CHAPTER 1
INTRODUCTION

1.1 Research Background

On a global level, the construction industry is widely recognized for its significant contributions to economic growth and social advancement. It has a pivotal position in shaping the physical environments of countries and driving their progress. Despite its significant contribution to the gross domestic product (GDP) and considerable influence on enhancing infrastructure, it has paradoxically faced criticism for its hesitance in embracing and utilizing transformative technologies (Chen et al., 2023; Radzi et al., 2019). It has consistently been characterized by low productivity, frequent project delays, and cost overruns. These challenges have become symbolic of the construction industry's operational environment. Further examination reveals a multifaceted workflow characterized by organizational fragmentation, resulting in deficiencies in communication and a noticeable lack of coordination among project stakeholders (Evans et al., 2023).

In response to these challenges, the trend toward collaborative approaches in project delivery is increasing, intending to align communication channels and coordinate activities to enhance project outcomes (Ahola, 2023; Azhar, 2011). In the current era of digital transformation, the construction industry is undergoing an unparalleled shift driven by a growing inclination toward digital technologies, which are anticipated to enhance production and efficiency. The introduction of Building Information Modeling (BIM) in project design, construction, and operations, along with the integration of augmented and virtual realities for enhanced visualization and the incorporation of artificial intelligence for project planning and risk mitigation, demonstrates the ongoing digital paradigm within the industry (Elghaish et al., 2021; Olanrewaju et al., 2022).

Durdyev et al. (2022) suggest that these technologies can enhance project outcomes through error reduction, improved communication channels, increased efficiency, and the promotion of collaborative efforts among various industry stakeholders. Within these transformative shifts, BIM emerges as a prominent theme, echoing across the Architecture, Engineering, Construction, and Operation (AECO) industry as an innovative substitute for the traditional project delivery

approach. The surge in BIM marks a significant departure in how construction projects are conceived, designed, constructed, and operated. This approach encompasses a whole-lifecycle perspective and can potentially revolutionize the industry. BIM's role has been recognized as a significant combination of technological, policy, and process changes that bring about a series of transformations in the entire lifecycle of AEC projects. These transformations lead to improved collaboration, communication, and coordination among the various stakeholders and industry participants (Badrinath et al., 2016; Li et al., 2023).

Eastman et al. (2011) emphasized the dual nature of BIM, viewing it as both a product and a process. As a product, Zhang et al. (2022) describe it as a digital structure precisely made of building components that incorporate detailed information ranging from spatial connections and architectural aesthetics to functional attributes, quantities, and even cost and time estimations. On the other hand, Huang et al. (2011) describe BIM as a process of creating and managing building information, incorporating both geometric and non-geometric data to support a range of construction-related activities. The integration of BIM as a dynamic process and a digital building model provides a platform that accelerates construction project delivery, informed decision-making, and establishes a strong management paradigm supporting the entire project lifecycle.

In recent years, there has been a growing global recognition of BIM as an effective means to align the AEC industry with the broader United Nations Sustainable Development Goals (SDGs) (Bernegger et al., 2022). Through virtual models and simulations, architects and engineers use BIM to improve energy performance, assess environmental impacts, and support sustainable decision-making. This directly advance SDG 9 (Industry, Innovation, and Infrastructure), SDG 11 (Sustainable Cities and Communities), and SDG 12 (Responsible Consumption and Production) (Girya & Romanov, 2022; Mellado & Lou, 2020). More broadly, BIM promotes collaboration, improves data quality, and supports life-cycle assessment, positioning it as a catalyst for safer, more resilient, and more efficient built assets.

Reflecting this potential, many developed countries, including the United Kingdom, Denmark, Norway, Sweden, Singapore, China, Hong Kong, Korea,

Japan, and the United States have mandated BIM on public projects to drive productivity and standardize best practices Cheng and Lu (2015). Over the past two decades, these mandates have been accompanied by national guidelines, standards, and reference protocols that clarify roles, deliverables, and information exchange. Training programs and procurement reforms have further encouraged adoption by aligning incentives and establishing common data environments. Together, these measures have normalized BIM as standard practice on public projects and, increasingly, across their construction industries.

By contrast, adoption patterns in the Global South (developing countries) remain uneven. Challenges commonly reported include limited awareness, inadequate infrastructure, and lack of skilled professionals, alongside the difficulty of adapting global standards to local market conditions (Andersson & Eidenskog, 2023; El Hajj et al., 2023; Toyin & Mewomo, 2023). These barriers can slow diffusion, prevent the achievement of scale, and weaken the business case for firms considering investment in BIM. Even so, many countries in the region see the urgency in advancing ambitious digital strategies to raise productivity, improve public services, and strengthen global competitiveness (Semyachkov, 2019).

Ghana is a prime example of this trend and is presently at the inception stage of this digital transformation agenda. The government's "Digital Ghana Agenda 2020–2030" seeks to leverage technology across all sectors of the (Boakye et al., 2022), even as the Global Innovation Index (2022) ranks Ghana 95th, behind several sub-Saharan peers such as Mauritius (45th), South Africa (61st), Botswana (86th), and Kenya (88th). Within this policy context, the construction industry, a crucial sector of Ghana's economy in terms of contribution to GDP and employment (Barajei, Kheni, et al., 2023), offers clear opportunities for digital gains. However, the industry is still marked by fragmentation associated with traditional procurement routes, limited integration between design and construction, and adversarial project cultures that reduce feedback and hinder learning. These characteristics negatively impacts project delivery by sustaining inefficiencies, increasing project complexities, and escalating costs (Maqbool et al., 2023; Ofori-Kuragu et al., 2016).

The pervasive fragmentation of the industry is largely attributed to the extensive use of the traditional procurement system (Maqbool et al., 2023; Ofori-Kuragu et al., 2016). This system inadvertently strengthens the separation between the project design and construction phases. The process is often fraught with a confrontational culture and a lack of feedback loops or coordination between the design and construction teams. This culture negatively impacts project delivery by sustaining inefficiencies, increasing project complexities, and escalating costs. Interestingly, Lu (2023) underscores the emergence of BIM as a promising solution to the long standing fragmentation in the construction industry, noting its potential to bridge gaps, align stakeholders and usher in a new era of collaborative practice. By extension, BIM holds the potential of propelling the construction industry into a full digital age.

Despite these promising prospects, the rate of BIM adoption in Ghana has been notably slow and gradual. The process is in its early stages, primarily driven by a cohort of early adopters who recognise its value in enhancing design processes. However, the limited body of research on the subject leaves significant gaps in understanding the broader trajectory of BIM integration within the Ghanaian construction industry (Appiah, 2020a). Most existing studies have largely focused on specific professional groups, such as architects or engineers or on narrow themes. This focus, while useful, fails to provide a holistic and industry-wide perspective. This lack of a holistic, macro-level analysis has left a significant gap in understanding how BIM can be effectively adopted within Ghana's construction industry. Moreover, there is no context-specific adoption framework that reflects Ghana's institutional arrangements, market structure, and cultural considerations.

Addressing this gap is critical, particularly as the global construction industry transitions toward digital transformation and Ghana seeks to align with international best practices while advancing its own development agenda.

Responding to these needs, the present study offers a novel macro-level analysis of BIM adoption in Ghana. It maps the current state of practice; examines how organizational, technological, and institutional factors interact; and proposes a framework and roadmap tailored to Ghana's conditions.

In doing so, the study makes a significant contribution to the broader digital transformation efforts within the construction industry by identifying the challenges and opportunities. While designed for Ghana, the approach and lessons also have relevance for other developing countries seeking to advance BIM-enabled digital transformation in their construction industries.

1.2 Problem Formulation

Despite a global shift toward BIM, Ghana lacks an in-depth, sector-wide understanding of adoption, awareness, and readiness. Prior research often isolates single issues or specific regions, leaving no comprehensive, macro-level assessment (Appiah, 2020a; Hajirasouli et al., 2023) The absence of an in-depth view limits evidence-based decisions by firms and policymakers and slows coordinated progress.

Moreover, beyond this descriptive gap, analytical gaps also persist. The relationship between influential factors and BIM adoption has not been adequately examined. For instance, the link between professionals' knowledge of BIM and their firms' organizational and technical readiness is not well articulated in existing literature (Takyi-Annan & Zhang, 2023a). Likewise, while barriers to BIM in developing contexts have been noted, their mechanisms and their combined effects on adoption in Ghana are insufficiently examined (Takyi-Annan & Zhang, 2023a). An integrated approach is therefore needed to map how awareness, organizational and technological capacity, drivers, and barriers interact, and how these interactions shape adoption outcomes.

The study distinguishes itself by using a mixed research approach, addressing a common limitation in prior studies that often rely solely on qualitative or quantitative methodologies. By integrating the strengths of both approaches, this research enables a more nuanced exploration of variables, relationships, and underlying processes. The mixed-method approach enhances the depth of analysis and provides a greater understanding of the multifaceted factors influencing BIM adoption. This methodological approach ensures a holistic examination of the subject, offering detailed and contextually rich insights. Eventually, the findings would contribute to a more informed discourse on BIM adoption. Accordingly, the research addressed the following questions:

1. What is the state of BIM awareness and knowledge among construction professionals in Ghana?
2. What is the organizational and technological readiness level of construction firms in Ghana for adopting BIM?
3. What are the key drivers and barriers influencing the adoption of BIM in Ghana's construction industry?
4. What is the perceived impact of BIM adoption on construction project performance in Ghana?
5. How could BIM be effectively adopted and implemented in the Ghanaian construction industry?

Motivated by these questions, the research aims to clear a path that accelerates the seamless integration of BIM technology within Ghana's unique construction industry. The primary objective of this effort is not only to provide pragmatic solutions but also to make a substantial scholarly contribution to the foundational principles of digital technologies for construction processes.

1.3 Research Objectives

The study generally aims to investigate the current state of BIM adoption in Ghana’s construction industry and develop a viable framework for implementation. Consistent with the research questions outline in Section 1.2, the objectives of the study are to:

1. Assess the current state of BIM awareness and knowledge among construction professionals in Ghana.
2. Examine the level of organizational and technological readiness of Ghana’s construction industry towards BIM adoption.
3. Identify the key drivers and barriers influencing the adoption of BIM in Ghana’s construction industry.
4. Examine the perceived impact of BIM adoption on construction project performance in Ghana.
5. Develop a framework for promoting the effective adoption of BIM in Ghana's construction industry.

1.4 Significance of Research

There are four distinct perspectives from which the significance of this study can be viewed, each highlights a facet of the research's contribution.

1.4.1 Theoretical Significance

This study aimed to make a substantial contribution to the existing knowledge base in the domain of BIM adoption. There is currently a scarcity of extensive macro-level research on the use of BIM within Ghana's construction industry. Prior studies have examined specific aspects of BIM adoption, such as the viewpoints of specific industry professions and localized barriers. This study addressed the existing knowledge gap by offering a complete analysis of the current state of BIM adoption, its impact on project performance, and potential avenues for improvement. This study is a pioneering approach to examining the dynamics of BIM adoption by effectively integrating qualitative and quantitative research methodologies. This novel approach contributes to the progression of the theoretical underpinnings of digital technologies in construction project management, particularly within the context of a developing nation. Therefore, this research explores lesser-known contexts, thereby expanding the theoretical framework for BIM adoption in the construction industry.

Accordingly, this study provides an original contribution to knowledge by bridging theoretical and practical domains, offering a foundation for future research and policy interventions to advance BIM adoption in Ghana and comparable developing contexts.

1.4.2 Policy Significance

The study's findings have significant policy implications as a foundation for developing informed policies to guide the construction industry's BIM adoption efforts. This study generated empirical findings that provide a deeper understanding of the prevalence and significance of challenges faced by the construction industry in Ghana. It does this by carefully examining the variables that drive and hinder the adoption of BIM. The empirical findings presented in this study provide a basis for formulating formal strategies to aid the widespread adoption of BIM in the industry. Therefore, these results serve as a valuable reference for policymakers and stakeholders in the field.

The research has significant implications for policy formation, given the crucial role of the construction industry in Ghana's economy and employment market. It offers empirically derived insights that may assist policymakers in formulating strategies and regulations to harness the transformative capabilities of BIM effectively in construction project delivery. These policies would potentially enable a paradigm shift towards heightened industrial efficiency. Hence, implementing informed policies derived from this research can support the expansion and advancement of digital technologies in Ghana's construction industry, thereby contributing to the country's overall economic growth and prosperity.

Overall, the study provides an evidence-based foundation for policy development that can drive the effective adoption of BIM and advance sustainable growth in Ghana’s construction industry.

1.4.3 Practical Significance

The study has practical significance as it has the potential to provide novel perspectives and viable solutions to the challenges faced by Ghana's construction industry in its quest to adopt technology. It offers various helpful insights for construction professionals and decision-makers by systematically analysing the intricate correlation between BIM competency, organizational and technological readiness, and project success. This research provides an enhanced understanding of the interrelated factors influencing the construction industry’s decision to adopt technology, enabling stakeholders to make more informed strategic decisions. Additionally, the study intends to present a framework for the effective adoption of BIM. Such a framework has the potential to guide professionals in achieving improved collaboration, enhanced communication, and increased efficiency in project delivery.

The practical application of this feature is highly advantageous in real-world scenarios. The operationalization of the proposed framework has the potential to offer numerous benefits for professionals in the construction industry in Ghana. These benefits include enhanced project efficiency, reduced instances of rework, and a more strategic allocation of resources. Hence, this research catalyses tangible transformation in practical settings, offering practical tools and valuable

perspectives to enhance Ghana's project outcomes, industry norms, and construction practices.

In sum, this study holds strong practical value by providing a framework and actionable insights that can support the construction industry in achieving more efficient technology-driven project delivery.

1.4.4 Social Issues and Actions

The impact of this research extends beyond academic and professional settings, as it has the potential to provide insights into real-world contexts and stimulate positive transformations with wide-ranging impacts in the construction industry and other domains. This study provides valuable insights into BIM adoption by shedding light on the complexities involved and highlighting the challenges and opportunities within the field to enhance awareness and understanding among various project stakeholders. Additionally, the results of this study possess the capacity to inspire substantial activity, including industry professionals seeking to enhance their practices and policymakers formulating strategies for industry advancement. The heightened level of understanding is predicted to serve as a catalyst, motivating actions to enhance the industry's established standards and methods and foster resourcefulness, cooperation, and a shared objective. Hence, it serves as an enlightening tool, stimulating constructive change and contributing to the gradual evolution of the construction industry in Ghana.

As the industry incorporates the anticipated outcomes and recommendations of the study, a ripple effect is expected to emerge, influencing decision-making processes, encouraging collaborative efforts, and nurturing a climate of ongoing improvement in the industry’s practices. It underscores the importance of conducting this study to educate the general public and inspire transformative actions to enhance the construction industry's efficiency, sustainability, and social responsibility. This study assumes the role of a guiding influence, imparting knowledge and instigating substantial transformation to enhance Ghana's construction industry and the broader community it caters to.

Overall, this study acts as a catalyst for transformative change and long-term development.

1.5 Organizational Structure of Research

The research is structured into six interconnected chapters that collectively build towards achieving the study's objectives. Chapter One introduces the study by outlining the background, research problem, objectives, and significance. It highlights the theoretical, policy, practical, and social contributions of the research, providing the foundation for the subsequent chapters. Chapter Two reviews the relevant literature and theoretical foundations. It presents the conceptual model, defines the research variables, and synthesizes gaps in the existing body of knowledge to guide the framework for BIM adoption in Ghana's construction industry.

Chapter Three explains the methodology employed in the study. It details the research design, sampling procedures, data collection instruments, analysis techniques, and ethical considerations. Chapter Four then presents the findings in a structured manner, beginning with descriptive statistics of the participants, followed by qualitative themes and patterns from interviews, and concluding with quantitative results supported by statistical analysis.

Chapter Five discusses the findings in relation to existing literature and the study's theoretical framework. It interprets the results critically, identifies areas of alignment and divergence with previous research, and emphasizes their broader implications. Finally, Chapter Six concludes the study by summarizing the key findings and their alignment with the research objectives. It highlights the implications for policy and practice, acknowledges the study's limitations, and provides recommendations for future research. The organizational structure is presented graphically, in Figure 1.1.

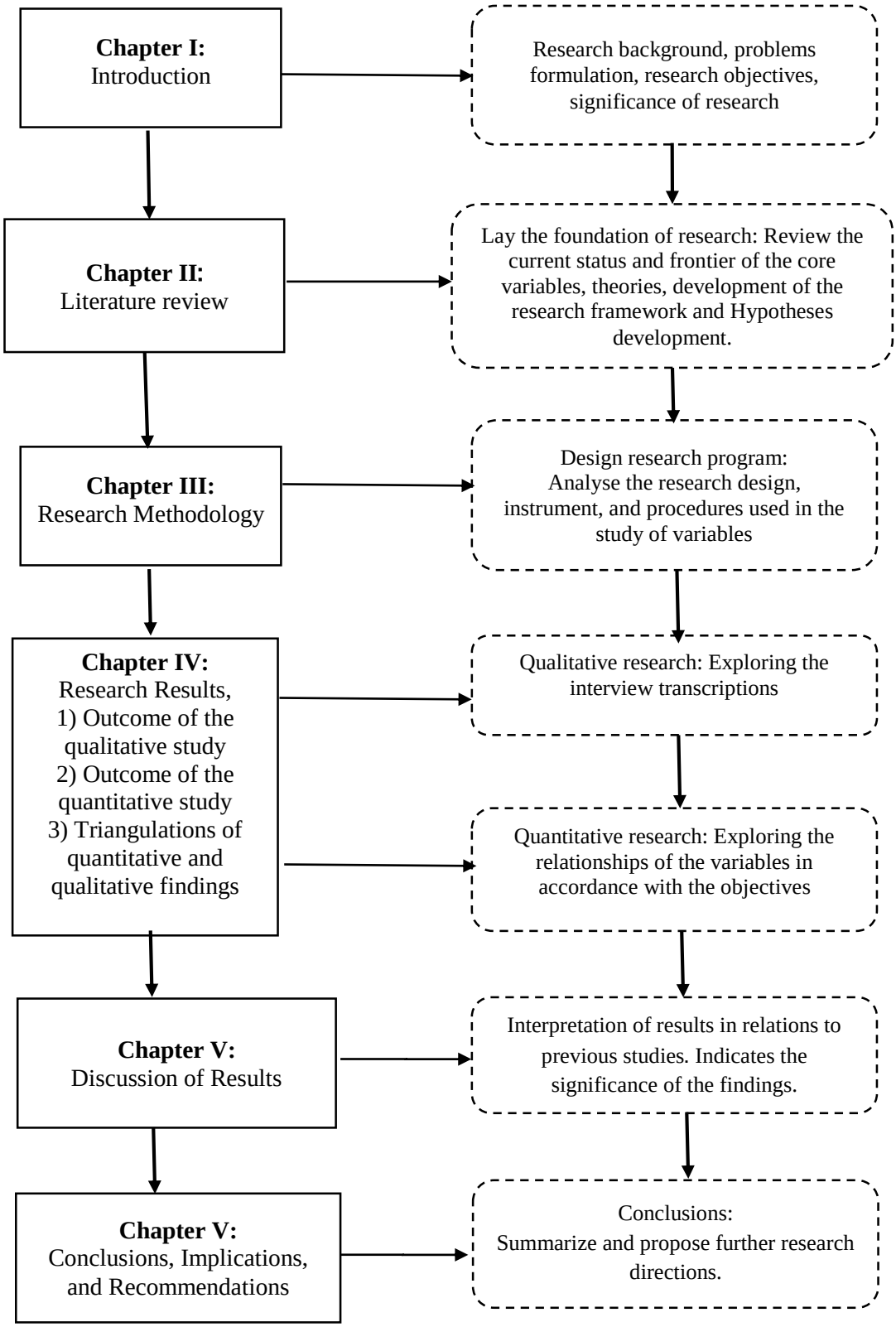

Figure 1. 1 Research Organizational Structure