against lawsuits hampers the potential of PtD (Toole & Carpenter, 2013). Thus, a designer's liability exposure may be a demotivating factor to implement PtD.

The TFV theory facilitates PtD by reducing waste and improving communication during the design phase. Koskela (1999) opined that the integration of TFV during design may help reduce construction safety challenges. Howell et al. (2017) stated that projects that implement lean management principles, such as PtD, help designers intercept design errors before it poses threats to construction safety. Reducing injury and fatality rates is a form of waste reduction (Bajjou et al., 2017b). Attention to safety through the TFV framework allows designers to optimize decision-making and present varying safety perspectives that might less waste and improve value (Moaveni et al., 2019).

Moaveni et al. (2019) argued that implementation of TFV enables design managers to integrate key design stakeholders and improve communication flow and engagement. Increasing safety considerations at the front-end of a building construction project is the main priority for successful PtD (Yuan et al., 2019). Proactive interactions with necessary stakeholders during the design phase help verify the flow of the design and check the iterative value of the design (Munir et al., 2019). However, traditional design processes have segregated phases where stakeholders work in silos (Xiaer et al., 201). The limitations of safety knowledge and lack of designer involvement in the safety management process may impede the successful implementation of PtD (Moaveni et al., 2019). The significance of information flow dynamics in the TFV framework might improve design workflow (Al Hattab & Hamzeh, 2018), thus, encouraging greater stakeholder participation that might improve safety considerations during design.

Transition

In Section 1, I provided background information about design management, along with a detailed description of the rationale behind the selection of the research question. Section 1 included the interview questions, social and business effect significant to the study, operational definitions, and assumptions, limitations, and delimitations. Also, Section 1 provided an exhaustive literature review on the topics of design, design management, project management, critical success factors, and strategies related to the research topic.

In Section 2, I included an explanation of the purpose of the case study, the role of the researcher, the research methodology, design of the study, and methods for selecting participants and specific population. Section 2 included data collection and validation techniques, ethical research considerations, data analysis process, and considerations for reliability and validity. Section 3 contains the findings of the study, recommendations, implications for social change, my reflections, and conclusions.

Section 2: The Project

Purpose Statement

The purpose of this qualitative single case study was to explore the safety design management process that building design managers use to mitigate design errors during the design phase to improve safety performance during building construction. The population consisted of seven building design managers from one design firm located in the northeast region of the United States who have successfully implemented safety design management processes during the design phase to improve safety performance during building construction. The implications for positive social change might include safer working conditions for building construction employees, which may lead to employment longevity, satisfaction, and maintaining healthy social relationships. Positive social change might include benefiting residents through enhanced stability of communities with increased employment opportunities that enable residents to increase their contributions to community betterment.

Role of the Researcher

I was the primary instrument for data collection for this qualitative study. The role of the researcher is to understand the actions, behaviors, opinions, and knowledge of the participants (Rosenthal, 2016; Yin, 2018). The principal means of collecting data for this study were semistructured interviews and company information, such as design activity reports, design specifications, and project design manuals. Although I have been working in the AEC industry within the engineering, design, and project management disciplines for over 18 years, I did not have any relationship with the building design firm or study participants.

The qualitative researcher is responsible for upholding the highest ethical standards and protecting the rights of the participants (Friesen et al., 2017; U.S. Department of Health and Human Services, 1979). The researcher may achieve ethical compliance by adhering to the principles of respect for participants, doing good by the participants, and treating participants equally and impartially as outlined in the *Belmont Report* (Miracle, 2016). The researcher obtains informed consent from participants, providing confidentiality and presenting findings (Myers & Newman, 2007). The Walden University Institutional Review Board (IRB) enforces ethical adherence to ensure the study complies with necessary research ethics. I adhered to the ethical principles by treating participants respectfully and equally, protecting their privacy, obtaining informed consent, and informing the participants of the benefits and risks of participating as a data collection participant after the receipt of IRB approval.

Biases are anything that can influence or distort the results of a study (Galdas, 2017). Biases, assumptions, and attitudes from participants and researchers can impact data reliability and validity (Spiers et al., 2018). Researchers should attempt to recognize their personal views and develop strategies during the research process to limit bias (Cypress, 2017). There are several strategies that researchers can implement to mitigate research bias. Fusch et al. (2018) stated that researchers could minimize bias by using multiple data collection methods to corroborate their findings (i.e., triangulation). Researchers may use member checking (Birt et al., 2016) and clarify one’s perspectives and views (Cypress, 2017) to mitigate bias. I mitigated bias and avoided viewing data through a personal perspective by allowing participants to express their perspectives, experiences, and opinions freely without interruption or interjection of my thoughts or beliefs. I adhered to the interview protocol, performed member checking, and maintained a reflexive journal to record my thoughts during participant interactions to mitigate bias.

Incorporating an interview protocol allows the qualitative researcher the ability to approach participant interviews systematically and comprehensively (Yeong et al., 2018). Yeong et al. (2018) posited that a quality interview protocol is essential to collecting quality data. Castillo-Montoya (2016) suggested that a quality interview protocol allows the researcher to obtain valuable data to address the research question. The interview protocol will detail a 3-step process: an opening statement and introduction of the research background and objectives, followed by the semistructured interviews and a closing statement. Semistructured interviews may allow for flexibility or improvisation by the researcher (Myers & Newman, 2007). An interview protocol provides a guide to ensure the interview remains consistent with the objectives of the study (Cronin, 2014; Yeong et al., 2018). I followed the interview protocol (see Appendix A) to ensure consistency during the interview process and increase the likelihood of rich data collection.

Participants

The eligibility criteria were the basis for selecting participants. Researchers should identify and select participants who have relevant knowledge and experience of the research phenomenon (Palinkas et al., 2015). Researchers use predetermined criteria to select participants who are relevant to the research objective in qualitative studies (Guest et al., 2016). The participant eligibility criteria in this study included (a) participants with a minimum of 5 years of experience in a management position overseeing building construction design, (b) participants with a professional engineering or design license or project management professional certification, (c) participants with the ability to provide detailed information about design management processes to mitigate design errors, and (d) participants who operate and practice engineering and design management in the northeast region of the United States.

Gaining access to participants is essential to ensure that the researcher can answer the research question (Yin, 2018). I searched for participants at LinkedIn https://www.linkedin.com under the group Building Design+Construction and the Blue Book Building and Construction Network at http://www.thebluebook.com to identify and contact a building design firm in the northeast region of the United States. I contacted a senior leader of a building design firm through email who was a gatekeeper to access participants. Peticca-Harris et al. (2016) suggested that gatekeepers may enable access and help introduce researchers to valuable participants. I provided a detailed explanation of the purpose of the study, the intended use of the collected data, and how the findings may be useful to the building design firm’s operations and performance to gain permission and access to a list of participants that meet the eligibility criteria. I requested the senior leader to read and sign a letter of cooperation and confidentiality.

The senior leader of the design firm provided me a list of prospective participant names and emails who met the eligibility criteria. Once receiving access to a list of eligible design managers, I contacted the prospective participants via email requesting their participation in the study using the participant invitation, and I provided the informed consent form. Elmir et al. (2011) stated that building rapport and trust with participants enables the interviewer to connect and gain in-depth access to the participants' experiences. The development of strategies may enhance the opportunity to establish rapport with participants. Practical strategies that researchers may use include explaining the research objectives early and clearly, adhering to an interview protocol, explaining confidentiality protection procedures, scheduling interviews at convenient times, and conducting interviews at an agreed location (Elmir et al., 2011; Yeong et al., 2018), which I used during my study. Implementing strategies to build a working and robust dynamic with participants may result in quality data and facilitate the objectives of the study.

Research Method and Design

Research Method

The methods for conducting research are qualitative, quantitative, and mixed methods (Thamhain, 2014). Qualitative researchers explore a phenomenon through the underlying meanings and motivations of participants (Park & Park, 2016). Researchers use qualitative research method to obtain an in-depth understanding of *how* and *why* a phenomenon exists (Barnham, 2015; Fusch et al., 2018). Qualitative research consists of investigating the knowledge and understanding of a phenomenon through the experiences of a group of people or a program and developing systematic interpretations to generate new concepts or new theories (Mohajan, 2018). Qualitative research is optimal when creating a holistic, in-depth understanding of a phenomenon (Rutberg & Bouikidis, 2018). Researchers use a qualitative research method when prior research of a phenomenon is unexplored or underexplored (Cahill, 1996). Safety design management processes to mitigate design errors in building construction is a relatively new phenomenon despite the common understanding that prevention through design may result in improved safety performance during construction. The qualitative method aligned best to explore an in-depth understanding of the study phenomenon to answer the research question.

Quantitative researchers focus on numerical data and statistical measurements to test hypotheses by identifying, comparing, and examining relationships of study variables (Dasgupta, 2015). Quantitative researchers collect data through standardized questionnaires or secondary data to determine the relationships between variables to develop hypotheses, measure variables, and draw conclusions (Rutberg & Bouikidis, 2018). Mixed method researchers integrate qualitative and quantitative methods in the same study to provide empirical support to investigate the intricacies of the phenomenon (Molina-Azorin et al., 2017). Quantitative and mixed methods research were not appropriate for this study as both methods depend on analyzing numerical data and hypotheses testing to validate relationships between examined variables associated with the phenomenon and would not answer my research question.

Research Design

The qualitative designs that I considered were case study, phenomenological, and ethnographic. Alpi and Evans (2019) described a case study design as a research design for researchers to study a phenomenon bounded by place and time. A case study consists of a comprehensive and systematic analysis of a particular phenomenon, which may include a person, a group of people, or an organization (Karim Jallow et al., 2014; Yin, 2018). Using a case study design allows researchers to explore real-life, bounded systems through the collection of detailed data (Yazan, 2015) and to identify specific themes or patterns to extend the understanding of the phenomenon (Nguyen et al., 2019). Researchers use case studies due to its emphasis on depth over breadth of a phenomenon (Boddy, 2016).

Phenomenological is a research design to explore the meaning of phenomenon in the context of the participants' world through their inner and outer consciousness according to their recollections, meaning, and depictions (Mohajan, 2018; Sun et al., 2016). Researchers use a phenomenological design to understand a phenomenon through the personal meanings and lived experiences of participants (Davidsen, 2013). Researchers use a phenomenological design to focus on the perspectives of the participants to describe the essence of a phenomenon (San Miguel & Kim, 2014). Mohajan (2018) stated that a phenomenological design is useful when scant information is available about the phenomenon.

Researchers use the ethnographic design to explore intact cultures or social constructs of participants, which requires a level of immersion into the environment of the participants to understand the phenomenon (Oswald et al., 2015). Ethnographic foundation lies in anthropology and aims to under the various aspects of the human experience and social perspectives (Ingham-Broomfield, 2015). While researchers have considered ethnographic design as one of the most in-depth research methods, it requires the researcher to become engaged in the culture of the participants (Baskerville & Myers, 2015; Mohajan, 2018). Phenomenological and ethnographic designs did not align with my research question and were unsuitable for this study. I chose a case study design to investigate a phenomenon bounded by place and time to help answer my research question.

Data saturation refers to the point during the research in which no new evidence or data emerges, and additional coding is no longer feasible (Guest et al., 2016). Case study research should rely upon multiple sources of data and converge to achieve triangulation (Yazan, 2015; Yin, 2018) to help achieve data saturation (Fusch & Ness, 2015). I used multiple data collection techniques, including semistructured interviews and review of company documents, to ensure data saturation.

Population and Sampling

The targeted population for this qualitative single case study consisted of building design managers from one design firm with a population sample of seven design managers located in the northeast region of the United States who have successfully implemented safety design management processes during the design phase to improve safety performance during building construction. Qualitative researchers should target a specific sample group of people with defined characteristics to ensure the reliability of the study (Cleary et al., 2014). Researchers use sampling methods in case study design to select cases and data sources to understand the phenomenon (Gentles et al., 2015).

I used purposive sampling method to select design managers who meet the eligibility criteria. According to Palinkas et al. (2015), purposive sampling is a commonly used method in qualitative research for identifying and selecting a sample. Researchers use purposive sampling to select information-rich participants according to the level of knowledge, experience, willingness to participate, and the ability to communicate about the phenomenon of interest (Gentles et al., 2015; Palinkas et al., 2015).

An explicit and precise sample size estimation for qualitative research does not exist (Hagaman & Wutich, 2016). Instead, researchers should consider a sample size that provides quality information to achieve saturation (Fusch & Ness, 2015). Spiers et al. (2018) stated that an appropriate sample size allows for saturation and replication. Failure to achieve data saturation may impact the quality of the research, which will affect the validity of the study (Fusch & Ness, 2015).

Beskow et al. (2014) suggested that thematic saturation in qualitative studies may occur between six to 12 interviews. Hagaman and Wutich (2016) noted that 16 or fewer interviews might be enough to identify common themes within homogenous groups. While there is no specified limit to achieve data saturation in a qualitative case study, previous researchers who explored the TFV theory in design management may serve as a basis for the number of recommended interviews required to achieve data saturation. Munir et al. (2019) conducted seven interviews to evaluate TFV and BIM design management processes. Wernicke et al. (2019) conducted nine interviews to study flow dimensions within lean construction based on TFV theory. I anticipated a sample size of seven design managers from one building design firm to be adequate to obtain data saturation.

Researchers define data saturation as the point during the research in which no new evidence or data emerges, and additional coding is no longer feasible (Guest et al., 2016). Interviews are a common and popular method to reach data saturation (Fusch & Ness, 2015; O'Reilly & Parker, 2012). Pekuri et al. (2015) concluded that data saturation is the result of interviews producing the same concepts and characteristics of different participants. I verified data saturation during the review and analysis of the collected data until no new data, themes, patterns, or codes emerge.

I provided the eligibility criteria to the selected firm and requested a list of prospective participants for the study from the design firm's senior leader. The senior leader of the design firm provided a list of potential participants, and initial communications with the participants began. I communicated with the individual participants via email, provided a general overview of the study, requested their availability to schedule the interview, and provided the prospective participant the informed consent form.

I conducted semistructured interviews that lasted 30-45 minutes using Zoom video conferencing software. Zoom video conferencing is a contemporary approach to qualitative data collection using technology to conduct computer-based interviews (Farooq & de Villiers, 2017) and advantageous for gaining access to a broader population and increased scheduling flexibility and convenience for the participants and researcher (Gray et al., 2020). Considerations for participant availability and level of comfort may influence a researcher’s ability to establish rapport and a working relationship (Gray et al., 2020). Zoom video conferencing was the preferred method to conduct the interviews due to participant proximity, participant availability, and participant meeting preference. Also, due to the COVID-19 pandemic, participants preferred to meet using Zoom video conferencing to observe the recommended health and social distancing precautions.

Ethical Research

Consideration and protection for the well-being of the participants is an essential component in an ethical study. Researchers have stated that observing ethical standards in research may prevent any direct harm or loss of confidentiality (Jeanes, 2016; Wessels & Visagie, 2016). Øye et al. (2015) posited that qualitative researchers should formulate and practice ethical guidelines due to the level of human interaction between the researcher and the participant. I obtained permission and approval to start research per the ethical guidelines set forth by the IRB before the start of the study. The primary function of the IRB is to protect the rights of the participants (Miracle, 2016). The Walden IRB approval number is 09-14-20-0954350.

Once I received approval to proceed with the study, I contacted the participants via email and invited them to participate in the study using the email script. I also attached a copy of the informed consent form. I explained to the participants (a) the purpose of the study, (b) the extent of their participation, (c) any potential risks of harm, and (d) their right to withdraw from the study at any time. The invitation included instructions to consent to the study. The participants were required to provide informed consent by responding to the email invitation from my Walden University account with the words, *I consent*, before the commencement of the formal interview to acknowledge their formal approval to participate in the research. I explained that participation is voluntary, and a participant had the right to withdraw at any time. Participant withdrawal protocol consisted of (a) ensuring that any communication before the exit remains confidential, (b) ensuring that any personal information is safeguarded, and (c) ensuring that there will be no consequences for withdrawing the research. Any data collected from the withdrawn participant was not used in the study.

Researchers may use incentives to recruit participants (Grant & Sugarman, 2004). However, researchers caution against the use of incentives because of possible coercion or undue influences that may jeopardize the integrity of the research (Largent & Lynch, 2017). Participation in this study will be voluntary, with no incentives or benefits offered to participants. All participants received an email of appreciation for participating in the study after the interview and member checking process. I offered a summary of the findings after publication.

The ethical protection measures of the participants were in conformance with the guidelines of the IRB. The *Belmont Report* highlights three primary principles for ethical research as respect for persons, beneficence, and justice (Adams & Miles, 2013). I upheld ethical measures to protect participants by being transparent about the intent of the study, disclosing all relevant information and risks for participating, respecting a participant's decision to participate or withdraw, and protecting their identity.

To protect the identity of the individual participants and organization, I followed the recommendations made by Beskow et al. (2014) and Morse and Coulehan (2014) by assigning codes to identify each participant and organization. Codification ensured the protection of the participants' identity. Researchers have used codes to identify participants and remove any links to personal identification (Kirilova & Karcher, 2017). I identified the organization as company A and the participants as P followed by a number corresponding to the interview order. For example, participants were assigned codes as P1, P2, P3, and I followed the same logic for all seven interviews.

Conducting ethical research and protecting the privacy and confidentiality of the research participants is a priority for qualitative researchers (Jeanes, 2016). Researchers should ensure that all confidential information is protected and stored in a secured location (Kirilova & Karcher, 2017). I stored all data collection information throughout the research on a secured password protected and encrypted storage system. All the collected data will remain locked inside a storage cabinet in my home office accessible only to me for 5 years to safeguard the rights of the participants and the organization. Upon completion of the 5-year storage period, I will dispose of all the paper documentation using a local professional shredding company. I will destroy all electronic documentation saved on the encrypted storage system using DBAN data wiping software.

Data Collection Instruments

In qualitative research, the researcher is the primary data collection instrument (Fusch & Ness, 2015; Mohajan, 2018). Consequently, I was the primary data collection instrument to explore the safety design management process that building design managers use to mitigate design errors during the design phase to improve safety performance during building construction. Qualitative case studies should have a minimum of two data collection methods (Yin, 2018). I used semistructured interviews as the primary data collection method and company documents, such as design management plans, quality management plans, drawing review checklists, and design service policies as my secondary data collection method.

The purpose of semistructured interviews is to explore participants' perspectives and insights regarding a phenomenon (McIntosh & Morse, 2015; Mohajan, 2018). For example, Harvey (2014) used semistructured interviews to elicit participants' language-learning perspectives and motivations for learning English. Leung (2015) identified the use of semistructured interviews in a variety of healthcare studies to understand patient perspectives that impact primary care. Banihashemi et al. (2017) used semistructured interviews to ascertain the perspectives of project managers on critical success factors affecting the integration of sustainability into project management practices. Researchers use semistructured interviews due to their level of flexibility, allowing slight divergence from the interview protocol (McIntosh & Morse, 2015). The flexibility of semistructured interviews enables participants to elaborate beyond the scheduled interview questions and can yield rich data (McIntosh & Morse, 2015; Morse, 2015).

I used semistructured interviews detailed in the interview protocol (see Appendix A) to collect the data from seven design managers from one building design firm. Researchers have used interview protocols to increase the effectiveness of the interview and ensure the collection of comprehensive information within the allotted timeframe (Yeong et al., 2018). The interview protocol can provide structure to allow for consistency (Brown et al., 2013) and replicability (Gugiu & Rodríguez-Campos, 2007) of the interview process. I asked the same questions from all the participants in the exact order and analyzed the data to identify common themes.

Ranney et al. (2015) recommended using two audio recording devices when conducting interviews in qualitative research. I collected data using two digital audio recording devices and maintained a reflexive journal to record my thoughts during participant interactions. The use of digital audio recording devices allowed me to capture the data and enhanced the opportunity to transcribe participants' verbatim responses accurately. I used a Sony ICDUX560 digital voice recorder as the primary recording device and an iPhone 8 MQ722LL/A using Otter Premium application for automatic transcription as the secondary recording device.

Member checking is a technique that qualitative researchers use to ensure the credibility of the study (Birt et al., 2016) and may help mitigate bias through validation and confirmation of accuracy and resonance of the recorded experiences and perspectives of the participants (Thomas, 2017). After transcribing the interviews, I interpreted and summarized the participants' responses. I scheduled a 30-minute follow-up meeting using Zoom video conferencing software to review the summarized interview with each participant to validate my interpretation of the participants' responses. Each participant read and checked the accuracy of the summarized interview transcripts. Participants had the opportunity to confirm, clarify, correct, or add to their initial responses, which may ensure the reliability and validity of the collected data. Hadi and José Closs (2016) stated that respondent validation might be the most important method for ensuring credibility in qualitative studies.

Data Collection Technique

Researchers use multiple data collection techniques in qualitative studies to strengthen the quality of the study (Smith, 2018; Yin, 2018). To achieve the objectives of the research question, I used semistructured interviews as the primary data collection method. Upon receiving IRB approval, I contacted eligible participants from one building design firm that met the eligibility criteria and selected participants using purposive sampling.

I contacted the participants via email, provided the participants with the informed consent form and invited them to participate in a 30-45 minute semistructured interview using Zoom video conferencing software. Researchers should develop a methodical and structured interview protocol. Ranney et al. (2015) posited that an interview protocol allows for accurate content, clarity, validity, and time management. Ranney et al. (2015) further stated that a lack of protocol or poorly structured protocol might result in flawed data with poor study. I used the interview protocol in Appendix A to ensure consistency, clarification, and proper time management.

The interview protocol process with eligible participants proceeded through three steps: an opening statement and introduction of the research background and objectives, followed by the semistructured interviews, and a closing statement. During the opening statement and introduction, I welcomed the participant, introduced myself as the researcher, explained the objectives of the study, the confidentiality procedures, and the conditions for withdrawing from the study. I informed each participant of the use of digital audio recording devices to ask for their consent to record participant responses and member checking process.

I proceeded with the 30-45 minute semistructured interviews. I asked the same six interview questions from all the participants in the exact order to analyze each response per interview question systematically. McIntosh and Morse (2015) stated that asking each participant the same questions provides interview standardization and replicability. However, McIntosh and Morse (2015) also suggested that researchers maintain a level of flexibility to allow for divergence from the interview script through probes to yield relevant, rich data. I probed participants with follow-up questions as necessary to allow participants to add to or clarify their initial responses to ensure the comprehensiveness of the collected data.

I recorded the participant responses using two digital audio recording devices, one as the primary recording source and the second as a backup. Ranney et al. (2015) stated that audio transcripts allow researchers the ability to capture additional complexity of data and is a preliminary form of data analysis. Upon completing the interviews, I used the member checking technique. Member checking is a validation technique that ensures the trustworthiness of data and enhances the credibility of the study (Birt et al., 2016; Ranney et al., 2015). I scheduled a 30-minute member checking session with each participant via email and provided a summary interpretation of their responses for review and validation approximately three days after concluding the interview. Participants had the opportunity to confirm, clarify, correct, or add to their initial responses.

There are advantages and disadvantages to semistructured interviews as the data collection method. Researchers have favored semistructured interviews as a data collection technique in qualitative research due to its simplicity in organizing and executing interviews (Johnson et al., 2017). Rosenthal (2016) stated that an advantage of using semistructured interviews for data collection is that it allows researchers to access in-depth participant perspectives, opinions, and feelings, which may produce rich and thick data. McIntosh and Morse (2015) also noted that semistructured interview formats allow for freedom and flexibility to divert from the establishing protocol as to solicit fully expressed perspectives and opinions. Disadvantages of semistructured interviews include deviation from research objectives due to interviewer lack of experience and control of the interview process (Yeong et al., 2018), reliance on the participant's ability to recall information (Johnson et al., 2017), and prolonged transcription processes (Opdenakker, 2006).

Data Organization Techniques

Effective data organization is imperative to the success of qualitative research (Nowell et al., 2017). File and document categorization and management of collected data may facilitate data retrieval effectiveness, track research activity (Cronin, 2014), and enhance data analysis efficiency (Nowell et al., 2017). Researchers may use central data repositories with specific folder types, naming conventions, and date on a secured network location to store and organize raw data (Nowell et al., 2017). I used a secured, password-protected network to store and organize the data collected from the semistructured interviews and company documents. I created two primary folders for each data collection method with the naming convention interviews and company documents. The interviews folder contained a subfolder for each participant label P1, P2, P3, continuing with the same naming logic for all seven participants. Each participant folder included (a) the signed informed consent form, (b) the raw audio recordings from both digital audio devices, (c) the interview transcripts, (d) the summarized interpretations for member checking, (e) the participants' member checking responses, and (f) the handwritten notes taken during the interview process. The company documents folder contained relevant company information, including (a) design management plans, (b) quality management plans, (c) drawing review checklists, and (d) design service policies. I scanned all hard copies of all collected data to maintain an electronic copy, and I added the file to the relevant folder. I filed all hard copies using manila folders with the same naming convention as the electronic file format. I stored the hard copies in a locked filing cabinet accessible to only me.

Researchers need to maintain a locked and secured storage system for all collected data (Kirilova & Karcher, 2017) to protect the privacy and confidentiality of each participant (Friesen et al., 2017). I stored all data collection information throughout the research on a secured password protected and encrypted storage system. All the collected data, either electronic or hard copy, will remain locked inside a storage cabinet in my home office accessible only to me for 5 years after completion of the study to safeguard the rights of the participants and the organization. Upon completion of the 5-year storage period, I will dispose of all the paper documentation using a local professional shredding company. I will destroy all electronic documentation saved on the encrypted storage system using DBAN data wiping software.

Data Analysis

Methodological Triangulation

Qualitative researchers using case study design commonly adopt methodological triangulation. Methodological triangulation refers to the use of multiple methods of data collection of the phenomenon within the same study (Johnson et al., 2017). I collected data using semistructured interviews and company documents and validated the interpretation of the interviews using member checking, to achieve methodological triangulation. By using methodological triangulation and member checking, I expected to enhance the validity and reliability of the study.

Yin’s 5 Step Data Analysis Model

The data analysis process may be the most intricate phase of qualitative research (Thorne, 2000). Researchers should conduct systematic data analysis and provide a logical and sequential narrative of the analysis process (Nowell et al., 2017). I used Yin’s 5-step data analysis model consisting of (a) compiling, (b) disassembling, (c), reassembling, (d) interpreting, and (e) concluding.

Compiling

The first step of Yin’s data analysis model is to compile the collected data into to format that the researcher can use to find meaningful answers to the research question (Castleberry & Nolen, 2018). Castleberry and Nolen (2018) suggested that a critical aspect of the compiling step is for a researcher to become familiar with the collected data through repetitive review. I compiled the collected data from the interview process and the provided company documents using Microsoft Word. I thoroughly reviewed the transcribed interview files, member checked interview notes, and the company documents and organized the data. Once I completed compiling the data, I disassembled the data.

Disassembling

Researchers disassemble the compiled data to choose the necessary data for the study (Wulansari, 2019). Disassembling consists of separating and creating specific groupings such as themes, concepts, or ideas through the coding process (Castleberry & Nolen, 2018). Belotto (2018) stated that coding allows researchers the ability to interpret large segments of text data to assess the meaning and identify common themes. I reviewed the compiled data to identify common themes, phrases, or similarities in the data. I disassembled the data into fragments and labels based on similar wording and sentences that convey a similar meaning, which I then codified and reassembled.

Reassembling

Reassembling consists of grouping codes with each other to create themes, which may represent a patterned response or meaning within the collected data (Castleberry & Nolen, 2018). After disassembling the data into fragments, I reassembled the data by clustering similar codes to categorize the data into higher-order themes using thematic hierarchies. I created hierarchical themes through the lens of the TFV theory. I used NVivo computer-aided qualitative data analysis software (CAQDAS) to organize the data and assist in identifying patterns of codes.

Interpreting

After reassembling the data into patterns and themes, I continued to interpret the data. Researchers interpret the codes and develop themes in an analytical narrative of the significance of the findings concerning the overall research question (Castleberry & Nolen, 2018). Castleberry and Nolen (2018) cautioned researchers from simply restating codes or themes as interpretations and suggested identifying and aligning the interpretations with the overarching research question. I reviewed all the identified codes and themes and discussed the relationships between the themes by ensuring the interpretations aligns with the research question.

Concluding

After the interpreting step, researchers represent their findings and conclusions using the concluding step (Yin, 2015). Conclusions are the final summation of the findings in response to the overarching research question (Castleberry & Nolen, 2018). After interpreting the data, I concluded the data analysis by summarizing the interpretation of the findings with the conceptual framework and overarching research question.

Codification Software and Theme Identification

Researchers use CAQDAS to separate, compile, codify, and efficiently manage large text data sets (Chowdhury, 2015; Yin, 2018). I used NVivo software to organize, codify, create themes, and manage the collected data during the analysis process. Researchers use NVivo to help identify patterns of codes and links between large sets of data (Castleberry & Nolen, 2018). I began by importing all the collected data into NVivo;

then, I created a preliminary set of codes of concepts and ideas based on keywords determined from the research question. Researchers may develop descriptions for each code to ensure codes are used consistently throughout the data (Castleberry & Nolen, 2018). I developed and maintained the list of codes and descriptions to ensure consistency through the data analysis process. I analyzed the data in thematic hierarchies of the grouped and coded concepts using NVivo. Castleberry and Nolen (2018) stated that researchers might use hierarchies to cluster similar codes into higher-order codes to view across a broader thematic landscape of data. Saldana (2016) suggested that researchers should base their coding decisions on the conceptual framework of the study. I selected the TFV theory of production as a conceptual framework and identified themes from semistructured interviews to understand building design management processes through the concepts of transformation, flow, and value generation. I reviewed and compared the determined codes and themes with the existing literature findings and the TFV theory of production. Correlating research findings with existing literature and the conceptual framework tenets may help close the knowledge gap between theory and practice (Van Rijt & Coppen, 2017).

Reliability and Validity

Establishing the quality of the research is essential within qualitative research. Researchers strive to enhance the quality of qualitative research through rigor (Connelly, 2016). Rigor refers to the state of confidence or strength in the research design, the carefulness of the research method, the thoroughness of the data collection process, and the accurateness of the interpretation (Connelly, 2016; Cypress, 2017). There are two fundamental concepts within the qualitative evaluation process to establish rigor, which are reliability and validity (Cypress, 2017). According to Mohajan (2018), reliability and validity increase transparency and decreases the opportunities for researcher bias.

Reliability

Reliability is synonymous with dependability in qualitative research (Lincoln & Guba, 1985). Dependability refers to the stability of the data over time to which the findings may be consistent and replicable (Castleberry & Nolen, 2018). Cypress (2017) stated that researchers might ensure dependability in qualitative research through consistency and attention in the application of the research process. Researchers have offered several strategies to establish the dependability of the study, such as using code-recode procedure (Castleberry & Nolen, 2018) and member checking of interpreted data (Hadi & José Closs, 2016). I used the code-recode procedure by coding the data, then recoding a second time about two weeks later to ensure that the initial coded data was coded in the same manner. I also used member checking by providing the participants with an opportunity to review a summary of the interpreted data to confirm, clarify, correct, or add to their initial responses. Guba and Lincoln (1989) suggested that researchers should use triangulation to attain dependability. I ensured dependability of the study by triangulating the interview data, company documents, and academic literature view about safety design management processes.

Validity

Validity refers to the state of integrity and appropriateness of the research process and data to which the findings represent an accurate interpretation of the experiences of the participants by establishing the trustworthiness of the study based on credibility, transferability, and confirmability (Lincoln & Guba, 1985; Spiers et al., 2018). Qualitative researchers use the term validity to judge the quality of the findings (Yazan, 2015). Bashir et al. (2008) stated that validity in qualitative research is dependent on implementing verification strategies to ensure data is credible and trustworthy.

Credibility

Credibility refers to the accurate and truthful depiction of the participant's perspectives and experiences (Cypress. 2017). There are several strategies qualitative researchers may adopt to ensure the credibility of the study, such as triangulation (Smith, 2018) and member checking (Nowell et al., 2017). I ensured the trustworthiness of the study through methodological triangulation and performing member checking of the interpreted data.

Transferability

Transferability refers to the extent to which the findings of one study may be applicable in other contexts or settings (Connelly, 2016; Nowell et al., 2017). Connelly (2016) stated that transparency of the analysis and trustworthiness of the research process ensures transferability. Researchers may demonstrate transferability through rich and thick descriptions of the context of the study, processes, location, and the studied participants and purposive sampling (Cypress, 2017; Nowell et al., 2017). I used purposive sampling and provided detailed descriptions of the research process, study context, sources of data, participants, and boundaries to ensure that readers and future researchers can determine the transferability of the study.

Confirmability

Confirmability refers to the neutrality of the study to ensure the responses and findings result from the data and not the researcher's biases (Castleberry & Nolen, 2018). Qualitative researchers should acknowledge that multiple realities exist and adopt strategies to negate personal experiences and viewpoints from tainting the research findings (Noble & Smith, 2015). Cypress (2017) and Johnson et al. (2017) suggested triangulation and reflexive journaling as strategies to ensure confirmability. I ensured that the findings of the study reflect the shared perspectives and experiences of the participants only. After each interview, I prepared a careful interpretation of the collected data and performed member checking with each participant. Kornbluh (2015) posited that member checking mitigates researcher bias and increases researcher responsibility to reflect participant experiences or perspectives accurately. I maintained detailed handwritten notes and documented introspection to help facilitate objectivity and researcher bias. I also used triangulation to ensure confirmability.

Data Saturation

Data saturation is the point during the research in which no new evidence or data emerges, and additional coding is no longer feasible (Guest et al., 2016). Fusch and Ness (2015) and Spiers et al. (2018) further defined the saturation state as the point where a researcher has collected enough data to gain an understanding of the phenomenon and could replicate the study. Interviews are a common and popular method to reach data saturation (Fusch & Ness, 2015; O'Reilly & Parker, 2012). Pekuri et al. (2015) concluded that data saturation is the result of interviews producing the same concepts and characteristics of different participants. To achieve data saturation, I asked participants to clarify responses during the interview process using follow-up questions to obtain a full comprehension of their perspectives and to participate in a member checking session to review the interpreted data ensures a complete representation of their responses. I also used methodological triangulation to achieve data saturation.

Transition and Summary

In Section 2, I stated the purpose of the case study and provided specific information and explanations regarding the role of the researcher, the study method, study design, the selection of the study participants, and the population and sample size. I explained the process of achieving data saturation, ensuring ethical considerations to protect the confidentiality and well-being of the participants during the data collection process, and considerations to ensure reliability and validity through the use of triangulation, member checking, and reflexive journaling. I outlined the data collection instrument, collection and organization techniques, and the data analysis process using methodological triangulation, Yin's 5 steps, codification software, and theme identification process.

In Section 3, I presented a summary of the findings of the research. The presentation of the findings describes the alignment of the emerging themes collected and analyzed through the interview process with the conceptual framework. I also discussed the application of the research to professional business practices and implications for social change that emerge from the research that might contribute to future research within the field of design management. Lastly, I presented recommendations, reflections, and conclusions.

Section 3: Application to Professional Practice and Implications for Change

Introduction

The purpose of this qualitative single case study was to explore the safety design management process that building design managers use to mitigate design errors during the design phase to improve safety performance during building construction. Seven design managers from one building design firm with design management process experience participated in the study. The data collection process included validating and triangulating information gathered from semistructured interviews, member checking of interpreted interview transcripts, review of company documents, and peer-reviewed journals. My findings indicated that participants used design management processes consisting of (a) developing standardized processes and procedures, (b) collaboration and information sharing, (c) active senior management involvement, (d) allocating technical design experts, and (d) leveraging technology platforms to mitigate design errors. The participants' experiences of design management processes could benefit other design managers and provide insight on effective processes that may help reduce or eliminate design errors to improve safety performance during construction.

Presentation of the Findings

The research question for this study was as follows: What safety design management processes do building design managers use to mitigate design errors during the design phase to improve safety performance during building construction? From the research question, I presented six predetermined open-ended interview questions to participants. Participants were identified with a code, such as P1, P2, P3, and so on, to maintain confidentiality, protect the participants' identities, and present evidence from participant responses in support of the themes. I identified five themes from the interview notes, interview data, and company documents: (a) developing standardized processes and procedures, (b) collaboration and information sharing, (c) active senior management involvement, (d) allocating technical design experts, and (e) leveraging technology platforms. I used the themes to link the literature review and the conceptual framework.

Theme 1: Developing Standardized Processes and Procedures

The first theme that emerged from the data analysis was developing standardized processes and procedures. All seven participants indicated that using standardized design processes and procedures ensures the final design product aligns with the client's expectations and upholds the highest level of design integrity and value, free from design errors. P2 stated, "Having that structure and understanding helps all the staff plug into the performance metrics required." P7 said, "Our company has specific design protocols that we use to review everything, including safety, overall design, and constructability of the design." Researchers stated that identifying reoccurring tasks and procedures and developing a standardized process is a fundamental method to ensure the design process's value and reduce the variability that may mitigate design errors (Hoppmann et al., 2015). da Rocha and Kemmer (2018) stated that the standardization of the design process might simplify building construction. The review of the participating company's quality management plan identified the use of standardized design and operating procedures to create a unified appearance and structure for the design and reduce potential errors.

Six participants concurred that standardized processes and procedures may consist of codes, guidelines, checklists, design standards, specifications, and quality assurance and quality control (QA/QC) plan, which design managers use as tools to reduce variability during the design lifecycle. P5 stated, “The organization also has standard methods, specifications, and design guidelines that determine the final design product.” P5 added, “The chief engineers will review the design documents and provide comments to ensure that the design is according to the proper codes and internal design standards.” P4 stated, “The tools that are used to implement effective design management are quality control checklists, and project initiation forms.” P6 shared, “The checklists act as a tool to track the different design levels and ensure the necessary components of the design are included with the submissions and meet the requirements of the internal quality control process.” P2 asserted, “The QA/QC plan includes supporting material such as project checklists and third-party review sign-off sheets.” P7 claimed, “We use standard tools like codes.” An extract from the participating company’s quality management plans confirmed the responses by P5 and P7, indicating that the design process includes design methodologies, design parameters, and the use of codes and standards.

Koskela (1999) posited that reducing variability is an essential principle of the TFV theory that AEC professionals may achieve through standardization. Michaud et al. (2019) stated that the standardization may improve the efficiency and productivity of the design process and is a foundation for improving information flow. Martinez et al. (2019) suggested that standardization may facilitate TFV of the design phase if developed and executed thoughtfully. The evidence presented from the collected data indicated that the standardization of the design process is supported by the literature review and aligns with TFV.

Michaud et al. (2019) stated that standard vocabulary, centralizing information between the project phases, and reducing knowledge scarcity may help decrease design waste in information flows and increase design optimization between phases. All the participants referred to the QA/QC process as the primary source of standardization during the design phase. P6 stated, “There is a very rigorous quality control process through the life of the design.” P6 added, “There are quality control checklists used by the engineers at every submission issued from our office to our clients.” P3 shared, “The tools to implement effective design management processes include interim checks, final checks, and independent reviews by experienced reviewers for completion and accuracy. Designers will check off that the contractual requirements and internal quality control processes are met.” P4 stated, “During the design phase, we have frequent quality control reviews at submission milestones.” P4 indicated that the implementation of effective design management processes primarily depends on the quality control process. P5 claimed,

> It is essential to establish a strict quality assurance guideline to prevent or minimize design errors. In construction, there is no perfect job. There will always be a design flaw on any project that designers try to prevent, but design flaws arise, so the goal is to minimize flaws. There is a need to create a strict and formal quality assurance program that starts with dedicated chief engineers. The process

> includes a quality control program, including detailed reviews and addressing every project's comments before being released to the client.

P5 added, "I believe the process does an excellent job of minimizing or eliminating as many design errors as possible."

According to Bhattacharjee (2018), quality assurance and quality control are essential components of effective design practices that may contribute to project success. Implementing quality control on AEC projects ensures design managers complete projects to the specified design standards and expectations (Kimeria et al., 2019). Researchers have stated that the QA/QC process is a comprehensive framework consisting of codes, specifications, and design requirements that designers use to prepare the design systematically, improve information flow, reduce design errors, and ensure value generation to the client (Bhattacharjee, 2018; Simanjuntak & Khorasani, 2018).

The participants indicated that the standardization of the design approach is a method to mitigate design errors to prevent safety hazards during construction. Researchers have suggested that standardization is an effective strategy to control the design process and avert design errors that may impact the construction phase stated that standardization aids in preventing errors in the design (Ajayi & Oyedele, 2018; Baiburin, 2017). According to Knotten et al. (2015), designers may implement design control through a standardized coordination process. P5 stated, "It is essential to establish strict, quality assurance guidelines to prevent or minimize design errors." P5 added, "The quality assurance program is thorough and has a cost impact but needed to minimize mistakes." The participating company's quality management plan and design management plans revealed standardized policies and practices to ensure the design products meet all safety requirements to promote the project stakeholders' safety and health, supporting the participants' responses. Additionally, the participating company's quality management plan emphasizes the importance of accident prevention and promoting a zero harm and no safety violation policy.

P2 indicated that design managers used a standardized quality control process to track errors. P2 stated,

> We are able to identify where errors originated by discipline and even down to the personnel, making it easier to identify, isolate, and mitigate errors and log in the project performance. Errors are tracked through the third-party review and throughout the design lifecycle. The third-party review is one of the multiple aspects of the QA/QC program.

Design review is a standard method for quality assurance and control (Pikas et al., 2020). Researchers have advocated the need for design review to identify design deficiencies (Yap et al., 2018). P2 shared,

> The design professional's responsibility is to manage the quality of their work as if they would be the last set of eyes on their work effort before release. Quality begins and ends with the design professional; therefore, their work should be complete and accurate. The peer review consists of independent review with resources that are not involved in the project that would look over the design at various points to ensure submission requirements are met and quality is embedded into the design process. At this point, the number of design errors could be

> significantly reduced. The internal third-party review (ITR) includes all discipline reviews and the design integration review.

P1 claimed, “The quality control and peer reviews before a project is issued catch design errors that could lead to safety issues.” P3 asserted, “The process consists of numerical and design and engineering philosophy and concepts that are often repeated and set at the project start.” P7 stated, “Basic design codes also help mitigate safety issues during the design phase, as the project has to be code compliant.”

Koskela (1999) opined that the theory of production should be prescriptive and define the actions necessary to contribute to the production goals. Koskela also suggested that TFV emphasizes the importance of considering modeling, structuring, controlling, and improving production through the concepts of transformation, flow, and value generation. Pikas et al. (2020) stated that from this perspective, the design process might be viewed as (a) the conversion of inputs to outputs, (b) the flow of information through space and time, and (c) the process of producing value for the client. The collected data highlighted hierarchal design activities and systemic control of workflows and activities and focused on quality generation through a robust QA/QC process indicating the transformative nature of the design process and dependency of information flow and value considerations for optimal design results.

Theme 2: Collaboration and Information Sharing

The second theme to emerge from the data analysis was collaboration and information sharing, which all seven participants indicated during the interviews. Design managers depend on effective communication to define the project scope of work and design parameters and ensure the design team comprehends the client's expectations (Boujaoudeh Khoury, 2019). Kärnä and Junnonen (2017) posited that effective communication might ensure design coordination and prevent design clashes. Lewis et al. (2019) argued that ineffective communication between the project stakeholders might hinder information transfer. P1 stated, "Communication is an essential tool to ensure that the design people are fully aware of the project scope." P3 said, "It is essential to develop a basis for the design that is agreed upon by the design team and client." P5 shared, "The team sits down with the chief engineers to walk through the project's scope of work to discuss and understand the design expectations." The participating company quality management plans, design service policies, and design management plans revealed that collaboration and information sharing is necessary during the design process, supporting participants' responses. For example, an excerpt from the quality management plan indicated that the project deliverables are a collaborative effort between the design team and the client to ensure appropriate information transfer through the design phase.

Researchers have stated that reducing uncertainty and poor information by identifying and defining the client expectations during the early stages of the design process increases value generation (Tzortzopoulos et al., 2020). Consequently, P4 said, "If managers possess poor communication skills and receive information from the client or consultant, such as an architect or structural engineer, and it is not shared with other design team members, it may cause issues." P5 concurred with P4 and claimed, "If you do not have proper communication, it will lead to problems." Ajayi and Oyedele (2018) suggested that a lack of understanding of the project requirements may result in design errors.

The collected data from the participants indicated the use of kickoff meetings and design check-ins during the design process as methods for effective communication and information flow. P1 and P5 referred to kickoff meetings as an essential tool and strategy to implement effective design processes. P1 stated, “The kickoff meetings are an essential tool to ensure the staff is aware of the project and understands the scope.” P1 added, “During the design phase, there are frequent check-ins between senior staff and younger staff to ensure the project is on track. This process is carried out throughout the life of the project.”

Similarly, P4 said, “The next step is to hold a kickoff meeting with the design team to ensure the design team is familiar with the project’s scope of work and goals.” P4 added, “There is a significant dependency on ensuring that the design team is doing their job correctly, so asking questions and performing high-level checks to ensure the data is correct is essential.” P3 claimed, “It is essential to develop a basis for the design that is agreed upon by the design team and client.” Researchers have suggested that weekly meetings encourage engagement and create an opportunity for knowledge sharing (Wang et al., 2017). Svalestuen et al. (2017) posited that the AEC professionals might resolve industry challenges through more effective communication between project stakeholders. A review of the participating company’s quality management plans revealed periodic design checks, and coordination meetings occur throughout the design project lifecycle as a method of effective information sharing.

Four of the seven participants coupled communication and collaboration between the design team to improve design management effectiveness and design error mitigation. P1 asserted, “Teamwork is key. Collaboration helps between all the consultants, code officials, and clients. The more you collaborate, the more you communicate, the better chances for a successful project.” P2 stated, “It is essential to ensure that everyone integrates and universally understands the quality control measures.” P6 shared, “The design process involves working with other consultants and clients.” P7 claimed,

> The design process includes various reviews and comments that are tracked and responded to by the design team. The design team reviews and communicates back and forth to check and resolve any issues. This approach to design is one of the methods that help us mitigate design errors.

P1 concurred with P7’s link between communication, collaboration, and design error mitigation and stated, “Collaboration and communication are critical to mitigating design errors even during construction.”

The participants’ responses suggested that communication and collaboration are an iterative design process, which is indicative of repetitive, bilateral information flow to ensure design quality and value. Researchers have identified similar findings concluding that the design process is a reciprocal process composed of thought-sharing iterations between the design team that impacts the end value of the product (Knotten et al., 2015). According to the participants, the design process consists of multiple feedback loops and design stage gates indicative of collaborative efforts between designers, managers, peer reviewers, third-party reviewers, and the client. P2 and P7 considered ITR as a comprehensive and integrated review of all design disciplines that help identify errors and improve the design. P7 stated, “We also perform ITR throughout the project, so other professionals review the design and serve as a second set of eyes. We also have peer reviews as another layer of review.” P1 said, “The purpose of peer reviews is to have two sets of eyes to review the design to best minimize any construction errors.” P4 shared, “We have two individuals performing quality control reviews, full-time, before releasing the project to the client.” P6 stated, “As the project progresses, the quality control engineers oversee the work and provide an internal, independent opinion of the project’s progress and the quality of the design.” Al Hattab and Hamzeh (2015) stated that design team integration and communication are essential and suggested that design charrettes are the best design stakeholder integration method, aligning with the participants’ responses. A review of the participating company’s design management plans and design review checklists indicated the hierarchical design review process and participant roles and responsibilities, including checks and verification for completeness, technical accuracy, conformance to design standards, and correction of previous errors.

The literature and TFV support the evidence collected from the participants’ responses concerning communication and collaboration. Osmani (2012) stated that increasing collaborative efforts help prevent waste from design errors and rework. From the value perspective, waste contributes to value loss (Osuizugbo, 2020). Ajayi and Oyedele (2018) suggested that improved communication and early collaboration effectively reduce waste during the design phase. According to Al Hattab and Hamzeh (2018), the essence of the design management process is the management of information flow between the design stakeholders, which includes the design team and client. Al Hattab and Hamzeh (2018) used TFV to highlight the significance of information flow within a transformative design process that results in value generation. Similarly, Bajjou et al. (2017b) suggested that collaboration among the project stakeholders is supported by TFV to create flow through successive stages that map and create value.

Theme 3: Active Senior Management Involvement

The third theme to emerge from the data analysis was active senior management involvement. All seven participants referenced the importance of involving senior managers throughout the design process. According to the collected data, the previous two themes of developing standardized processes and procedures and collaboration and information sharing are dependent on the active involvement of senior leaders and managers. Participants' responses suggested that senior leader involvement has a significant value on the effectiveness of the design process and value generation of the design product. P1 reported that the design check-ins during the design phase consist of collaboration between senior staff and younger staff to ensure the project meets the design expectations. P3 stated, "Senior design managers identify the path for the design team to guide them towards what systems to assess and perform interim evaluations to conduct progress monitoring and experience-based observations to ensure the design is headed in the right path." P2 shared, "The QA/QC plan must be signed off by senior leadership in the appropriate role and level of responsibility based on contract size." P2's response indicates that the design team cannot fully complete and release a design unless approved by a senior leader, suggesting a great dependency on senior leadership involvement. A review of the participating company's quality management plans and design management plans revealed the reliance of senior management professionals as team leaders or technical leads who are accountable for design coordination, design performance, information sharing, the innovation of new design standards, and quality control.

Senior leaders serve as mentors and technical advisors that impact design quality. P2 stated that the goal is to team up more senior or knowledgeable individuals with junior team members. P5 shared,

> Chief engineers are responsible for quality assurance and training younger, less experienced staff to ensure they follow proper codes and design standards. The chief engineers have over 30 years of experience with a rich history and lessons learned who develop our standards.

Similarly, P1 said, "Having senior people among the disciplines brings experiences and an understanding of the design process. Mentoring is essential to ensure senior staff exposes the junior staff to the process and helps them understand." P4 suggested that senior leadership involvement and supervision of junior-level engineers are crucial to ensure the design teams fulfill the client's design expectations.

The participants indicated that a lack of senior leadership involvement is detrimental to the design process and the quality of the final design product. P4 asserted,

> In our business, activities depend on each other, so if the engineers are not calculating heating and cooling loads correctly, then the sizing of the equipment is incorrect, then the duct distribution is incorrect, and the sizing of the power is

> incorrect. Incorrect design can create a ripple effect, so the basic engineering and oversight of basic engineering are critical. Since junior-level engineers perform much of the basic engineering due to the repetitive nature of design and cost-effectiveness, it is crucial for design managers to supervise junior-level engineers closely. A lack of supervision of younger engineers could be disastrous. Even the simplest projects could create significant problems if there is a lack of supervision.

The review of the participating company's design management plans highlighted senior managers' involvement in technical training recommendations and served as a technical resource for the design team, supporting the participants' responses.

Robin et al. (2007) identified leadership as an essential design competency, along with communication and collaboration. Libânio et al. (2017) corroborated with the early work by Robin et al. (2007). Libânio et al. (2017) suggested that the integration of leadership is a well-established and necessary ability on a design team. Al Hattab and Hamzeh (2018) suggested that design team leaders have a more significant role and responsibility in terms of collaboration and coordination during the design process. Although the participants' responses concerning senior leadership involvement oscillate between leadership and management modes, researchers have suggested that leadership and management are compatible elements that individuals may synthesize to contribute to value generation (Miller & Moultrie, 2013). Concerning the TFV framework, Savolainen et al. (2018) evaluated design management styles and the impact on design quality through TFV and stated that leadership is essential to create value and address flow requirements. Other researchers have indicated that design leaders' role towards effective communication, encouraging collaboration, and ensuring quality control to generate value (Al Hattab & Hamzeh, 2018; Robin et al., 2007) correlate with TFV.

Theme 4: Allocating Technical Design Experts

The fourth theme the emerged from the data analysis process was allocating technical design experts. Five participants indicated the reliance on technical design expertise during the design process consisting of basic engineering, technical design reviews, knowledge of software implementation, licensed engineer approvals, chief engineers, design standards and specifications, performing design calculations, and creating design models. P2 stated, "Each stage of the design would have a signoff requirement by a licensed professional assigned to that quality control effort." P2 added, "Quality begins and ends with the design professional; therefore, their work should be complete and accurate." P4 provided an example of the technical applications during the design phase, "We have load calculations, power calculations, static pressure calculations." P5 said, "The design team will be responsible for putting together a model divided into stages and milestones. Our role is to make the design accurate, complete, and detailed enough for the contractor to build without making changes during construction." P7 shared, "We perform design resource evaluations by considering the past experiences of the design team personnel. For example, if it is a specialized field, we would make sure we have experts on the design team in that specialization." A review of the participating company's quality management plans, design management plan, and design service policies revealed a significant dependency on identifying and selecting the appropriate technical expertise to perform the design according to the company's design process and procedures and project requirements.

Young engineers play a significant role in the overall design process; however, the participants indicated that younger engineers require greater oversight and technical training to improve design skills and prevent design errors due to a lack of experience or human error. P1 and P4 indicated the reliance of young engineers to perform basic engineering and, at times, work that may be above their experience level. The reliance on young engineers presents significant challenges. P5 claimed, "There is a difficulty training and educating young engineers who do not have industry experience." However, P5 added, "If you do not keep your staff and train them properly, you will run into potential problems." P1 added, "Mentoring is essential to ensure the senior staff exposes the junior staff to the process and helps them understand." P2 stated,

> Not everyone on the design team is on the same level. It is a knowledge-based issue where all levels are working within the same model. Training is a method to mitigate this challenge. Mentorship is another method to mitigate this challenge.

Based on the responses from the participants, technical design expertise is an essential component of efficient design. The significance given to training and mentorship from the participant's responses indicates the need to improve technical proficiencies that may translate to higher performance output.

Researchers have suggested that individuals involved in a design team should possess the knowledge of basic engineering and design principles to ensure proper design performance (Silva & Merino, 2017). Assaf et al. (2018) posited that identifying the appropriate design staff resources should be a priority of the design firm. Researchers have also identified a dependency on designer experience and knowledge for reducing safety hazards during the design phase as part of an approach to PtD (Poghosyan et al., 2018; Yuan et al., 2019). Similarly, Assaf's et al. (2018) research on the causes of deficiencies in design documents (DDD) identified a lack of work experience as a significant cause of DDD. The literature highlighted reliance on technical design expertise during the design phase, supporting the evidence found from the collected data. I did not find articles that addressed technical design expertise using TFV. Researchers have evaluated design management using TFV and determined that the process of design focuses primarily on *why* (i.e., value generation), *what* (i.e., transformation), and *how* (i.e., flow; Pikas et al., 2020). There is no consideration for *who* in the existing literature. However, in reviewing, coding, and analyzing the collected data, I concluded that five of the seven participants indicated the dependency on technical design expertise as an essential component of the design process to mitigating design errors.

Theme 5: Leveraging Technology Platforms

The fifth theme that emerged from the data analysis was leveraging technology platforms. Six of the seven participants discussed the effectiveness of using technology to improve design management. Researchers have highlighted the AEC industry's shift towards technology implementation on design projects (Michaud et al., 2019; Pikas et al., 2020). In conducting the interviews, five of the participants noted that the design team relies on the use and implementation of technology to facilitate the design process and improve the information flow and value generation. P1 stated, “Technology, such as AutoCAD and Revit, make the design more manageable.” P2 shared,

> We rely on technology, such as AutoCAD, Revit, and BIM, to develop the design and models, which help coordinate the project and actual construction and create a single source of data. In the past, we relied on paper sheets and separate files, which created a coordination challenge. Revit addresses coordination issues. Technology makes it easy to see coordination issues because it is in a consolidated model.

According to researchers such as Ilozor and Kelly (2012) and Mishra et al. (2020), the integration of technological platforms, such as BIM, to enhance collaboration, production, and information sharing has become a significant factor of the design process and should replace traditional delivery methods. Similarly, the review of the participating company’s design services policies revealed that the use of design technology, such as BIM, facilitates communication, collaboration, problem-solving, risk mitigation, decision-making, and constructability.

P5 said, “There is a communication barrier within the AEC industry, although it has gotten better with technology.” P3 noted, “The design team uses technology to facilitate review and tracking, such as Blue Beam. The design team uses these tools to track comments, responses, agreements, and verification of addressed comments.” P7 concurred with P3 on the use of Blue Beam to help track comments and responses. Researchers posited that the use of technology, such as BIM during the design phase, may have the potential to reduce waste, such as overproduction of information or challenges with information transfer, and add value through information processing improvements (Akinade et al., 2018; Michaud et al., 2019). Design managers may use TFV to identify information flow barriers using BIM and present waste reduction strategies (Michaud et al., 2019) and understand value generation (Munir et al., 2019). TFV is related to this theme because technology implementation facilitates information flow on a project.

Technology, such as BIM and Revit, may be used to identify conflicts during the design and improve the quality of the design product. P2 stated, "Once the model has been significantly developed, a BIM clash detection software can identify conflicts. Eliminating conflicts during the design phase reduces impacts during construction, including time and schedule." P4 said, "The tools that are used to implement effective design management are Revit to perform clash detection." P7's response supported P2 and P4's responses concerning the use of software, such as BIM, to help mitigate errors by identifying conflicts using clash detection. BIM provides information centralization, improves information flow (Michaud et al., 2019), and may minimize design errors with the application of clash detection and BIM-based constructability reviews (Ahuja et al., 2017).

While six of the participants noted a positive perception of the industry's dependency of technology, the participants also expressed challenges that design managers should consider during the design process. For example, P1 claimed, "Technology also raises expectations." Researchers have suggested that managing BIM outputs within project time constraints are challenging (Ghaffarianhoseini et al., 2017).

P4 acknowledged the use of technology as part of the design process but discussed that technology dependency might hinder traditional communication and collaboration approaches. Ghaffarianhoseini et al. (2017) also argued that data exchange standards are necessary to promote collaboration among BIM users fully.

User knowledge is a challenge with implementing technology, especially within the older workforce, consisting of senior-level design team members. P4 said, “With technology, senior engineers may not have the necessary experience using Revit to evaluation projects easily.” P2 concurred with P4 and identified the technology user experience as a barrier to implement effective design management processes. P2 stated, “The challenge with technology lies in the understanding of the software, which is complex and robust. Not everyone on the design team is on the same level concerning using and understanding the software.” An excerpt from the participating company’s design service policies revealed that the challenges of fully implementing and leveraging design technology are a lack of understanding of technology platforms and the inability to diverge from a traditional design process on a project. Leite et al. (2011) stated that although the AEC industry is shifting towards technology integration during the design phase, design managers manage the use of the software with a traditional mindset that limits the complete operability and benefit of the tools. Chan et al. (2019) identified several challenges with implementing technology, including resistance to change and a lack of user knowledge. Despite the potential benefits of technology implementation, the participants highlighted challenges that impact the effectiveness of technology, which is supported by the literature. The TFV framework may help design managers extend the benefits of BIM to guide the development of the design process and reduce implementation challenges from an activity and product perspective (Abou-Ibrahim & Hamzeh, 2016a).

Applications to Professional Practice

The findings from the study could be of value and contribute to AEC professional practices by furthering design managers' understanding and offer practical approaches for improving design management processes to mitigate design errors during the design phase using TFV. Design deficiencies during the design phase are a significant cause of construction-related injuries and fatalities in the United States. (Hallowell et al., 2017; Karakhan, 2016). Researchers have considered TFV as the most suitable framework for improving design processes (Munir et al., 2019) and identifying parameters to reduce waste, including design errors (Lekan & Segunfumni, 2018). Identifying and implementing methods that may reduce the risk of accidents may improve overall productivity and avoid indirect expenses that may have financial implications to stakeholders associated with the construction project lifecycle (Bajjou et al., 2017b).

Based on the participants' responses to the semistructured interview questions and review of the company documents, I found that establishing and implementing a systematic and standardized approach to the design process that includes reoccurring design activities along with a strong focus on effective collaboration, information sharing, support, and guidance between all levels of the design team and stakeholders are critical to mitigate design errors and maximize design value. Design managers may encourage collaborative engagement to prevent design deficiencies that may cause safety implications during the construction phase through standardization. Standardization of the design process may improve design efficiency, decrease design errors, increase value generation, and directly impact competitive advantage and profit increase (Simanjuntak & Khorasani, 2018). My findings also indicated that a traditional and modern collaborative approach to the design process is necessary. Design managers should consider the implementation of technology platforms as an integral part of the collaborative effort to improve the design process and business practices. AEC industry professionals rely significantly on the transfer of information; therefore, adopting new technologies improves design practices and increases competitive advantage in a competitive market (Tulubas Gokuc & Arditi, 2017). Design managers could apply the themes of the study in a structured approach to improve business practices and design management process success.

Implications for Social Change

The implications for positive social change include safe and healthy working environments during the construction phase to protect workers' well-being from injuries or fatalities. Reducing the impacts of safety hazardous during construction and its effect on workers, families, and communities is essential. This study may contribute to positive social change by promoting awareness and training of safety hazard prevention through design to design personnel and emphasizing the importance of developing standardized design processes and procedures that focuses on reducing or eliminating design errors and safety hazards during the design phase to ensure safer conditions for workers and communities. Eliminating hazards and controlling the safety risks to workers should start at the early stages of the project lifecycle (Howell et al., 2017).

The study findings supported the importance of safety hazard prevention to ensure human health, safety, and social stability while creating an optimal working environment for people. Workers and families affected by workplace injuries or fatalities could suffer from significant psychological and economic stresses. Improvements in the design process may directly decrease social implications such as loss of work productivity, economic instability, relationship losses, and psychological and behavioral instability (Dembe, 2001; Zikriyoev & Crane, 2019). My findings suggested that developing and implementing standardized design processes and procedures, encouraging collaboration and information sharing, actively involving senior management during the design process, allocating technical design expertise on the design projects, and leveraging technology platforms, such as BIM or Revit, may help reduce design errors and promote safety and health during construction. Design managers may actively encourage and advocate the importance of designing safer working conditions that may increase construction worker morale and commitment. Local communities with safer working conditions may also benefit from social change by increasing construction labor employment opportunities. Safer working conditions might enable residents to contribute to the local community economy by purchasing locally produced goods and services and increase residents' well-being and living standards.

Recommendations for Action

Koskela (1999) suggested a need to introduce a new theory of production relevant to the AEC industry that coupled transformation with flow and value generation. The integration of TFV enables the understanding and management of task interdependencies (Mota et al., 2019), the need for participation and collaboration (Naar et al., 2016), and identification of waste (Bajjou et al., 2017a) to develop and implement effective design management process. The research question addressed in this study was that some building design managers lack safety design management processes to mitigate design errors during the design phase to improve safety performance during building construction. From this study, I found that the participants implemented various design management processes to mitigate design errors to reduce safety hazards during the construction phase. Based on the study findings, I recommend the following strategies and practices to design firm leaders and managers to improve design management processes to mitigate design errors and improve safety performance:

- Develop and implement a systemic and systematic approach to mitigating design errors through detailed design phasing plans, design standards and protocols, quality assurance and control plan, and design tools to check, track, and measure interim and final design quality progression. A standardized approach to the design process that is understood and practiced by all design team members may be the best method to ensure design error mitigation during the design phase.
- Establish detailed communication protocols and encourage a collaborative design approach to develop trust, promote effective information-sharing, and quality

control through defined design review hierarchies that include frequent design checks, monthly meetings, internal and external reviews. Collaboration should consist of all design team members, especially the client, to clearly understand the design expectations and ensure the design team achieves anticipated value generation.

- Emphasize senior management involvement during the design process to increase technical expertise, historical knowledge dissemination, effective design team collaboration, and improve value generation. Senior leaders and managers should be active participants during the design project lifecycle, specifically for technical and managerial support.
- Develop and offer technical training and mentorship opportunities that allow younger, less experienced engineers to improve technical knowledge and skills to increase their performance level and contributions during the design process. Improving technical knowledge and practices may help reduce design errors due to cognitive oversight and technical knowledge limitations.
- Consider alternative delivery methods to encourage and improve collaboration efforts, build strategic partnerships, and share project vision between the design team and client to reduce conflicts, scope changes, design errors, and design quality impacts.
- Incorporate the use of technology platforms during the design phase to improve collaboration between design disciplines, detect design conflicts, address design

errors proactively, and ensure the expected design quality from a value and safety perspective.

The findings in this study could be a useful resource to design firms, leaders, and managers in developing effective design management processes that emphasize improving design performance by reducing or eliminating design errors and preventing safety hazards during the design phase to improve safety performance during construction. The research community could use the findings in this study to research and advance knowledge of design management and safety hazard prevention through design. After the publication of my study, I will share a summary of the findings with study participants. I also will strive to disseminate the research findings with other design management professionals at AEC industry technical conferences, workshops, and training seminars.

Recommendations for Further Research

AEC professionals have long considered the traditional design process as an exclusively transformative process based on technical applications that neglect flow and value (Koskela, 1999). Researchers opined that design performance optimization requires a comprehensive understanding of production and an integrated application of TFV concepts (Pikas et al., 2020). Researchers have also used TFV as a foundation for safety-based lean design and construction to adopt preventive methods to reduce injuries and accidents during construction (Moaveni et al., 2019). However, in conducting this study, I found that the design error mitigation processes focused primarily on information flow and value generation for the end-user with minimal considerations for hazard prevent through design. The obstacles to the limited considerations of safety prevention through design may result from a knowledge gap in applying TFV and PtD among design professionals (Moaveni et al., 2019). To further increase the understanding of TFV on safety design management processes, I recommend future research by:

- Investigating the research problem through strategical development towards mitigating design errors during the design phase rather than focusing on the design process.
- Exploring the use of TFV and the practical development and application of technological platforms, such as BIM, Revit, or design automation, that may improve standardization, coordination, and design error mitigation for safety performance improvement.
- Investigating a safety-based design management framework or model that may provide new insights into design error mitigation to improve safety performance.

A study limitation was that the findings might not be generalizable for other construction projects and other organizations. Researchers could also extend the current research to include other design and construction projects, such as horizontal or residential projects, which could increase generalization. Researchers may also consider extending the research scope beyond a qualitative, single case study and conduct a qualitative, multiple case study to gain different perspectives from more than one organization and potentially further understand design management processes through the combination of varying perspectives. Researchers could conduct quantitative research to measure the relationship of the identified themes with design error mitigation and safer working conditions during construction.

Reflections

I found the doctoral study process rewarding and challenging. My initial goal was to further my knowledge of project management in a higher academic setting. However, in pursuit of this goal, I also gain valuable skills and experience as an independent learner in academic research, critical reading and thinking, synthesis, data analysis, and academic writing. The doctoral study also helped me strengthen my communication, emotional intelligence, and time management skills with my cohort and study participants. The doctoral journey also presented several challenges. The first challenge I faced was transitioning from a technical writing style to an academic-based writing style, which included synthesizing information and maintaining a scholarly voice. During this journey, the second challenge was keeping an open mind to feedback and comments from my peers and committee members and allowing the process to take place organically.

I had to ensure an objective approach and manage any personal biases or preconceived ideas using reflexive journaling due to my experience as an engineer in the AEC industry. I set aside my initial perspectives and design management practices that could have potentially limited the exploration of the research question. I determined my conclusions solely on the facts and evidence I identified through the participants' shared experiences and data analysis process. Although there are common terminology and roles within the general domain of design management, the focus on building construction presented different approaches and perspectives to the design process and management applications that were not typical to my ideas, opinions, and professional experiences. This realization allowed me to maintain objectivity throughout the study.

The COVID-19 pandemic created unique challenges for collecting data. My initial intent was to meet with participants face-to-face. Since the workplace dynamic throughout the United States shifted towards teleworking and limiting social interaction to ensure the general public's health and mitigate health risks, participants were not accessible in person to conduct face-to-face interviews. I relied on technology to perform virtual interviews using Zoom video conferencing. My initial concerns were developing a rapport with the participants and potential technical difficulties that may occur, which could disrupt the flow of the interview and create unnecessary complications. Thankfully, through thorough planning and consideration for participant availability, I conducted the interviews without complications. I did my best to provide a seamless interview process for the participants to minimize challenges from conducting virtual interviews and create an opportunity for insightful discussions and experience sharing.

I have developed a greater perspective and understanding of design management due to the research process on an academic and social level. One of the most significant insights I gained that has changed my perspective is considering effective design management processes to improve workplace conditions and create safer working environments. My opinions on design management processes were bound by a traditional transformative perspective, which has expanded to include social impact elements that may contribute to health and safety improvements. That is one of the greatest appreciations I have about Walden University's mission and vision to educational excellence and social change.

Conclusion

The construction industry has one of the highest injuries and fatality rates among all industries in the United States (Thanaraj & Priya, 2019). Design errors are among the leading causes of building construction injuries and fatalities (Mohammadi et al., 2018). Researchers argued that design errors indicate poor management during the design phase (Knotten et al., 2015). Design professionals have given limited attention to design error control (Mohammadi et al., 2018) and have traditionally focused on end-user safety during the design phase (Mroszczyk, 2015). More practical design management processes and tools are necessary to mitigate design errors and improve safety performance during the construction phase (Al Hattab & Hamzeh, 2015; Mohammadi et al., 2018)

The focus of the study was to explore safety design management processes that building design managers use to mitigate design errors during the design phase. Based on the findings of the study, design managers could mitigate design errors through (a) developing standardized processes and procedures, (b) collaboration and information sharing, (c) active senior management involvement, (d) allocating technical design experts, and (d) leveraging technology platforms. The research findings can potentially impact professional business and social change by implementing effective design management processes, which could impact a company's operational effectiveness, profitability, and competitive advantage and promote safer and healthier working environments that could reduce construction-related injuries and fatalities.

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Appendix: Sample of Instrument

Date_______________________________________

Location_____________________________________

Interviewer___________________________________

Interviewee___________________________________

Opening introduction

I will provide an opening introduction and exchange of pleasantries using the following script: Good morning/afternoon. First and foremost, thank you for deciding to participate in this study and attend this interview. My name is Hernán Guadalupe. I am a doctoral student at Walden University pursuing a doctorate in Business Administration. I am currently conducting a research study entitled “Safety Design Management Processes to Mitigate Design Errors.”

General Reminders to Participants

1. The interviewer will remind participants of the purpose of the study using the following script: The purpose of this qualitative single case study is to explore the safety design management process that building design managers use to mitigate design errors during the design phase to improve safety performance during building construction.
2. The interviewer will reaffirm the participant that all the information that is shared will be confidential and for the sole use of the study. Reports coming out of this study will not share the identities of individual participants. Details that might identify participants, such as the location of the study, also will not be shared. The

researcher will not use your personal information for any purpose outside of this research project. Data will be kept secured by using code names for all participants and storing all information on a secured password protected and encrypted storage system. All the collected data will remain locked inside a storage cabinet in my home office accessible only to me for 5 years to safeguard the rights of the participants and organization. Upon completion of the five-year storage period, I will dispose of all the paper documentation using a local professional shredding company. I will destroy all electronic documentation saved on the encrypted storage system using DBAN data wiping software.

3. The interviewer will inform the participant that the conversation will be recorded by two digital audio recording devices, one as the primary recording source and the second as a backup.
4. The interviewer will inform the participant that handwritten notes will also be taken during the interview process.
5. The interview will inform the participant that a summary of the interview responses will be conducted and provided to each participate to ensure the accuracy and resonance of the participant's expressions, views, and statements. The interviewer will schedule a follow up meeting to review the specific transcription with each participant approximately three days after concluding the interview.

Participants

The target population and participants will include seven design managers who have successfully implemented safety design management processes during the design phase to improve safety performance during building construction. Participants will included design managers from a building design firm located in the northeast region of the United States.

Length of Interviews

All interviews will last between 30-45 minutes followed by a 30 minute follow up meeting at a later date to review the summary of the interview responses to ensure accuracy.

Central Research Question

What safety design management processes do building design managers use to mitigate design errors during the design phase to improve safety performance during building construction?

Interview Questions

1. What design management processes do you implement during the design phase to mitigate design errors to improve safety performance during building construction?
2. What key barriers exist, if any, to implement effective safety design management processes to mitigate design errors to improve safety performance?
3. What tools do you use to implement effective safety design management processes to mitigate design errors?

4. What challenges exist to mitigate design errors to improve safety design management processes?
5. How do you measure the effectiveness of the design management process to mitigate design errors to improve safety performance during building construction?
6. What additional information would you like to add about the processes you use to mitigate design errors to improve safety performance during building construction?

Probing questions

Upon completion of the interview questions, the interview will follow up with probing questions if further questioning will allow for additional clarity.

Closing

1. The interviewer will explain to the participants the need to contact them to schedule a follow up meeting to verify the accuracy of the interview transcript and engage in member checking to obtain additional information the participants may offer.
2. The interviewer will thank the participants for their time and contribution to the study using the follow script: Thank you for taking time out of your busy schedule to participate in the research study. I will follow up with you in the coming days to schedule the follow up meeting. Your participation is greatly appreciated.