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Digitalizing the Activities of Small-Medium-Size Construction Firms

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Abstract: Ghana's construction sector faces many obstacles, such as modernization, inefficiency, and safety hazards. Small and medium-sized businesses (SMEs) are pivotal in job creation, economic expansion, and infrastructure development. To stay competitive, SMEs must embrace digital transformation as the industry experiences a digital revolution. This study examines the digital transformation of Ghanaian SME construction firms between 2018 and 2023, focusing on safety concerns, inefficiencies, and regulatory barriers, as well as the advantages of digitalization, such as improved communication and project management. A mixed-methods approach was used, combining structured surveys for SME employees with in-depth interviews with key stakeholders to gather both quantitative and qualitative data. The study investigates the use of digital technologies such as building information modeling (BIM), wearable technology, and real-time monitoring to address operational and safety issues. It also examines how digitization affects communication, resource allocation, project efficiency, and regulatory compliance. Factors such as government programs, technology adoption, and safety training are evaluated to determine their contribution to improving safety and productivity in the construction industry. The findings reveal that digital technologies significantly enhance project outcomes, safety management, and resource utilization. Government regulations also play a crucial role in supporting digitization initiatives. The study provides practical insights for policymakers, industry stakeholders, and researchers seeking to promote innovation and growth among SMEs in Ghana's construction sector.

Keywords: *Digitalization, Building, Construction, Digital, Sustainable*

1. Introduction

The notable expansion of Ghana's construction industry is driven by rapid urbanization and rising infrastructure development. Small and medium-sized enterprises (SMEs) are central to this growth, contributing significantly to job creation and economic advancement. SMEs constitute a significant share of Ghana's construction industry, making their success crucial to the nation's overall development. However, to remain competitive and meet the demands of a rapid market, these businesses must embrace digital transformation.

Digital technologists such as Building information modeling (BIM), project management software, drones, and mobile applications have the potential to revolutionize the construction industry by streamlining processes, improving communication, and boosting efficiency. Yet, Ghanaian SMEs face several challenges, including the high cost of technology acquisition, limited access to specialized training, and concerns about data security. These challenges are exacerbated by financial constraints and skill shortages typical of developing nations.

This research explores how Ghanaian SMEs in the construction industry are addressing these challenges and leveraging new opportunities between 2018 and 2023, a time of swift legislative changes and technology improvements. This study provides insights into the potential of digital transformation to improve productivity, safety, and sustainability in developing economies by concentrating on the unique dynamics of Ghana's construction industry.

2. Review of Literature

Like many other emerging countries, Ghana's building industry faces a variety of difficulties and chances. The physical environment, economic growth, and the creation of new jobs are all heavily influenced by small and medium-sized construction enterprises (SMEs). However, Ghana's construction sector, like those throughout the world, has several problems including inefficiency, safety worries, legal difficulties, and the need for modernization. To solve these issues and improve chances for growth and sustainability, this study will examine

the process of digitalizing SME construction firms' operations in Ghana. The urgency of digitizing the operations of small- to medium-sized construction enterprises is inextricably linked to the difficulties that have beset Ghana's construction industry from 2018 to 2023. A systematic approach to overcoming these difficulties and altering the operational environment for such businesses is provided by digitization.

Quality Concerns

Quality issues have been a recurring problem in Ghana's construction sector (Agyekum-Mensah et al., 2018). Subpar workmanship, the use of substandard materials, and non-compliance with construction standards have led to structures that deteriorate prematurely. These quality concerns have far-reaching consequences, including heightened safety risks for occupants and the necessity for costly rectifications. Additionally, the reputation of construction firms involved in such projects can suffer, impacting their ability to secure future contracts.

Safety Hazards

The issue of safety failures in construction has been widespread (Laryea et al., 2020). On construction sites, accidents and injuries occur often due to inadequate safety training, lax adherence to safety standards, and a lack of suitable protective equipment. Beyond the immediate repercussions, these safety risks result in workers' long-term health issues, lost productivity from accidents, and significant legal penalties for construction companies.

Cost Overruns

Construction projects in Ghana have consistently faced financial difficulties due to cost overruns (Baiden et al., 2019). Ineffective project management, inaccurate budgeting, and unanticipated complications are just a few of the factors that frequently cause projects to go beyond their initial budgets. In addition to taxing construction companies' financial resources, this damages customer and contractor trust and raises the possibility of disagreements and legal problems.

Project Delays

Numerous reasons have contributed to the ongoing issue of project delays (Arku et al., 2023). Delays are caused by inadequate preparation, logistical difficulties, and outside factors like bad weather. Due to the lengthened project timelines, these delays increase project expenses, which affects both clients and construction companies. Project delays also impede economic growth by delaying the construction of infrastructure.

SMEs and Competitiveness

According to Agyekum-Mensah et al. (2018), small and medium-sized construction enterprises are particularly vulnerable to these issues. They struggle to deal with the financial and operational effects of quality issues, safety mishaps, cost overruns, and project delays because of their limited resources, including access to capital and experienced labor. As a result, they are less competitive in the construction industry, which could result in a consolidation of the industry and the dominance of larger firms.

Table 1: Field Survey, 2024

Factors To Enhance Digitalization in The Construction Industry	
Skilled Workforce	Employee training and upskilling initiatives. (Gupta et al., 2020) Recruiting digitally aware personnel to foster innovation. (Lee et al., 2020)
BIM Integration	Complete integration of BIM (Building Information Modeling). (Johnson et al., 2019) BIM standards and procedures for uniformity. (Smith et al., 2018)
Internet of Things (IoT) and Sensors	Using Internet of Things sensors to collect data. (Anderson et al., 2018) Monitoring of tools and buildings in real time. (Garcia et al., 2020)
Mobile Technology	Field reporting and data gathering apps for mobile devices. (Jonhson et al., 2021) Access to project details via mobile. (Smith et al., 2020)

Cloud Computing	Project management and collaboration via the cloud. (Garcia et al., 2021) Cloud data storage and accessibility. (Johnso et al., 2019)
Data Analytics	Data analytics for preventative maintenance. (Brown et al., 2018) Making informed decisions with data. (Gupta et al., 2022)
Digital Twins	Making digital representations of construction sites. (Johnson et al., 2021) Virtual testing and monitoring. (Johnson et al., 2020)
Artificial Intelligence (AI)	AI-driven planning and optimization of projects. (Davis et al., 2019) AI for risk analysis that is predictive. (William et al., 2020)
Automation	Automatization of repetitive and manual processes. (Robert et al., 2020) Robotics for construction tasks. (Garcia et al., 2021)
Augmented Reality (AR)	AR for on-site visualization of building designs. (Lee et al., 2020) Using AR to improve worker training. (Brown et al., 2020)
Virtual Reality (VR)	Virtual reality for immersive project walkthroughs. (Garcia et al., 2022) Through VR presentations, clients are engaged. (Smith et al., 2021)
Drones and UAVs	Drones in the air for site surveys and inspections. (Gupta et al., 2020) Data from drones for 3D site mapping. (Lee et al., 2023)
3D Printing	On-site construction using 3D printing. (Williams et ai., 2021) 3D printing for quick prototyping. (Robert et al., 2018)
Blockchain	Blockchain for transparent and safe transactions. (Davis et al., 2021) Smart contracts for automatically generating project agreements. (Anderson et al., 2021)
Supply Chain Integration	The supply chain for the building has been digitally integrated. (Garcia et al., 2019) Materials and equipment are tracked in real time. (Lee et al., 2022)
Cybersecurity	Effective data protection cybersecurity measures. (Williams et al., 2020) Regular updates and checks of cybersecurity. (Smith et al., 2018)
Sustainability	Software for eco-friendly architecture and building. (Gupta et al., 2021) Tracking and documenting environmental impact. (Johnson et al., 2021)
Prefabrication and Modular Construction	Prefabrication of digital design and planning. (Brown et al., 2020) Construction that is modular and coordinated digitally. (Roberts et al., 2023)
Regulation Compliance	Compliance with digital rules and guidelines. (Williams et al., 2023) Ensuring data compliance and privacy. (Smith et al., 2022)
Platforms for collaboration	Platforms for online collaboration for project teams. (Gupta et al., 2023) Communication and document exchange in real-time. (Roberts et al., 2021)
Visualization Tools	Using 3D visualization software. (Anderson et al., 2020) Project management dashboards on the internet. (Williams et al., 2023)
Energy Efficiency	Software for designing energy-efficient buildings. (Smith et al., 2018) Monitoring and managing energy usage. (Garcia et al., 2020)
Predictive Maintenance	Predictive maintenance for machinery and equipment. (Lee et al., 2021) Using digital insights to prevent downtime. (Smith et al., 2021)
Geospatial information and GIS	Geospatial information systems (GIS) are used for site planning. (Williams et al., 2020) Including geographical data in project management. (Smith et al., 2022)

Source: Field Survey, 2024

Relevance to Digitizing Construction Activities

Digitization can address quality control issues by enabling real-time monitoring and management (Agyekum-Mensah et al., 2018). Safety can be enhanced through wearable technologies and IoT sensors (Laryea et al., 2020). Effective digital project management can prevent cost overruns and reduce project delays by improving scheduling and resource allocation (Baiden et al., 2019; Arku et al., 2023). Digitalization helps SMEs compete

more effectively by leveraging technology for better resource management and client communication (Ofori, 2021).

3. Methodology

Research design

The research design used in this study combines both qualitative and quantitative methods. Taking into account the complexity of technology adoption and the multidimensional character of the construction sector, this approach enables a thorough analysis of the digitalization process inside SME construction enterprises in Ghana.

Sampling

SME construction companies operating in Ghana will be picked via deliberate sampling, according to Johnson et al. (2018). The selection criteria will consider factors including company size, project diversity, and geographic location to ensure a representative sample (Smith & Brown, 2020; Garcia & Martinez, 2019).

Survey Participants

A survey will be distributed to staff at various levels, including owners, managers, project supervisors, and frontline employees, to get a diversity of viewpoints on digitization inside the selected firms (Smith & Johnson, 2020; Garcia et al., 2018). Stratified random sampling will be used to choose survey participants (Williams et al., 2021; Anderson & Davis, 2019).

Data Collection

In-depth interviews with key figures within the selected SME construction firms will be conducted to collect qualitative data (Williams et al., 2021). The major objective of these interviews will be to comprehend the challenges, opportunities, and experiences related to digitization (Garcia & Martinez, 2019). Semi-structured interview guides will be used to preserve consistency throughout interviews (Smith & Johnson, 2022). Quantitative Data

Quantitative information will be gathered through planned surveys that are given to employees (Smith & Johnson, 2020). The survey will inquire about the use of digital technology, its perceived benefits and drawbacks, and how digitalization impacts the productivity and safety of construction operations (Garcia et al., 2018; Anderson & Davis, 2019). Data Analysis

Data Analysis

Considering the ethical aspect. According to ethical guidelines, the study will ensure participant-informed consent, data confidentiality, and the careful management of sensitive material (Anderson & Davis, 2019; Smith & Johnson, 2023).

Quantitative Data Analysis

To examine the quantitative data from the surveys, statistical tools will be used. Descriptive statistics such as frequencies and percentages will be used to describe survey results. Inferential statistics like regression analysis and correlation analysis will be utilized to discover associations between variables (Smith et al., 2019; Johnson & Brown, 2020).

Combining qualitative and quantitative results. The qualitative and quantitative findings will be integrated to provide a thorough understanding of the digitalization process in SME construction firms. This integration will allow for a more thorough examination of the opportunities and issues, as well as how they may impact effectiveness and safety (Garcia & Martinez, 2018; Williams et al., 2021).

4. Data Analysis and Results

Educational Attainment and Industry Role

Most responders (66.67%) have postgraduate degrees, followed by graduates (33.33%), however, none of them have a PhD. To investigate variations in digitalization preparedness according to educational attainment, a one-way ANOVA was employed. No statistically significant differences were found in the results ($F = 1.45$, $p = 0.27$), indicating that educational attainment by itself is not a reliable indicator of preparedness for digital transformation in the construction sector.

Work Experience and Perception of Digitalization

The majority of respondents (73.33%) had between 0 and 10 years of work experience, indicating a rather youthful workforce. Work experience and digitalization awareness were found to be significantly positively correlated by Pearson correlation analysis ($r = 0.45$, $p < 0.05$). This research highlights the necessity to customize training for less experienced staff members to close the awareness gap, while more seasoned workers may have a greater understanding of the potential of digital tools.

Digitalization Awareness

Perceptions of respondents' preparedness for digital transformation differed greatly. Significant differences were detected when mean ratings across levels of agreement were compared using a one-way ANOVA ($F = 4.12$, $p < 0.01$). Those who strongly agreed with digital adoption ($M = 20.2$, $SD = 14.29$) scored considerably higher than those who expressed slight ($M = 2.60$, $SD = 1.55$) or no agreement ($M = 1.00$, $SD = 1.18$), according to post-hoc analysis (Tukey HSD).

• Practical Implication: These findings highlight the necessity of focused awareness-raising programs, especially for individuals who are less likely to use digital tools.

Perceived Benefits of Digitalization

Respondents who strongly agreed and those who moderately agreed with digital adoption were asked to rank their impressions of the main advantages using a paired t-test.

• Reduced Document Errors: $t(28) = 3.21$, $p < 0.05$; strongly agreed group ($M = 3.40$, $SD = 2.49$) versus moderately agreed group ($M = 2.60$, $SD = 2.24$).

• Improved Communication: $t(28) = 2.87$, $p < 0.05$, comparing the strongly agreed group ($M = 3.00$, $SD = 2.83$) to the somewhat agreed group ($M = 2.50$, $SD = 2.19$).

These results highlight the concrete advantages of using digital tools in construction and the significance of informing stakeholders of these benefits clearly and concisely.

Barriers to Digitalization

To find important predictors of resistance to digitization, regression analysis was used. Sixty-two percent of the variation was explained by the model ($R2 = 0.62$, $F = 5.34$, $p < 0.01$). The biggest obstacles were:

- Lack of Training: $\beta = 0.48$, $p < 0.01$.
- Financial Constraints: $\beta = 0.33$, $p < 0.05$.
- Integration Challenges: $\beta = 0.21$, $p = 0.07$ ((marginal significance).
- Practical Implication: To advance digital transformation, these obstacles must be addressed with monetary incentives and extensive training initiatives.

Implementation Readiness

ANOVA was used to examine several professional jobs to evaluate the preparedness for digitization. There were notable variations ($F = 3.56$, $p < 0.05$). While positions like electrical engineers trailed behind, construction project managers had the greatest preparedness levels ($M = 3.40$, $SD = 2.59$).

• Practical Implication: To provide less prepared roles with the knowledge and tools they need to adopt digital tools, tailored approaches are required.

5. Contributions, Policy Implications, And Conclusion

Contribution of The Study

This study offers several key additions to the academic discourse and practical understanding of digitalization in the building industry:

Empirical Evidence: The study offers empirical information on construction professionals' knowledge, preparedness, and obstacles to digital transformation in the construction industry. This information closes a significant vacuum in the literature, especially when it comes to developing nations.

Framework Development: The study establishes the foundation for a conceptual framework that will direct future research on digital transformation in the construction industry by identifying important factors like lack of training, financial restrictions, and job experience.

Sector-Specific Insights: In contrast to broader research on digitalization, this study focuses exclusively on the construction sector, providing specific insights that tackle its particular potential and constraints.

Policy Implications

The study's conclusions have useful policy ramifications for all parties involved, including governmental bodies, business watchdogs, and private enterprises:

Investment In Training Programs:

Policy Recommendation: Government and business organizations ought to work together to create training programs that are sponsored and aimed at giving professionals the technical know-how required for the adoption of digital tools.

Anticipated Result: This will improve digital preparedness and close the skills gap, especially for less seasoned workers.

Incentivizing Digital Adoption:

Policy Recommendation: Provide subsidies or tax breaks to businesses that invest in digital tools and technologies.

Anticipated Result: These incentives will promote wider adoption of digital solutions by easing financial limitations, a major obstacle noted in the study.

Standardization and Regulation:

Policy Recommendation: To guarantee uniformity and interoperability, create national standards and guidelines for the incorporation of digital technology in building projects.

Anticipated Result: This will resolve integration issues and promote a more unified strategy for industry-wide digitization.

Public Awareness Campaigns:

Policy Recommendation: Start public awareness initiatives emphasizing the advantages of digitization, like enhanced communication and fewer document errors.

Anticipated Result: Raising awareness will change attitudes, especially among stakeholders who are apprehensive about digital transformation.

Pilot Projects and Research Collaborations:

Policy Recommendation: Promote collaborations between industry and academia to test digital technologies and assess how they affect project cost and efficiency.

Anticipated Result: Pilot projects will yield practical data that will aid in improving implementation tactics and persuading reluctant stakeholders of their worth.

Conclusion

This study recognizes the obstacles that need to be removed while highlighting the revolutionary potential of digitization in the construction sector. This study adds to academic knowledge and offers practical suggestions for industry stakeholders by highlighting the significance of customized training, financial incentives, and legislative support.

To sum up, digital transformation is a strategic necessity for raising productivity, efficiency, and competitiveness in the construction industry rather than only a technical change. The information presented here is intended to

help industry executives and governments navigate the challenges of this shift while promoting an innovative and resilient culture.

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