

EMPIRICAL ARTICLE

Beyond Adoption: Evidence of a Digital Technology Integration Gap Among Engineering Professionals in Ghana

Frank Boateng^{1,2} | Clifford Benjamin Oppong¹ | Akyene Tetteh¹

¹Department of Management Studies, Faculty of Integrated Management Science, University of Mines and Technology (UMaT), Tarkwa, Ghana

²CEIBA Business School, Hong Kong, China

Correspondence

Corresponding author Frank Boateng.
Email: fboateng@umat.edu.gh

Abstract

Purpose: Digital technology adoption is widely promoted as a means of improving professional performance, yet evidence on whether adopted technologies become deeply embedded in everyday work remains limited, particularly in sub-Saharan Africa. This study examines the breadth of digital technology adoption, the depth of integration into professional practice, perceived work-performance impacts, and implementation barriers among engineering professionals in Ghana.

Design/methodology/approach: A quantitative cross-sectional survey was conducted with 151 engineering professionals working across construction, infrastructure, manufacturing, and mining in Ghana. The study examines the use of Building Information Modelling (BIM), the Internet of Things (IoT), artificial intelligence (AI), and Cloud Computing, together with integration depth, perceived impacts on project management, productivity, cost efficiency and risk mitigation, training coverage, and implementation barriers. Data were analysed descriptively using frequencies, percentages, means, standard deviations, and cross-tabulations. Diffusion of Innovations theory provides the primary individual-level interpretive lens, while the Technology–Organisation–Environment framework is used to characterise the surrounding technological and organisational context.

Findings: Digital technology adoption is relatively broad but integration into everyday professional practice remains shallow. BIM is the most widely used technology, followed by IoT, AI, and Cloud Computing, with combined technology use more common than standalone use. Respondents report positive perceived impacts on project management, productivity, cost efficiency, and risk mitigation. At the same time, resistance to change, legacy-system integration, implementation costs, skills shortages, and limited training coverage constrain deeper integration.

Originality/value: The study moves beyond conventional measures of whether technologies have been adopted by distinguishing the *breadth of adoption* from the *depth of integration* into professional practice. It identifies an *adoption–integration gap* in which engineering professionals have acquired and combined digital technologies and perceive them as beneficial, yet have not embedded them extensively across their work activities.

KEYWORDS

digital technology adoption; technology integration; adoption-integration gap; perceived work performance; engineering professionals; emerging economies; Ghana

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1 | INTRODUCTION

The global engineering profession faces mounting pressure to modernise work practices, enhance project delivery capabilities and improve professional service provision through the adoption of digital technology (Nyqvist et al. 2025). The convergence of Building Information Modelling (BIM), the Internet of Things (IoT), Artificial Intelligence (AI)

and Cloud Computing marks a shift in how engineering professionals conceptualise, design and execute their work (Heidari et al. 2024). Advanced technologies now enable more precise identification of project challenges and enhanced professional capability (Zhou et al. 2024). In this context, digital technology adoption extends beyond simple tool utilisation to encompass changes in work processes, professional practices and collaborative arrangements (Plekhanov et al. 2023), creating opportunities for real-time project monitoring, improved stakeholder communication and more effective risk management (Luo 2025).

These benefits, however, are not realised automatically upon the implementation of technology (Paul et al. 2024). Engineering professionals in developing countries lag in implementing digital technologies and must overcome high implementation costs, resistance to technological change, skills gaps, legacy system integration challenges and unclear adoption strategies (Oke et al. 2024, Gkrimpizi et al. 2023). The African landscape presents both additional complexity and a distinctive opportunity: approximately 473 million Africans have embraced the digital world, with projections of a further 300 million users (Mwaura 2025), creating conditions for engineering professionals to leapfrog traditional technological constraints while addressing fundamental infrastructure needs (Signé 2024).

Ghana's position as a regional leader in digital adoption initiatives makes it a particularly instructive setting for studying the digitalisation of engineering work. Ghana's digital ecosystem has grown substantially, with roughly 24 million active internet users, representing a 70% penetration rate (United Nations in Ghana 2024). Government commitment through the Ghana Digital Economy Development Plan (2020 to 2030) and the National Digital Transformation Agenda creates a supportive policy environment for professional experimentation with digital technologies (Yawson 2024).

Despite this enabling context, significant knowledge gaps remain about how engineering professionals in developing countries navigate digital technology adoption (Rinchen et al. 2024). Three limitations of the current literature are particularly consequential for this study. First, most research focuses on developed economies, limiting the transferability of findings to practitioners operating under different resource, infrastructure and readiness conditions (Rinchen et al. 2024). Second, existing work tends to examine individual technologies or isolated aspects of adoption rather than the combined use of multiple digital technologies in everyday practice (Hashim Mohammed et al. 2022). Third, the literature has concentrated on whether practitioners adopt technologies at all, and has paid comparatively little attention to how deeply adopted technologies are embedded in day-to-day professional activity (Kraus et al. 2021, Paul et al. 2024).

This last limitation motivates the organising idea of the present paper. Analysing survey responses from 151 engineering professionals in Ghana, we document a consistent and, in our view, under-recognised pattern: adoption is broad but integration is shallow. A clear majority of respondents report using BIM, and most combine several digital technologies rather than relying on any single tool, yet fewer than one in ten report using digital tools across more than three-quarters of their work

activities. We term this divergence between adoption breadth and integration depth the adoption-integration gap. Framing the evidence in this way shifts the practical question away from whether engineering professionals in emerging economies can be persuaded to acquire digital tools, a question this study suggests is largely settled in this setting, and towards the more demanding question of what it would take for them to embed those tools in routine practice.

Accordingly, the study addresses three objectives: to assess the current breadth and depth of digital technology adoption among engineering professionals in Ghana; to examine the perceived effects of digital technology adoption on work performance; and to identify the barriers professionals encounter when adopting and embedding these technologies.

The study contributes on three fronts. Empirically, it provides baseline evidence on individual-level adoption patterns, integration depth and perceived performance outcomes within a sub-Saharan African engineering community, a setting under-represented in the digital adoption literature. Conceptually, it draws on Diffusion of Innovations theory as an individual-level interpretive lens and on the Technology-Organisation-Environment framework as a means of characterising the surrounding technological and organisational context, and uses both to make sense of an empirically important distinction between adoption breadth and integration depth. The study does not claim to extend or test either framework; the descriptive design supports interpretation rather than theory testing. Practically, it offers engineering professionals, employers, professional bodies and policymakers a diagnostic account of where Ghana's engineering workforce currently stands and which constraints most warrant intervention.

The remainder of the paper is organised as follows. Section 2 reviews the literature on professional adoption, integration depth and barriers to embedding technology in work practice, and sets out the theoretical lenses and conceptual framework. Section 3 outlines the methodology. Section 4 presents and discusses the findings. Section 5 concludes and sets out implications, limitations and directions for future research.

2 | LITERATURE REVIEW

2.1 | Digital Technology Adoption Among Engineering Professionals

Digital technology adoption is the process by which individual professionals acquire, implement and use digital tools and systems in their work practices (Nassir-Deen et al. 2026). For this study, digital technology adoption refers to the extent to which individual engineering professionals use BIM, IoT, AI and Cloud Computing in their daily work, project execution and professional practice.

The concept has evolved from traditional digitalisation approaches into a strategic professional competency for practitioners seeking advantage in increasingly complex markets (Díaz-Arancibia et al. 2024).

Meaningful adoption differs from superficial tool use through systematic changes to work processes and collaborative arrangements (Plekhanov et al. 2023). Engineering professionals face distinct adoption challenges arising from technical complexity and the project-based nature of their work, and must navigate integration complexities while managing traditional professional demands. Contemporary adoption increasingly focuses on integrated technology ecosystems rather than isolated tool implementations (Duan et al. 2024, Lissillour and Sahut 2026), reflecting the interconnected nature of modern engineering work.

2.2 | From Adoption to Integration: The Depth of Technology Use

A growing strand of the literature distinguishes the decision to adopt a technology from the extent to which that technology is subsequently embedded in routine work. Adoption among engineering professionals shows distinct patterns that reflect the technical and collaborative demands of engineering work (Leesakul et al. 2022). BIM has emerged as the foundational technology for digital integration, serving as a platform onto which additional digital tools and capabilities are layered (Hashim Mohammed et al. 2022). Integrating BIM with IoT marks a significant advance in real-time project monitoring and data collection (Luo 2025), while cloud computing platforms facilitate the collaborative arrangements and data sharing essential to modern practice (Huang et al. 2023).

Adoption typically follows a hierarchical pattern in which foundational technologies establish the infrastructure for more advanced integration scenarios (Baghalzadeh Shishehgarkhaneh et al. 2022), requiring systematic progression from basic tool utilisation to deeper integration. Integrating AI and machine learning with professional systems offers advanced analytical capabilities (Bassir et al. 2023), though it demands substantial data processing capacity and specialised expertise. Data integration difficulties remain a primary constraint, with individuals struggling to achieve seamless information exchange between systems (Kraus et al. 2021).

Work on digital maturity makes the adoption-integration distinction explicit. Hortovanyi et al. (2023) show that firms at similar levels of technology acquisition differ substantially in the capabilities built around those technologies, and that maturity, rather than acquisition, accounts for observed performance differences. The implication at the individual level is that measuring whether a professional uses a technology is a weak proxy for how far that technology has reshaped their work. Despite this, empirical studies of professional adoption in emerging economies rarely report integration depth alongside adoption rates, which is the omission this study addresses.

2.3 | Barriers to Embedding Technologies in Work Practice

Barriers to digital technology adoption typically manifest as interconnected combinations rather than as isolated obstacles (Gkrimpizi et al. 2023), reflecting systemic issues such as resource constraints, skills gaps and limited institutional support. For this study, implementation barriers are the obstacles that individual engineering professionals encounter when adopting and embedding digital technologies, including financial constraints, resistance to change, skills gaps, difficulties integrating legacy systems and unclear adoption strategies.

Financial constraints are among the most frequently cited barriers (Díaz-Arancibia et al. 2024), with engineering professionals facing particular cost pressures from specialised software platforms, training investments and extended implementation timelines. Individual and cultural resistance is a pervasive constraint on adoption success regardless of technology quality or strategic vision; professionals with established work procedures find it particularly difficult to displace ingrained patterns that favour proven methodologies over experimental approaches. Skills gaps limit effectiveness even when financial resources and commitment are available, and workplace literacy, including information and digital literacy, significantly affects adoption success (Nikou et al. 2022). Legacy system integration poses technical challenges beyond software compatibility, including data migration, process redesign and operational continuity (Bassir et al. 2023). Finally, deficiencies in strategic clarity lead to fragmented implementation that fails to realise comprehensive benefits (Kraus et al. 2021).

Notably, most of these barriers bear more directly on deepening use than on initial acquisition. A professional can purchase and begin using a software package despite resistance, cost pressure or an incompatible legacy environment; embedding that package across the full range of professional activities is considerably more sensitive to all three. This observation motivates the interpretation developed in Section 4.7.

2.4 | Theoretical Lenses and Levels of Analysis

This study draws on two complementary theoretical perspectives, used as interpretive lenses rather than as frameworks to be tested or extended.

Diffusion of Innovations (DOI) theory serves as the study's primary lens, because its unit of analysis matches our own. DOI explains how new ideas and technologies spread among individuals and professional groups over time (Rogers 2003). It highlights five attributes of innovations that influence the speed of adoption: relative advantage, compatibility, complexity, trialability and observability. It also segments adopters into innovators, early adopters, the early majority, the late majority and laggards, and identifies five stages at which implementation may encounter difficulty: knowledge, persuasion, decision, implementation and confirmation (Sahin 2006). DOI is particularly useful here

because the implementation and confirmation stages, rather than the earlier decision stage, correspond to the depth-of-integration question this study foregrounds. A recognised limitation of the theory is its assumption that innovations are inherently advantageous, which may obscure rational resistance.

The Technology-Organisation-Environment (TOE) framework is used more cautiously and for a different purpose. TOE holds that the adoption of technological innovations depends on three interconnected dimensions: technological, organisational and environmental (Tornatzky and Fleischer 1990). The technological dimension concerns existing and accessible technologies; the organisational dimension encompasses workplace characteristics such as size, structure, management support and resource availability; and the environmental dimension reflects industry characteristics, competitive pressures and regulatory conditions (Baker 2012).

An explicit note on levels of analysis is warranted here. TOE was developed as an organisational-level framework, whereas the unit of analysis in this study is the individual engineering professional. We therefore do not treat TOE as a model of individual adoption, and we do not substitute an individual dimension for its organisational dimension. Instead, TOE is used descriptively, to characterise the technological and organisational context within which the professionals in our sample work: the technologies available to them, the size and resourcing of their employing organisations, and the sectoral and regulatory conditions of Ghanaian engineering practice. Individual-level interpretation is carried by DOI. Where respondents report organisational features such as employer size or sector, these are treated as contextual attributes of the individual's work setting rather than as measured organisational-level constructs. Readers should note that such single-respondent reports are not a substitute for organisational-level data, a point we return to in Section 5.3. The generality of TOE, which permits considerable latitude in selecting and measuring factors, is a recognised limitation (Zhu and Kraemer 2005, Li 2020) and a further reason for using it as contextual framing rather than as an explanatory model.

2.5 | Empirical Review and Research Gap

Four empirical studies inform this research. Hortovanyi et al. (2023) analysed the digital maturity of 302 manufacturing professionals across Slovakia, Hungary, Romania and Serbia, introducing a Digital Capability Maturity Model with four levels and emphasising strategy and organisational capabilities. Duan et al. (2024) applied technology affordance theory and structural equation modelling to show that digital technologies are associated with improved job performance through better coordination, communication, knowledge sharing and decision-making. Leesakul et al. (2022) investigated digital manufacturing from a workforce perspective, finding that mental workload rose after adoption while stress, fatigue and anxiety declined, and identified lack of knowledge as the primary barrier, followed by acceptance, cost and regulatory issues. Gurcan et al. (2023) conducted a large-scale retrospective analysis of 5,350 peer-reviewed articles published between

2013 and 2022, identifying 34 topics across four dimensions, with implementation accounting for the largest share (45.76%) and people the smallest (5.63%).

This body of work points to three gaps. First, evidence on digital technology adoption among individual engineering professionals in sub-Saharan Africa is limited. Second, most studies address organisational-level adoption or specific technology implementations rather than how individual professionals use combinations of technologies in daily practice. Third, and most consequential for this paper, adoption rates are routinely reported while the depth to which adopted technologies penetrate professional work is not, leaving the adoption-integration distinction empirically underexplored in emerging-economy professional settings. This study addresses these gaps by reporting adoption breadth and integration depth alongside one another, documenting perceived performance impacts across four dimensions, and examining the interconnected barriers that constrain deeper use.

2.6 | Conceptual Framework

The study's conceptual framework organises four descriptive themes: technology adoption patterns, including BIM as a core platform and the combination of BIM with IoT, AI and Cloud Computing; depth of integration, understood as the proportion of professional activities in which digital tools are actually used; perceived work performance outcomes across productivity, project management effectiveness, cost efficiency and risk mitigation; and implementation barriers, including financial constraints, resistance to change, skills gaps and legacy system integration. DOI informs interpretation of individual adoption behaviour across these themes, while TOE characterises the technological and organisational context in which that behaviour occurs.

The framework is descriptive rather than causal, consistent with the study's design. It does not specify directional relationships for testing, and no hypotheses are advanced or tested in this paper. We note, however, that the pattern of findings reported in Section 4 is consistent with a more specific process mechanism worth pursuing in subsequent confirmatory work: that the depth to which adopted technologies are integrated into daily practice, rather than adoption alone, may be what converts technology acquisition into performance gains, and that this conversion may be conditioned by how well professionals are prepared to use the tools they have adopted. This reasoning parallels evidence that the performance returns to digital technology adoption operate through intervening mechanisms such as the depth of capability built around the technology rather than through adoption status alone (Gong 2023), and that technology adoption yields larger performance gains when combined with adequate training investment than when training is absent (Boothby et al. 2010). We present this as a research avenue in Section 5.3 rather than as a claim supported by the present analysis.

3 | METHODOLOGY

3.1 | Research Philosophy, Approach and Design

This research adopts a positivist philosophy, focusing on observable phenomena that can be measured systematically and independently of the researcher (Bell et al. 2022). Positivism suits this study because it examines quantifiable patterns of digital technology adoption and respondents' rated perceptions of performance effects. A deductive approach was used, moving from established theoretical perspectives, particularly DOI and TOE, to specific observations about adoption among Ghanaian engineering professionals.

A descriptive research design was adopted in order to characterise current adoption patterns, integration depth, perceived performance effects and barriers. The study used a quantitative cross-sectional survey, which enables efficient collection of standardised data from a dispersed sample at a single point in time (Kumar 2019). The descriptive design is appropriate to the study's purpose, which is to establish an empirical baseline rather than to estimate causal effects. Consistent with this, the analysis and discussion that follow report associations and respondent perceptions, and avoid causal interpretation.

3.2 | Study Setting, Population and Unit of Analysis

The study covered engineering professionals in Ghana working across the construction, infrastructure, manufacturing and mining sectors. Ghana's engineering community was selected because of ongoing national efforts to promote digital adoption and government commitment to digitalising key economic sectors (Yawson 2024). Participants included civil, mechanical and electrical engineers, alongside project managers, engineering managers, production managers and BIM practitioners, all with direct experience of using digital technologies in their roles.

The unit of analysis is the individual engineering professional. This focus captures personal accounts of adoption, integration, implementation difficulty and perceived performance effects, and permits examination of how these vary across roles, experience levels and project domains. As noted in Section 2.4, organisational attributes reported by respondents are treated as descriptors of the individual's work context rather than as organisational-level measures.

3.3 | Sampling and Data Collection

Convenience sampling was used because no sampling frame enumerating engineering professionals in Ghana was available, and respondents had to be reached through existing professional networks (Kumar 2019). Because the population size was unknown, sample size formulas requiring known population parameters, such as Yamane's formula, could

not be applied (Adam 2020, Yamane 1967). Following the sample-size justification principles discussed by Lakens (2022), a target of 150 respondents was set, reflecting available resources, the study's descriptive purpose, and the need to represent several professional groups. A sample of 150 or more is generally considered adequate for descriptive survey research when population parameters are uncertain (Memon et al. 2020).

The research team administered the questionnaire electronically via an online survey form, distributed through professional WhatsApp groups and LinkedIn networks of Ghanaian engineering practitioners, including sector-specific groups covering construction, infrastructure, manufacturing, and mining. These channels were selected for their reach among Ghanaian professionals and their capacity to access respondents in geographically dispersed project locations. Eligibility was screened at the start of the instrument: respondents had to confirm that they were practising engineering professionals in Ghana and identify their current professional role; responses that failed this screen were excluded before analysis. The survey form was configured to accept one response per device to limit duplicate submissions, and submissions were also reviewed for duplicate response patterns during data cleaning. Because the survey was distributed through open professional groups, the number of professionals who viewed the invitation cannot be determined, so the response rate cannot be calculated. The final dataset comprised 151 valid responses. The structured questionnaire contained five sections: demographic details, digital technology adoption and integration, perceived effects on work performance, barriers and challenges, and enabling factors.

This recruitment strategy has clear implications for inference. Respondents were not randomly selected, and more digitally engaged professionals may have been more likely to encounter and complete an online survey about digital technology. The sample should therefore be understood as a purposive snapshot of digitally active engineering professionals in Ghana rather than as a representative sample of the profession, and the percentages reported below should not be read as population estimates.

3.4 | Measurement of Variables

All constructs were measured using single items, and this is stated explicitly because it bears directly on how the descriptive statistics should be interpreted. No composite or scale scores were constructed, and no scale reliability coefficients are reported, because single-item measures do not permit the calculation of internal consistency.

Perceived work performance impact was measured with four separate single items, one for each dimension: project management effectiveness, productivity, cost efficiency and risk mitigation. Respondents rated the perceived impact of digital technology on each dimension using a five-point scale (1 = Minimal Impact, 2 = Slight Impact, 3 = Moderate Impact, 4 = Significant Impact, 5 = Highly Significant Impact). Means and standard deviations reported in Section 4.4 are therefore item-level statistics for four distinct single-item measures, not subscale

scores. These items capture perceived impact as reported by the respondent; they do not measure realised or objectively verified work performance.

Breadth of adoption was measured with a multiple-response item in which respondents indicated which of four digital technologies (BIM, IoT, AI and Cloud Computing) they used in their work. Respondents could select more than one technology, so category percentages for this item sum to more than 100%.

Depth of integration was measured with a single ordinal item asking respondents to indicate the proportion of their work activities in which digital tools are used, using four bands (less than 25%, 25% to 50%, 51% to 75%, more than 75%). A separate single item asked respondents to rate their overall progress in adopting digital tools on a five-point scale.

Digital training coverage was assessed using a single ordinal question with four options, asking respondents what proportion of their digital skill needs had been fulfilled by training. **Barriers** were evaluated through a multiple-response question listing five barrier categories, while **resistance to change** was measured with a frequency scale (Rarely, Occasionally, Often, Always). Demographic details were collected via categorical questions.

3.5 | Validity, Reliability and Ethical Considerations

The questionnaire was pilot-tested with 20 engineering professionals in Ghana before the main data collection. The pilot identified ambiguous items, unclear instructions and sequencing problems, and minor adjustments were made to question wording, particularly for technical terms and digital technology categories. Because all constructs are measured with single items, the pilot assessed clarity, interpretability and consistency of understanding rather than internal consistency reliability.

Content validity was supported by an instrument development process grounded in a review of the digital adoption and work performance literature and in the DOI and TOE perspectives. Academic supervisors specialising in technology adoption and quantitative methods, and senior engineering practitioners experienced in technology implementation, reviewed the draft instrument, and their comments informed the final item set.

Ethical guidelines were observed throughout. Participation was voluntary, and all participants provided informed consent before completing the questionnaire. Respondent identities were kept confidential, findings were reported only in aggregate, and all data were stored securely.

3.6 | Data Analysis

Data were analysed using SPSS and Microsoft Excel. Completed questionnaires were coded and entered, then cleaned to identify missing values, inconsistencies and out-of-range entries. The analytical approach

is descriptive. Frequency distributions and percentages characterise demographic attributes, technology types, integration depth and barriers; means and standard deviations summarise the four perceived performance items; and cross-tabulation examines variation by professional role, experience band and project domain.

Missing data were handled by pairwise deletion, and the valid number of responses is reported separately for each variable. Percentages are calculated on the valid responses for that variable rather than on the full sample of 151, so that reported proportions are not deflated by item non-response. Valid N is stated in every table. Percentages may not sum to exactly 100% because of rounding. Because the analysis is descriptive and cross-sectional, no inferential tests of association, mediation or moderation are conducted, and the results reported in Section 4 are presented as observed patterns rather than as estimated effects.

4 | ANALYSIS AND DISCUSSION

4.1 | Demographic Characteristics of Respondents

A total of 151 valid responses were obtained. Table 1 presents the demographic profile. The most common role was Engineering Manager (31.8%), followed by Engineer (23.2%) and Production Manager (19.9%). BIM Practitioners comprised 9.9% and Project Managers 6.6%. The sample was predominantly mid-career: 48.0% reported 5 to 10 years of engineering experience and 28.7% reported 10 to 20 years, while only 6.7% reported more than 20 years. Construction was the most common project domain (39.1%), followed by infrastructure and manufacturing at 22.5% each and mining at 7.3%. Respondents from medium-sized organisations (51 to 250 employees) were the largest group (43.3%).

4.2 | Breadth of Digital Technology Adoption

Table 2 reports adoption of the four focal technologies. BIM was the most widely used, reported by 103 respondents (68.2%), either alone or alongside other tools. IoT was reported by 79 respondents (52.3%), AI by 71 (47.0%) and Cloud Computing by 69 (45.7%). The prominence of BIM aligns with its established role in engineering workflows for visualisation, collaboration, and project coordination, and with Hashim Mohammed et al.'s (2022) characterisation of BIM as the core platform for digital integration. Through the TOE lens, this pattern reflects the technological context of Ghanaian engineering practice, where BIM is the most available and best supported of the four technologies.

Table 2 shows a clear pattern that combined use is more common than standalone use. Of 103 BIM users, 80 (53.0% of the sample) reported using BIM alongside at least one other technology. The most frequent pairing was BIM with IoT, reported by 18 respondents (11.9%), followed by BIM with AI (13 respondents, 8.6%) and BIM with

TABLE 1 Demographic Characteristics of Respondents

Variable	Category	Frequency	Valid %
Job Role (n = 151)	Engineering Manager	48	31.8
	Engineer	35	23.2
	Production Manager	30	19.9
	BIM Practitioner	15	9.9
	Project Manager	10	6.6
	Other	13	8.6
Experience (n = 150)	Less than 5 years	25	16.7
	5 to 10 years	72	48.0
	10 to 20 years	43	28.7
	More than 20 years	10	6.7
Project Domain (n = 151)	Construction	59	39.1
	Infrastructure	34	22.5
	Manufacturing	34	22.5
	Mining	11	7.3
	Other	13	8.6
Organisation Size (n = 150)	Small (1 to 50)	41	27.3
	Medium (51 to 250)	65	43.3
	Large (250+)	44	29.3

Source: Field data, 2025. Note: Valid percentages are calculated on the valid responses for each variable. One response was missing for Experience and one for Organisation Size. Percentages may not sum to exactly 100% because of rounding.

Cloud Computing (10 respondents, 6.6%). Three-technology combinations were also present, with BIM-IoT-AI and BIM-IoT-Cloud Computing each reported by 13 respondents (8.6%). These patterns align with Baghalzadeh Shishehgarhaneh et al.'s (2022) account of layered technology adoption and with Plekhanov et al.'s (2023) observation that professionals at more advanced adoption levels operate within platform ecosystems that require new forms of planning and coordination.

4.3 | Depth of Digital Technology Integration

The picture changes markedly when attention shifts from which technologies professionals use to how far those technologies extend across their work. Table 3 reports depth of integration.

Only 13 respondents (8.7%) reported using digital tools in more than 75% of their work activities. The largest group, 63 respondents (42.0%), reported use in only 25% to 50% of activities, while 26.0% reported use in 51% to 75% and 23.3% in less than 25%. When asked to rate their overall progress in adopting digital tools, respondents reported a mean of 3.2 on a five-point scale, indicating moderate self-assessed progress. This pattern of partial implementation is consistent with Paul et al. (2024)'s observation that widespread acquisition of digital tools has not been matched by systematic integration across professional activity, and with Oke et al. (2024) finding that engineering professionals in developing economies progress more slowly through implementation. In DOI terms, the sample is distributed well past the decision stage

but concentrated short of the confirmation stage, where sustained and routinised use would be observed.

The contrast between Tables 2 and 3 is the study's central empirical observation. Adoption is broad: roughly two-thirds of respondents use BIM, and most combine multiple technologies. Integration is shallow: fewer than one in ten have extended digital tools across most of their work. Breadth of adoption is therefore a poor guide to how substantially digital technology has reshaped professional practice in this setting, which supports the argument advanced in Section 2.2 that adoption rates alone are an insufficient measure of digitalisation.

Cross-tabulation indicates that integration depth varied by experience and sector. Respondents in the 5 to 10 and 10 to 20 year experience bands accounted for the majority of multi-technology use, while those with more than 20 years of experience more often reported use confined to established tools such as BIM and Cloud Computing, and those with less than 5 years more often reported simpler, lower-cost configurations. This is consistent with DOI's proposition that individual characteristics shape adoption behaviour (Rogers 2003). By sector, integration was most extensive among construction respondents and least extensive among mining respondents, a variation that plausibly reflects differences in project characteristics and technology fit across domains and that is consistent with BIM's particular traction in construction applications (Zhou et al. 2024). These sectoral comparisons should be treated as indicative only: the mining subgroup contains just 11 respondents and the resulting cell counts are too small to support reliable comparison.

TABLE 2 Digital Technology Adoption Patterns (n = 151)

Technology Type	Frequency	%	Standalone	In Combination
Building Information Modelling (BIM)	103	68.2	23 (15.2%)	80 (53.0%)
Internet of Things (IoT)	79	52.3	7 (4.6%)	72 (47.7%)
Artificial Intelligence (AI)	71	47.0	5 (3.3%)	66 (43.7%)
Cloud Computing	69	45.7	6 (4.0%)	63 (41.7%)

Source: Field data, 2025. Note: Respondents could report more than one technology, so percentages sum to more than 100%.

TABLE 3 Depth of Digital Technology Integration Into Work Activities (n = 150)

Proportion of work activities using digital tools	Frequency	Valid %
Less than 25%	35	23.3
25% to 50%	63	42.0
51% to 75%	39	26.0
More than 75%	13	8.7
Total	150	100.0

Source: Field data, 2025. Note: One response was missing for this item. Valid percentages are calculated on 150 valid responses.

4.4 | Perceived Work Performance Impacts

Table 4 reports the distribution of perceived performance impacts across the four measured dimensions. Perceptions were positive across all four, with Significant the most frequent response and Highly Significant the second most frequent. As set out in Section 3.4, these items measure respondents' perceptions of impact and not realised performance, and the statistics below should be read accordingly.

Respondents rated project management effectiveness most positively, with the highest mean (4.03, SD 0.94). Nearly three-quarters of respondents (74.7%) rated the impact as significant or highly significant, and only 1.3% rated it minimal. Respondents thus perceived digital tools as most valuable for collaboration, communication, and project oversight, consistent with Paul et al.'s (2024) account of digital technology supporting coordination and oversight functions.

Productivity received similarly positive ratings (mean 3.85, SD 0.96), with 65.1% of respondents reporting significant or highly significant perceived impact. Cost efficiency recorded a mean of 3.84 (SD 0.92), with 63.6% rating the perceived impact as significant or highly significant, though nearly one-third (29.8%) rated it moderate, indicating greater variability in perceived financial benefit. This more tempered assessment is consistent with Plekhanov et al.'s (2023) observation that cost-efficiency gains typically require substantial upfront investment before benefits accumulate.

Risk mitigation recorded the lowest mean (3.74, SD 1.00) and the widest dispersion. While 62.8% reported significant or highly significant perceived benefits, 11.5% perceived minimal or slight benefit. The greater spread suggests that perceived risk management benefits vary considerably across professional settings and project types, consistent

with evidence that such benefits depend heavily on implementation quality and individual readiness (Paul et al. 2024).

The ordering of the four dimensions is informative. Respondents perceived the strongest effects in collaborative and coordination activities, followed by operational efficiency, with risk management benefits perceived as the most variable. Read through DOI, the consistently positive ratings indicate that respondents perceive a clear relative advantage from the technologies they have adopted, which Rogers (2003) identifies as a key attribute sustaining continued use. The rarity of minimal-impact ratings suggests that few respondents perceive digital adoption as detrimental to their work. Two cautions apply. These are perceptions rather than measured outcomes, and respondents who have invested effort in adopting a technology may be disposed to evaluate it favourably. The uniformly positive ratings should therefore be read as evidence that these professionals believe digital tools help them, which is itself consequential for the interpretation developed in Section 4.7, rather than as evidence that performance has objectively improved.

4.5 | Barriers to Adoption

Table 5 reports the frequency and relative ranking of implementation barriers. Resistance to change was the most frequently reported, cited by 72 respondents (47.7%). This is consistent with Gkrimpizi et al.'s (2023) identification of resistance as a major obstacle to digital transformation, and with DOI's emphasis on individual characteristics in shaping whether new technologies are taken up (Rogers 2003). Its prominence indicates that implementation depends on human and behavioural factors at least as much as on technical provision.

Legacy system integration was reported by 70 respondents (46.4%), consistent with the identification of data integration difficulty as a primary implementation constraint (Hashim Mohammed et al. 2022) and with the technological dimension of TOE, in which compatibility between new and existing systems conditions adoption (Baker 2012). High implementation costs affected 67 respondents (44.4%), consistent with Egala et al. (2024)'s evidence that financial and resource constraints weigh heavily on digital implementation in emerging economies. A lack of skilled personnel was reported by 58 respondents (38.4%), consistent with DOI's proposition that perceived complexity influences adoption, and unclear digital strategy by 34 respondents (22.5%), reflecting the strategic clarity deficits identified by Kraus et al. (2021).

TABLE 4 Perceived Impact of Digital Technology on Work Performance

Performance Dimension	Minimal	Slight	Moderate	Significant	Highly Sig.	Valid N	Mean	SD
Project Management	2 (1.3)	8 (5.3)	28 (18.7)	58 (38.7)	54 (36.0)	150	4.03	0.94
Productivity	2 (1.3)	10 (6.7)	40 (26.8)	54 (36.2)	43 (28.9)	149	3.85	0.96
Cost Efficiency	1 (0.7)	9 (6.0)	45 (29.8)	54 (35.8)	42 (27.8)	151	3.84	0.92
Risk Mitigation	3 (2.0)	14 (9.5)	38 (25.7)	56 (37.8)	37 (25.0)	148	3.74	1.00

Source: Field data, 2025. Note: Cell entries are frequencies with valid percentages in parentheses. Each dimension was measured with a single five-point item (1 = Minimal Impact to 5 = Highly Significant Impact). Valid N differs across dimensions because of item non-response; percentages, means, and standard deviations are computed on the valid responses for each item. Percentages may not sum to exactly 100% because of rounding.

TABLE 5 Primary Barriers Hindering Digital Technology Adoption (n = 151)

Barrier Type	Frequency	%	Rank
Resistance to change	72	47.7	1
Integration with legacy systems	70	46.4	2
High implementation costs	67	44.4	3
Lack of skilled personnel	58	38.4	4
Unclear digital strategy	34	22.5	5

Source: Field data, 2025. Note: Respondents could report more than one barrier, so percentages sum to more than 100%.

Barriers were rarely encountered in isolation: 73% of respondents reported facing more than one barrier simultaneously. Frequently reported combinations included resistance together with cost and legacy system problems (9.9% of respondents) and cost together with skills and integration difficulties (7.9%). This is consistent with Gurcan et al. (2023)'s finding that barriers to digital adoption cluster rather than operate independently. In TOE terms, the reported barriers span the technological context (legacy system compatibility), the organisational context (cost and resourcing, skills availability, strategic clarity) and the individual level captured by DOI (resistance, perceived complexity).

4.6 | Resistance to Change and Training Coverage

Table 6 reports two behavioural and human capital patterns relevant to integration depth.

The most common response on resistance was occasional resistance (45.0%), suggesting that resistance is widespread but episodic rather than entrenched, and therefore potentially responsive to targeted intervention. Frequent resistance was reported by 31.8%, pointing to more systemic change management difficulties, while only 4.6% reported constant resistance.

Training coverage was limited. Only 13 respondents (8.7%) reported that training had addressed more than 75% of their digital skill needs, while the largest group (42.0%) reported coverage of 25% to 50% and a further 23.3% reported coverage below 25%. Most respondents are therefore attempting to use digital technologies, having had only part of their skill requirements addressed by formal training. The persistence

TABLE 6 Resistance to Change and Digital Training Coverage

Panel	Category	Frequency	Valid %
A. Resistance to change (n = 151)	Rarely	28	18.5
	Occasionally	68	45.0
	Often	48	31.8
	Always	7	4.6
B. Digital training coverage (n = 150)	Less than 25%	35	23.3
	25% to 50%	63	42.0
	51% to 75%	39	26.0
	More than 75%	13	8.7

Source: Field data, 2025. Note: For Panel B, one respondent did not specify training coverage and is excluded from the valid base. Percentages may not sum to exactly 100% because of rounding.

of skills-related barriers alongside reported training suggests that training quality, relevance, and follow-up support may matter as much as coverage, although the present data cannot adjudicate this.

4.7 | Synthesis: The Adoption-Integration Gap

Taken together, the findings describe a workforce positioned at a particular and identifiable point in its digitalisation. Adoption is established: 68.2% of respondents use BIM, most combine several technologies, and perceived benefits are consistently positive across all four performance dimensions. Integration is not: only 8.7% of respondents report using digital tools across more than three-quarters of their work activities, and 42.0% report use in only a quarter to a half. We describe this divergence as an adoption-integration gap.

Two features of the barrier profile help characterise the gap. First, the barriers respondents report most frequently, namely resistance to change, legacy system integration and implementation cost, bear more directly on extending and routinising use than on initial acquisition, as argued in Section 2.3. A professional can begin using a tool despite each of these constraints; embedding it across a full portfolio of activities is considerably more sensitive to all three. Second, preparation appears incomplete: separately from the integration findings, only 8.7% of respondents report training coverage above 75%, while 65.3% report coverage at or below 50%.

We note explicitly that the proportions reporting integration above 75% and training coverage above 75% are numerically identical in this sample. These are two separate univariate distributions, and because the variables were not cross-tabulated, we cannot determine whether the same respondents appear in both categories. No overlap between the two groups is claimed or implied here, and the correspondence should not be read as evidence of a relationship between training and integration. Establishing whether training coverage and integration depth are in fact associated requires cross-tabulating the two items, which we identify as a priority for further analysis in Section 5.3.

The significance of the gap lies in its indication of where efforts should be focused. Persuasion does not seem to be the main barrier in this context, as respondents have already adopted digital technologies and recognize their benefits, indicating an existing awareness of relative advantage within DOI terms. Instead, the challenge appears to be in shifting from partial to full utilization, which involves change management, legacy system compatibility, financial resources, and skills development. Adding more tools to an already extensive toolkit is unlikely to be the main obstacle; instead, enhancing the use of existing tools is a more effective approach. This view aligns with the descriptive evidence provided but is not definitively proven and requires the confirmatory analysis outlined in Section 5.3.

5 | CONCLUSION, IMPLICATIONS AND LIMITATIONS

5.1 | Conclusion

This study examined how engineering professionals in Ghana adopt and use digital technology, focusing on the breadth of adoption, the depth of integration, perceived effects on work performance and the barriers encountered. Drawing on responses from 151 professionals, three conclusions emerge.

First, adoption is broad, but integration is shallow. BIM leads at 68.2%, followed by IoT (52.3%), AI (47.0%) and Cloud Computing (45.7%), and respondents show a marked preference for combined rather than standalone use. Yet only 8.7% report using digital tools across more than 75% of their work activities, while 42.0% report use in only 25% to 50%. This divergence, which we describe as the adoption-integration gap, is the study's principal empirical contribution.

Second, respondents perceive positive effects across all four measured performance dimensions. Project management effectiveness was rated highest (mean 4.03), followed by productivity (3.85), cost efficiency (3.84) and risk mitigation (3.74). Ratings clustered in the significant and highly significant categories, and negative assessments were rare. Because these are self-reported perceptions collected at a single point in time, they indicate that respondents believe digital technologies benefit their work; they do not establish that measured performance has improved.

Third, barriers are numerous and interconnected. Resistance to change was most frequently reported (47.7%), followed by legacy system integration (46.4%), high implementation costs (44.4%), skills gaps (38.4%) and unclear digital strategy (22.5%), with 73% of respondents reporting multiple simultaneous barriers. Training coverage was limited, with 65.3% of respondents reporting that formal training had addressed half or less of their digital skill needs.

Taken together, these findings suggest that the challenge facing digitalisation in Ghana's engineering profession is no longer primarily one of awareness or acquisition. Professionals have adopted digital tools and perceive their value. What remains incomplete is embedding those tools across the full range of everyday professional activity.

5.2 | Implications for Practice and Policy

For engineering professionals, the evidence indicates that enhancing the use of existing tools is likely more effective than acquiring new ones. With 68.2% of respondents already utilizing BIM, there is a substantial foundation to build upon. Additionally, since 42.0% use digital tools in only a quarter to half of their activities, there is significant potential for expansion within current tool portfolios. Practitioners could benefit from developing phased implementation plans that gradually integrate digital tools across different activities. This process should include identifying activities not yet supported by current tools and pairing these efforts with personal change management strategies, especially considering the resistance often encountered.

For employers, professional bodies, and training providers, the barrier profile aligns with a clear intervention strategy. Resistance to change, reported by 47.7% of respondents and mostly episodic rather than entrenched, suggests that structured change management support could be highly effective relative to its cost. Since 46.4% of respondents are affected by legacy system compatibility issues, phased integration that minimizes disruption is preferable to complete system overhauls. With 73% of respondents experiencing multiple barriers simultaneously, support programs targeting only one barrier are unlikely to significantly change behavior. Regarding skills, 65.3% of respondents report training coverage at or below half of their needs, indicating substantial unmet demand. The continued presence of skills barriers alongside reported training highlights the need for improved training design, delivery, and follow-up, not just increased volume. Training that supports integrated technology ecosystems, rather than isolated tools, would help enhance participants' legitimacy in their professional field (Lissilour and Sahut 2022). Low-cost measures such as peer networks and mentoring, which facilitate the exchange of practical implementation knowledge, are well suited to a profile where behavioral and knowledge constraints dominate technical issues.

For policymakers, evaluating policy frameworks for professional digitalisation should focus on the depth of integration rather than just adoption figures, as the latter can significantly overstate progress based on current evidence. Since 44.4% of respondents cite implementation

costs and 38.4% mention skills availability as barriers, targeted measures like professional development grants, tax relief, subsidised digital technology access, and funded skills programs are advisable. Industry standards that improve legacy system interoperability would help address a barrier reported by 46.4% of respondents, a challenge individual practitioners cannot resolve alone. Education policies should incorporate digital technology skills into engineering curricula, and professional certifications and ongoing education requirements should be updated to include digital proficiency. The sectoral differences in integration noted in Section 4.3 imply that tailored, sector-specific national programmes may be more effective than uniform approaches, although this needs further validation with larger sample sizes.

5.3 | Limitations and Future Research

Several limitations qualify these findings and should be borne in mind when interpreting them.

First, the study used convenience sampling via professional online networks. Respondents were not randomly selected, no sampling frame was available, and more digitally engaged professionals were plausibly more likely to encounter and complete the survey. The findings describe this sample and should not be generalised to the Ghanaian engineering profession as a whole. Second, the design is cross-sectional, providing a single snapshot and offering no insight into how adoption, integration or perceived benefits evolve over time. Third, all measures are self-reported, and performance is captured as perceived impact rather than as an objectively measured outcome; common method variance and favourable self-assessment cannot be excluded, and no causal inference about the effect of digital technology on work performance is warranted. Fourth, all constructs were measured with single items, which constrains measurement precision and precludes assessment of internal consistency. Fifth, the analysis is descriptive, so reported patterns are associations observed in the data rather than estimated effects. Sixth, organisational context was captured only through individual respondents' reports of employer size and sector, which are not a substitute for organisational-level data.

These limitations point to five research directions. First, and most immediately, the relationship between digital training coverage and depth of integration should be examined directly by cross-tabulating the two items within the present response-level dataset, which would establish whether the two distributions reported separately in Sections 4.3 and 4.6 are in fact related at the respondent level. Second, the process mechanism outlined in Section 2.6, in which integration depth mediates the relationship between adoption and performance and training coverage moderates that relationship, should be specified and tested inferentially on multi-item measures and, ideally, on objectively measured performance outcomes. Third, longitudinal designs would establish how integration deepens over time and whether perceived benefits persist. Fourth, mixed-method work combining surveys with interviews would illuminate the decision processes behind the barriers identified here, particularly the nature of resistance to change. Fifth, comparative

studies across West African engineering communities would establish whether the adoption-integration gap documented here is specific to Ghana's development context or a more general feature of professional digitalisation in emerging economies.

AUTHOR CONTRIBUTIONS

All authors contributed equally to the article.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interests.

REFERENCES

- Adam, A.M. (2020) Sample size determination in survey research. *Journal of Scientific Research and Reports*, 26(5), 90–97.
- Baghalzadeh Shishehgharkhaneh, M., Keivani, A., Moehler, R.C., Jلوداري, N. & Roshdi Laleh, S. (2022) Internet of things (IoT), building information modeling (BIM), and digital twin (DT) in construction industry: A review, bibliometric, and network analysis. *Buildings*, 12(10), 1503. doi:10.3390/buildings12101503.
- Baker, J. (2012) The technology-organization-environment framework. In: Dwivedi, Y.K., Wade, M.R. & Schneberger, S.L. (Eds.) *Information Systems Theory*, Springer, pp. 231–245.
- Bassir, D., Lodge, H., Chang, H., Majak, J. & Chen, G. (2023) Application of artificial intelligence and machine learning for bim: Review. *International Journal for Simulation and Multidisciplinary Design Optimisation*, 14, 5.
- Bell, E., Bryman, A. & Harley, B. (2022) *Business Research Methods*, 6th Edition. Oxford: Oxford University Press.
- Boothby, D., Dufour, A. & Tang, J. (2010) Technology adoption, training and productivity performance. *Research Policy*, 39(5), 650–661. doi:10.1016/j.respol.2010.03.011.
- Duan, S.X., Deng, H. & Wibowo, S. (2024) Technology affordances for enhancing job performance in digital work. *Journal of Computer Information Systems*, 64(2), 232–244. doi:10.1080/08874417.2023.2188497.
- Diaz-Arancibia, J., Hochstetter-Diez, J., Bustamante-Mora, A., Sepúlveda-Cuevas, S., Albayay, I. & Arango-López, J. (2024) Navigating digital transformation and technology adoption: A literature review from small and medium-sized enterprises in developing countries. *Sustainability*, 16(14), 5946. doi:10.3390/su16145946.
- Egala, S.B., Amoah, J., Bashiru Jibril, A., Opoku, R. & Bruce, E. (2024) Digital transformation in an emerging economy: Exploring organizational drivers. *Cogent Social Sciences*, 10(1), 2302217.
- Gkrimpizi, T., Peristeras, V. & Magnisalis, I. (2023) Classification of barriers to digital transformation in higher education institutions: Systematic literature review. *Education Sciences*, 13(7), 746. doi:10.3390/educsci13070746.
- Gong, L. (2023) Digital technology adoption and innovation performance: A moderated mediation model. *Technology Analysis and Strategic Management*, 36(11), 3341–3356.
- Gurcan, F., Boztas, G.D., Dalveren, G.G.M. & Derawi, M. (2023) Digital transformation strategies, practices, and trends: A large-scale retrospective study based on machine learning. *Sustainability*, 15(9), 7496. doi:10.3390/su15097496.
- Hashim Mohammed, B., Sallehuddin, H., Safie, N., Husairi, A., Abu Bakar, N.A., Yahya, F. et al. (2022) Building information modeling and internet of things integration in the construction industry:

- A scoping study. *Advances in Civil Engineering*, 2022(1), 7886497. doi:10.1155/2022/7886497.
- Heidari, A., Peyvastehtar, Y. & Amanzadegan, M. (2024) A systematic review of the bim in construction: From smart building management to interoperability of bim and ai. *Architectural Science Review*, 67(3), 237–254. doi:10.1080/00038628.2023.2262401.
- Hortovanyi, L., Morgan, R.E., Herceg, I.V., Djuricin, D., Hanak, R., Horvath, D. et al. (2023) Assessment of digital maturity: the role of resources and capabilities in digital transformation in b2b firms. *International Journal of Production Research*, 61(23), 8043–8061.
- Huang, X., Liu, Y., Huang, L., Onstein, E. & Merschbrock, C. (2023) Bim and iot data fusion: The data process model perspective. *Automation in Construction*, 149, 104792. doi:10.1016/j.autcon.2023.104792.
- Kraus, S., Jones, P., Kailer, N., Weinmann, A., Chaparro-Banegas, N. & Roig-Tierno, N. (2021) Digital transformation: An overview of the current state of the art of research. *SAGE Open*, 11(1). doi:10.1177/21582440211047576.
- Kumar, R. (2019) *Research Methodology: A Step-by-Step Guide for Beginners*, 5th Edition. London: Sage Publications.
- Lakens, D. (2022) Sample size justification. *Collabra: Psychology*, 8(1), 33267. doi:10.1525/collabra.33267.
- Leesakul, N., Oostveen, A.M., Eimontaite, I., Wilson, M.L. & Hyde, R. (2022) Workplace 4.0: Exploring the implications of technology adoption in digital manufacturing on a sustainable workforce. *Sustainability*, 14(6), 3311. doi:10.3390/su14063311.
- Li, H. (2020) Technology adoption decisions: Effects of individual and environmental factors. *Information Systems Management*, 37(4), 298–315.
- Lissillour, R. & Sahut, J.M. (2022) Comment les plateformes peuvent-elles développer leurs collaborations avec des développeurs externes en quête de légitimité? *Management & Prospective*, 39(5), 109–155.
- Lissillour, R. & Sahut, J.M. (2026) What future for ai chatbots in banking: from current challenges to mirages? *Information Technology & People*, 39(5), 2027–2062.
- Luo, R. (2025) Utilisation of sustainable bim technology based on the internet of things in construction projects. *Journal of Engineering and Applied Science*, 72(1), 46.
- Memon, M.A., Ting, H., Cheah, J.H., Ramayah, T., Chuah, F. & Cham, T.H. (2020) Sample size for survey research: Review and recommendations. *Journal of Applied Structural Equation Modeling*, 4(2), i–xx.
- Mwaura, J. (2025) Navigating the digital horizon: Future trends and predictions in africa. *Dialogues on Digital Society*, 1(1), 24–28.
- Nassir-Deen, M.H., Cobblah, C., Lissillour, R. & Sahut, J.M. (2026) Trust and intention in the continued usage of hospital information systems in developing countries: The case of ghana. *Gestion et management public*, 14(2), 81–104.
- Nikou, S., De Reuver, M. & Mahboob Kanafi, M. (2022) Workplace literacy skills: How information and digital literacy affect adoption of digital technology. *Journal of Documentation*, 78(7), 371–391.
- Nyqvist, R., Peltokorpi, A., Lavikka, R. & Ainamo, A. (2025) Building the digital age: Management of digital transformation in the construction industry. *Construction Management and Economics*, 43(4), 262–283.
- Oke, A.E., Aliu, J. & Onajite, S.A. (2024) Barriers to the adoption of digital technologies for sustainable construction in a developing economy. *Architectural Engineering and Design Management*, 20(3), 431–447.
- Paul, J., Lim, W.M., O'Cass, A., Hao, A.W. & Bresciani, S. (2024) Digital transformation: A multidisciplinary perspective and future research agenda. *International Journal of Consumer Studies*, 48(1), e13015. doi:10.1111/ijcs.13015.
- Plekhanov, D., Franke, H. & Netland, T.H. (2023) Digital transformation: A review and research agenda. *European Management Journal*, 41(6), 821–844. doi:10.1016/j.emj.2023.01.006.
- Rinchen, S., Banihashemi, S. & Alkilani, S. (2024) Driving digital transformation in construction: Strategic insights into building information modelling adoption in developing countries. *Project Leadership and Society*, 5, 100138.
- Rogers, E.M. (2003) *Diffusion of Innovations*, 5th Edition. New York: Free Press.
- Sahin, I. (2006) Detailed review of rogers' diffusion of innovations theory and educational technology-related studies based on rogers' theory. *Turkish Online Journal of Educational Technology*, 5(2), 14–23.
- Signé, L. (2024) *Greening infrastructure in africa through digital transformation*. Brookings Policy Brief.
- Tornatzky, L.G. & Fleischer, M. (1990) *The Processes of Technological Innovation*. Lexington, MA: Lexington Books.
- United Nations in Ghana (2024) *2024 ghana digital and innovation week*. UN Ghana Communications.
- Yamane, T. (1967) *Statistics: An Introductory Analysis*, 2nd Edition. New York: Harper & Row.
- Yawson, F. (2024) *Innovation meets growth? navigating the digital landscape in ghana*. African Center for Economic Transformation Policy Brief.
- Zhou, D., Pei, B., Li, X., Jiang, D. & Wen, L. (2024) Innovative bim technology application in the construction management of highway. *Scientific Reports*, 14, 15298. doi:10.1038/s41598-024-65909-5.
- Zhu, K. & Kraemer, K.L. (2005) Post-adoption variations in usage and value of e-business by organizations: Cross-country evidence from the retail industry. *Information Systems Research*, 16(1), 61–84. doi:10.1287/isre.1050.0045.

AUTHORS BIOGRAPHY

Frank Boateng is a Chartered Global Management Accountant, Fellow of the Chartered Institute of Management Accountants, Chartered Accountant Ghana, Chartered Manager, and Fellow of the Chartered Management Institute UK. He is also a Chartered Professional Administrator and a Chartered Management Consultant with the Chartered Institute of Administrators and Management Consultants of Ghana. He holds a PhD in Management from Walden University in Minneapolis, MN, USA; a Master of Philosophy in Business Consulting and Enterprise Risk Management from Kwame Nkrumah University of Science and Technology in Ghana; and an MBA in Finance from the University of Leicester Business School in the UK. He has a Bachelor of Science in Business Administration (Accounting option) and a Bachelor of Laws, both from the Central University Business School and Law Faculty, respectively. Dr Boateng has over twenty (21) years' experience in the mining industry and has held positions including Assistant Accountant, Senior Accountant, Accounts Payable Manager, Senior Business Analyst, Financial Controller, Finance Administration Manager, Commercial Manager, Country Managing Director, and Group CEO. He has served as an adviser and Board Member on Boards in Ghana and the United States of America. Currently, Dr Boateng is a Council Member of CIMA, a Senior Lecturer and Acting Director of the Institute of Minerals Resource Investments and Governance at the University of Mines and Technology, Tarkwa.

Clifford Benjamin Oppong holds an MSc in Engineering Management from the University of Mines and Technology (UMaT), Tarkwa,

a BSc in Construction Technology Education from the University of Education, Winneba, and an HND in Civil Engineering from Kumasi Technical University, where he graduated as the best student in the Civil Engineering Department. He is a certified Project Management Professional (PMP) with the Project Management Institute and holds the Google Project Management Certificate. His professional career spans engineering, construction, industrial operations and technology in Ghana and across Africa. He began as a Field Engineer with the Electricity Company of Ghana, working on distribution asset assessment and quality control, and later managed construction delivery in the mining sector, including the Tetrem Resettlement Project for Asanko Mining and the Ahafo North project for Newmont. He later served as Production Manager at Bordar-HKC Company Limited, leading process and workforce improvements in manufacturing operations, and as Chief Revenue Officer at FlipJungle AI Lab, where he led the company's expansion into South Africa, Nigeria and Ghana. He is the founder and Chief Executive Officer of Hues Apply AI, an artificial intelligence platform connecting young Africans to education and employment opportunities, and the founder and Managing Director of 6Cubits, an advisory practice supporting technology adoption and enterprise productivity among Ghanaian small and medium enterprises. His research interests include technology adoption and integration, digital transformation and organisational change in the construction, mining, and energy sectors, and the application of artificial intelligence to workforce development and employment outcomes in Africa. His master's research examined the relationship between technology adoption and work performance across Ghanaian industry, with particular attention to why adoption frequently fails to translate into measurable performance gains.

Akyene Tetteh is a Senior Lecturer in the Department of Management Studies at the University of Mines and Technology, Tarkwa, Ghana. He holds a PhD in Economic Management, Decision Making, and Analysis from Donghua University, China. He lectures in Supply Chain Management, Management Science, and related areas; he is also a researcher, and his research focuses on Supply Chain Management, Decision Science, and International Finance.