UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG 100 1922 2022 | WABER CONFERENCE | SuDBE SOUTH AFRICA 2024

PROCEEDINGS OF THE WABER SuDBE CONFERENCE 2024

30 – 31 July 2024
University of the Witwatersrand
Johannesburg, South Africa

EDITORS

Prof. Samuel Laryea, University of the Witwatersrand, South Africa
Prof. Baizhan Li, Chongqing University, China
A/Prof. Emmanuel Adu Essah, University of Reading, United Kingdom
A/Prof. Sarfo Mensah, Kumasi Technical University, Ghana
Prof. Hong Liu, Chongqing University, China
Prof. Runming Yao, University of Reading, UK/Chongqing University, China

ISBN: 978-0-7961-6032-4

In collaboration with:

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG 100 1922 2022
重慶大學 CHONGQING UNIVERSITY
UNIVERSITY OF CAMBRIDGE
UCL
University of Reading
清華大学 Tsinghua University
中国建筑科学研究院有限公司 China Academy of Building Research
GROWTHPOINT PROPERTIES
SCHOOL OF CONSTRUCTION ECONOMICS & MANAGEMENT
cidb Construction Industry Development Board
A&O SHEARMAN

Proceedings of the WABER SuDBE 2024 Conference

30th – 31st July 2024

University of the Witwatersrand, Johannesburg, South Africa

ISBN: 978-0-7961-6032-4 (e-book)

The ISBN for this publication was provided by the National Library of South Africa. Legal deposits of the publication have been supplied to the National Library of South Africa, Library of Parliament, and other places of Legal Deposit.

First published in July 2024

Published by:
WABER SuDBE Conference 2024
C/o Professor Samuel Laryea, Conference chair
School of Construction Economics and Management
University of the Witwatersrand, Johannesburg, South Africa
Email: info@wabersudbeconference.com / samuel.laryea@wits.ac.za
Website: www.wabersudbeconference.com

Editors

Prof Samuel Laryea, University of the Witwatersrand, South Africa
Prof Baizhan Li, Chongqing University, China
A/Prof Emmanuel Adu Essah, University of Reading, United Kingdom
A/Prof Sarfo Mensah, Kumasi Technical University, Ghana
Prof Hong Liu, Chongqing University, China
Prof Runming Yao, University of Reading, UK / Chongqing University, China

Declaration

All papers in this publication have been through a review process involving a review of abstracts, peer review of full papers by at least two referees, reporting of comments to authors, revision of papers by authors and re-evaluation of the revised papers to ensure quality of content.

ISBN: 978-0-7961-6032-4

A DIGITAL SKILLS GAP ANALYSIS OF BUILDING INSPECTORS: THE CASE OF THE CITY OF JOHANNESBURG METROPOLITAN AUTHORITY

Faranani Gethe[1], Bankole Awuzie[2], Prisca Simbanegavi[3] and Maruping Broderick Chiloane[4]

[1,3]*School of Construction Economics and Management, University of the Witwatersrand, Johannesburg, South Africa,*

[2]*Department of Construction Management Quantity Surveying, University of Johannesburg, Johannesburg, South Africa,*

[4]*Building Development Management, City of Johannesburg, Johannesburg, South Africa*

The utility of digital technologies in improving building inspection functions has been elucidated by relevant literature. However, the ability of building inspectors to deploy these technologies remains contentious as a paucity of studies, highlighting the digital capabilities possessed by these cohort has been observed. To bridge this gap, this study conducts a digital skills gap analysis of building inspectors in Johannesburg, South Africa. The study adopts a case study research strategy with a selected building inspectorate unit in South Africa's Gauteng province serving as the case study. Data was elicited within case surveys, 41 building inspectors responded out of 70 total population sampling sent out. Data was analyzed using descriptive and inferential statistics in SPSS. Results show substantial levels of digital illiteracy among building inspectors in the City of Johannesburg yet little drive-in adoption of the digital technologies in conducting building inspections. It is clear from this study that essential competencies required for the adoption of digital technologies are not at the acceptable level for practical application in the case of Johannesburg. Besides elucidating the growing importance of digital technologies in the execution of building inspection functions in developing countries, the study provides considerable insight into the existence of a skills gap which limits the ability of building inspectors to engage in the increased uptake of these technologies.

Keywords: building inspectors, digital skills, digital technologies, gap analysis

INTRODUCTION

Recently, a rise in the uptake of digital technologies in the architecture, engineering, and construction (AECO) sectors has been reported (Aliu & Oke, 2023). This upward trajectory has been attributed to the contribution of these technologies towards efficiencies in time and cost as well as mitigation of safety risks associated with the plethora of activities inherent in the sector (Awuzie & Moghayedi, 2024). Also, the emergence of the 4th industrial revolution (4IR) era and the increasing quest for sustainable futures in contemporary society have heightened the demand for these technologies due to their famed potential to engender

[1] faranani.gethe@wits.ac.za
[2] boawuzie@uj.ac.za
[3] prisca.simbanegavi@wits.ac.za
[4] marupingbroderickC@joburg.org.za

Gethe, *et al.* (2024) A digital skills gap analysis of building inspectors: the case of the City of Johannesburg Metropolitan Authority In: Laryea, S. *et al.* (Eds) Proceedings of the WABER SuDBE Conference, 30 to 31 July 2024, Johannesburg, South Africa 946-956

improved sustainability performance across all facets of societal endeavour (Awuzie & Moghayedi, 2024).

The utilization of digital technologies like Internet of Things (IoT), Artificial Intelligence (AI), Unmanned Aerial Vehicles (UAVs), Blockchain, Smart Contracts, Cloud Computing and Big Data analytics, amongst others across the lifecycle of construction projects and built assets for various purposes including procurement, construction, operations, management, and end-of-life decommissioning respectively, enjoys robust reportage (Aliu & Oke, 2023). Whilst the literature on the usefulness of these technologies across these phases to facilitate effective, efficient, and sustainable construction project delivery and facilities management has gained traction, studies detailing their application in the execution of activities relating to building inspection remains limited (Einizinab et al., 2023).

Scholars admit the significance of the building inspectorate functions as it pertains to engendering compliance with relevant by-laws, building codes and/or zoning ordinances during the development of built assets whilst ensuring harmony with the natural environment and improved health and wellbeing of building occupants (Einizinab et al., 2023; Ferraz, et al., 2016). Building inspection activities have also been known to highlight the technical performance of built assets and provide requisite information guiding the determination of planning maintenance regimes to enhance building functionality (Ferraz, et al., 2016). To buttress the significance of such functions, various countries have promulgated and implemented relevant legislations to govern building inspection functions within their respective jurisdictions. For instance, a country like Hong Kong mandates the inspection of buildings aged over 30 years once every 10 years and in Malaysia, the government has been reported as demanding the inspection of buildings based on a prescribed Total Asset Management Manual (Bortolini & Forcada, 2018). Similarly in South Africa, the National Building Regulations and Building Standards Act 103 of 1977 as amended serves as the definitive legal framework for governing building inspection functions. The responsibility for the administration of this framework rests with local authorities, typically in the form of building control officers and /or building inspectors (NBR, 1977).

However, it should be noted that whereas these building inspection functions span pre-development, development and operations and maintenance phases (City of Johannesburg, 2023; Barbanente, & Maiellaro,1998), most literature detailing the application of digital technologies in improving the performance levels therein have focused on the conduct of these functions during the operations and maintenance phases of the built asset’s lifecycle. The lack of reportage on the application of digital technologies for carrying out building inspection functions relating to all phases across the lifecycle of the built asset is worrisome as the use of manual approaches has met with considerable difficulties owing to the increasing complexities associated with contemporary building designs and construction methods (Meno, 2020). Scholars have admitted to these manual approaches being riddled with inconsistences and subjective judgements which do not portray an accurate depiction of the current state of the buildings being inspected (Elghaish et al., 2021; Tekin, 2022). To overcome such shortcomings, the increased use of digital technologies during building inspections.

Whilst the demonstration of the utility of these technologies during building inspection appears to be gaining ascendancy in the corpus of relevant literature (Ma & Hartmann, 2023; Einizinab et al., 2023), insights into the nature and availability of requisite competences needed by building inspectors to adopt and utilize such technologies appears scant. This is particularly the case in the South African context where attempts at the professionalization of the building inspectorate is currently at embryonic levels. Recently, the South African Council of Project and Construction Management Professions (SACPCMP) has developed a pathway to facilitate this objective. As its contribution towards the addressing this knowledge-practice gap, this exploratory study, which forms part of a broader study focusing on the development of a digital capability development framework for building inspectors in South Africa, seeks to establish the digital skills gap prevalent within the building inspectorate, albeit with a focus on the City of Johannesburg's building inspectorate. To achieve this objective, the study will be seeking answers to the following questions based on the perceptions of the participants:

What kind of digital technologies can be/are being used during building inspections?

What skillsets are required to use these technologies for building inspections and what percentage of the staff of the building inspectorate are in possession of such skills?

What is the degree of willingness exhibited by the staff of the building inspectorate to adopt and deploy these technologies in the execution of their assigned functions?

It is expected that the results of this study, whilst not generalizable, would engender further investigations towards determining the digital skills mix required to facilitate increased adoption of digital technologies by South African building inspectors.

FUNDAMENTAL BUILDING CONTROL AND INSPECTION FUNCTIONS

The primary objective of building control and codes in South Africa is for the promotion of uniformity in the law relating to the erection and maintenance of buildings in areas falling under the authority of various local authorities; prescription of building standards; and for matters connected therewith (Gazette & Notice, 1977). Building inspections as performed by building inspectors have served as a means through which impetus has been given to the attainment of this objective by local authorities in the country. These building inspectors conduct inspections of building projects within the jurisdiction of the local authority and enforce compliance to building regulations and codes. This process usually commences from plan submission and approval where building plans are examined to ensure compliance with the extant building codes. A building permit is issued in accordance with Section 4 of the Building Standards Act which permits the owner to commence with actual construction works. During this stage, building inspections are conducted to ensure compliance and adherence to the approved plans.

The building inspection process consists of two categories: non-mandatory and mandatory inspections. Non-mandatory inspections provide for the monitoring building work on site, as well as quality and safety thereof (Baiche et al., 2006; Gazette & Notice, 1977). Impliedly, inspection activities in this category are not compulsory but fall within the discretionary remit of the area building inspector. The complex and large projects usually get more non-mandatory inspections to minimize risks associated with magnitude and complexity of the project (Einizinab et al., 2023). Contrarily, mandatory inspections are compulsory inspections set out in the regulations which an area building inspector is required to conduct every building structure that is erected within his/her district to ensure compliance to the relevant laws (Baiche et al., 2006; Gazette & Notice, 1977; Tekin, 2022). The mandatory inspections consist of setting out, foundations, open drainage system and final building inspections, respectively.

Setting out inspection involves confirmation of the building footprint by the area building inspector using the approved building plans undertakes a task to verify if markings correspond with the dimensions of the approved plan. This inspection concentrates on various aspects such as boundary/building lines, accessibility, environmental considerations, utilities connection (water, electricity), levels & dimensions. The foundations inspections examine the structural integrity and compliance of the foundation to the building code or rational design of the structural engineer. It involves verifying the compliance of foundation type, materials, methods, and dimensions. The third inspection is the open drainage system inspection which is very crucial in preventing health hazards associated with hygiene and environmental contamination. This inspection involves examining sewer pipes, its levels, connections, and compliance with the building codes. The final inspection is the last step of the building control processes where area building inspector satisfies himself before issuing the certificate of occupancy. This inspection looks at aspects such as structural integrity, safety compliance, functionality of building systems, finishes, and required documentation. The building inspector will usually create a punch list for the builder/ owner to complete if he/she is not completely satisfied after the inspection before issuing Occupation certificate (Gazette & Notice, 1977).

Despite the growing use of digital technologies around the world, all four mentioned mandatory inspections are currently conducted using conventional methods of visual survey performed by inspector to verify compliance with permit and approved plans (Dias et al., 2021; Einizinab et al., 2023; Shafei et al., 2022). These visual surveys have been described as unreliable, hence the need for increased uptake of digital technologies (Ma & Hartmann, 2023).

USE OF DIGITAL TECHNOLOGIES FOR MANDATORY BUILDING INSPECTIONS

Einizinab et al., (2023) identified conventional inspection, remote inspection, and assistant-based inspection as three pathways for executing mandatory building inspections. The conventional inspection requires the area building inspector to be physically present on site to collect inspection data. This is the most adopted pathway in South Africa. Remote inspection does not require the physical presence of the inspector on the construction site as sensors are deployed for inspection data collection. The area building inspector will extract inspection data from sensors and proceed to determine the compliance status of the building and building components. The third approach “Assistant-based inspection” does not necessarily require the physical building inspector on the construction site but an assistant to operate the data acquisition technology and extract inspection data. The extracted inspection data is subsequently presented to the building inspector for determining the degree of compliance. However, processes relating to the assistant-based inspection are increasingly being automated and/or digitized (intelligent assistant-based inspections) (Barbanente & Maiellaro, 1998; Einizinab et al., 2023).

Various digital technologies have been adopted for remote and assistant-based inspection pathways. One such technology which has enjoyed considerable deployment for this purpose is the IoT. This refers to the network of sensors which are connected to a specific device to feed it with real time data using the internet. When applied in mandatory building inspections, IoTs can be used to collect real time inspection data about the sizes of the trenches, concrete, strength, etc (Einizinab et al., 2023; Meno, 2020; Shafei et al., 2022). Drones, otherwise referred to as UAVs, have also been used for mandatory building inspection activities (Eiris et al., 2021). UAVs are devices which are flown with the aid of a remote controller and usually fitted with high resolution cameras, sensors and aligned functions depending on the intended use (Rachmawati & Kim, 2022). For mandatory inspections, they collect data during setting out inspection, verifying boundaries, building lines and position of the building. They may also be used for open drain inspection to verify its mapping and connection points (Einizinab et al., 2023). Scholars have also reported the use of extended (virtual, augmented and/or mixed) (XR) reality platforms for the conduct of building inspections due to their utility in enhancing the visualization of reality on a real-time basis (Becker et al, 2023; Al-Sabbag et al., 2020). In mandatory building inspections, extended reality has been used to visualize the approved design versus the as built design during the final inspection to verify any discrepancies that might exist (Einizinab et al., 2023). Also, Khairadeen et al (2021) point to the usefulness of extended reality platforms in facilitating remote monitoring construction progress in indoor environment.

The Geographic Information System (GIS) and BIM have also been been deployed for building inspection purposes (AlSaggaf & Jrade, 2023). Whereas the GIS is an information system that stores, manages, visualizes, and analyses geographic data such as maps, addresses, land use rights, etc., BIM is an information system that stores, manages, visualizes, and analyses data of a building and its elements. Both systems play a critical role in advancing the efficacy of building inspections. GIS provides critical data in setting out, foundations and open drain inspections, while BIM provides critical data in final inspection to verify the as built against the desired design (Liu et al, 2017). Furthermore, Reality Capture Sensors (RCS) have been used for capturing and digitalizing physical/ real environments, objects, or structures into a detailed digital representation (Fobiri et al., 2024; Law et al., 2023) In mandatory building inspections, RCS is used for inspections such as open drainage system and foundations. The detailed representation can subsequently be compared to the building's BIM prototype. In their study, Ma and Hartman (2023) highlighted the relevance of Robots in the conduct of building inspections. They proposed an ontology titled RoboDesign which integrates two main ontology models: the robot system and the building and defect model respectively in the conduct of remote or assistant-based building inspection functions.

Whereas these technologies can be used individually for building inspection functions, extant literature is replete of examples where they have been combined to bring about improved outcomes. John Samuel et al (2022) and Pan and Isnaneni (2024) highlight the utility of a BIM and XR combination whilst Liu et al (2017) and AlSagaf & Jrade (2023) demonstrated the applicability of a BIM and GIS combination. Bognot et al (2018) adumbrated the salient contribution of the combination of UAVs, low-cost photogrammetry, and GIS for building inspection activities.

Based on the foregoing, the significant contributions of these technologies to successful building inspection functions can be deciphered. However, despite the emergence and increased uptake of these technologies in the AECO sector, limited studies have investigated the factors influencing their implementation by building inspectors, especially within the South African context. This observation has given rise to the need to explore the level of knowledge prevalent among this community of practice and to determine any gaps in digital skills which may potentially hinder the adoption of these technologies, therein.

ESSENTIAL DIGITAL SKILLS/COMPETENCIES

The emergence of these digital technologies necessitates the development of new skills and competencies to ensure their effective deployment. These technologies introduce environments characterized by vast amounts of data, human-machine interaction, network connectivity, computerization, interfaces, and control tasks (Adepoju & Aigbavboa, 2021). Consequently, users must possess a specialized skill set to navigate these environments effectively.

In today's digital landscape, Cyber protection and security are crucial skills. This primarily involves safeguarding data and information against unauthorized access. In the context of building inspections, digital technologies are data-driven, and users must be capable of protecting this data from unauthorized access. Similarly, proficiency in computer programming is essential. This skill is predicated on problem-solving, algorithmic thinking, and an understanding of fundamental concepts such as data structures, algorithms, and software development principles. Digital technologies used in building inspections rely on software and applications, necessitating the possession of this proficiency. Data processing entails techniques for transforming and preparing raw data for analysis, including tasks such as data cleaning, normalization, and aggregation. Data analytics focuses on extracting meaningful insights and patterns from data to support decision-making and drive business outcomes. During building inspections, data collected from inspections play a crucial role in decision-making. Unlike conventional methods, data is now collected through digital tools, requiring building inspectors to possess skills in data cleaning and processing for appropriate use.

The lack of essential skills and competencies in digital technologies can lead to errors, non-compliance, delays, and increased costs. While the benefits of digital technologies in building inspections are significant, they can only be fully realized if users possess the appropriate skills and competencies (Adepoju & Aigbavboa, 2021; Elghaish et al., 2021).

METHODS

To achieve its objective, this study adopts a case study research strategy wherein a building inspectorate unit within the City of Johannesburg municipality in South Africa’s Gauteng province was selected as a case. A closed ended structured questionnaire was used to elicit information from the respondents. The questionnaire is comprised of four sections with a total of 10 questions. Section A contains items measuring the background of the respondents, Section B accessed the knowledge of digital technologies in building inspections, Section C assessed the essential skills possessed by the building inspectors and lastly Section D assessed the willingness to adopt the digital technologies.

Data was elicited using a survey of 70 total population sampling of building inspectors working across seven regions covered by the City of Johannesburg municipality. Of the 70 questionnaires administered electronically, only 41 were returned and used for this study hence marking a response rate of 56%. Data was analyzed using descriptive statistics, specifically, mean item scores (MIS) and standard deviation with the aid of the Statistical Package for Social Science (SPSS) version 29.0.2.20 (20).

ANALYSIS AND DISCUSSION OF RESULTS

Background information of the respondents

Table 1: depicts the distribution of respondents’ demographics.

Gender		
Male	23	56.1%
Female	18	43.9%
Age		
18 -29	1	2.4%
30 - 49	30	73.2%
50 and older	10	24.4%
Years of experience as a Building Inspector		
0 - 2	7	17.1%
3 - 6	11	26.8%
7 - 10	10	24.4%

11 - 15	2	4.9%
Over 15	11	26.8%

Highest Qualification		
0 - 2	7	17.1%
3 - 6	11	26.8%
7 - 10	10	24.4%
11 - 15	2	4.9%
Over 15	11	26.8%

Among the respondents, 56.1% were male and 43.9% were female. The age distribution was categorized into three groups: a mere 2.4% were aged 18-29, the majority of 73.2% fell within the 30-49 range, and 24.4% were aged 50 and above. Experience levels among the inspectors were relatively even, with 26.8% having 3-6 years of experience, 26.8% with over 15 years, 24.4% with 7-10 years, 17.1% with 0-2 years, and only 4.9% with 11-15 years of experience.

The qualifications of respondents showed that 68.3% possessed a national diploma, followed by 12.2% with a bachelor's degree, 9.8% with matric, 7.3% with a master's degree, and 2.4% with a postgraduate diploma. The predominance of inspectors with only a diploma may present challenges in fostering awareness and adoption of digital technologies, which are more commonly addressed in further studies as they are relatively new skill.

Furthermore, it has been observed that older employees tend to be more resistant to change, possibly due to a belief that it is too late to acquire new skills or competencies. While male respondents slightly outnumbered females among the respondents, the difference was not considered substantial, which bodes well for diversity and inclusivity. However, there is a notable lack of representation among younger inspectors aged 18-29, indicating a potential gap in age diversity within the department unit.

Knowledge of the digital technologies in building inspection

Figure 1 presents a histogram that outlines the self-assessed knowledge levels of digital technologies among building inspectors. The data reveals that a plurality, 41.5% (17 respondents), consider their knowledge to be moderate. This is followed by 24.4% (10 respondents) who rate their knowledge as poor. The mean score of 3.12 suggests an overall moderate understanding of digital technologies within the group. Furthermore, a standard deviation of 0.98 indicates a tight clustering of responses around the mean, signifying relative homogeneity in knowledge levels.

Table 2: General knowledge of digital technologies in building inspections

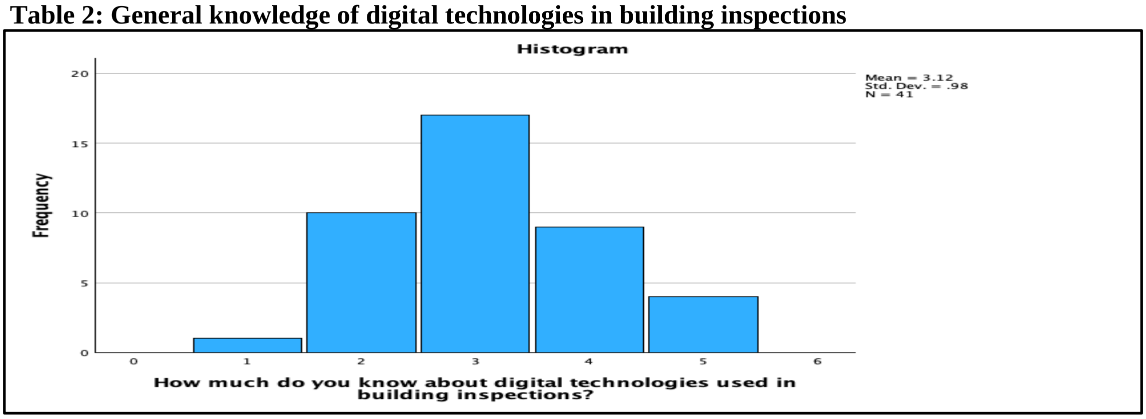

Table 2 presents the proficiency levels of building inspectors as it pertains to the use of various digital technologies, as determined by a survey employing a 1-5 Likert scale ranging from 1 'no knowledge' to 5 'very good knowledge.' Out of the 41 responses, Geographic Information Systems (GIS) attracted an average score of 3.72, reflecting moderate proficiency levels. Internet of Things (IoT) technology recorded a mean of 3.27, indicating moderate proficiency levels. However, a standard deviation of 1.073 points to a wider dispersion of responses. Extended reality received an average score of 2.42, suggesting a near-poor level of proficiency among the respondents. Building Information Modeling (BIM) and reality capture sensors each had 39 valid responses, with mean scores of 2.79 and 2.33 respectively, indicating a poor familiarity. Lastly, UAVs had a mean score of 2.39, implying an overall poor proficiency level among the inspectors.

Table 3: Knowledge about different technologies used in building inspections

	N	Minimum	Maximum	Mean	Std Deviation
Geographic Information Systems (GIS)	40	1	5	3.72	.847
Internet of things	41	1	5	3.27	1.073
BIM (Building Information Modelling)	39	1	5	2.79	1.031
Extended reality	38	1	4	2.42	.948
UAVs (drones)	41	1	5	2.39	.972
Reality capture sensors	39	1	4	2.33	.955
Valid N (listwise)	38				

Skills gap analysis

In this section, results of the skills gap analysis are presented.

Table 4: Required Competences

	N	Minimum	Maximum	Mean	Std. Deviation
Cyber Protection & Security	39	1	4	2.36	.932
Data & information processing	39	1	4	2.33	.982
Computer programming	39	1	5	2.28	1.075
Data & information analytics	39	1	4	2.26	.966
Valid N (listwise)	39				

Table 4 provides insights into the degree to which the respondents possessed core competencies necessary to effectively implement digital technologies. Survey participants rated their proficiency based on a Likert scale from 1 to 5, with 1 representing 'no knowledge' and 5 indicating 'very good knowledge.' The mean scores for each competency ranged between 2.2 and 2.3, suggesting a general lack of knowledge or at best, poor knowledge in these areas. Specifically, the competency in Cyber protection & security had a mean score of 2.36 with a standard deviation of 0.932, reflecting a concentration of responses around the mean, a pattern also observed in the Data & Information Processing competency. Competencies in Computer Programming and Data Analytics recorded slightly lower mean scores of 2.28 and 2.26 respectively, indicating a level of knowledge closer to none. Notably, Computer Programming exhibited a marginally higher standard deviation, revealing a broader dispersion of responses from Mean.

Organizational commitment and availability of training opportunities

In this section, the results regarding the perception of the respondents on the organizational commitment towards the adoption of these technologies and associated offerings of training opportunities regarding the use of these digital technologies are articulated.

Regarding the organizational commitment to technological adoption, 53.7% of the respondents perceive a lack of significant effort to embrace and use these technologies, in contrast to 41.5% who recognize a substantial drive towards their adoption and implementation.

Concerning exposure training and adoption and utilization of digital technologies within the case unit, 61% of the respondents admitted that they had not received any training related to digital technologies, while only 34.1% admitted to having undertaken some training in this regard. Additionally, 4.9% of respondents did not answer the question on training.

Judging on the foregoing, the utility of digital technologies in enabling optimal building inspection outcomes can be discerned. However, the lack of the relevant skillsets required to drive the adoption of these technologies among the respondents within the case department was elucidated. Also, the perceived low levels of organizational commitment towards the increased adoption of digital technologies which correlates with the minimal number of respondents who had been exposed to training opportunities relating to these technologies was enunciated through the results.

CONCLUSIONS AND LIMITATIONS

This study reports on the outcome of an exploratory investigation into the availability or otherwise of some digital skills amongst building inspectors working for the City of Johannesburg metro in South Africa. This investigation was predicated on the benefits associated with the deployment of a plethora of digital technologies towards effective and efficient building inspections in the area. Furthermore, the study was borne out of concerns about the paucity of studies seeking to establish the degree of proficiency possessed by building inspectors as it pertains the knowledge and use of these technologies.

Results from the study confirm limited knowledge and a considerable digital skills gap among the staff of the case building inspectorate. Also, the results indicate low levels of organizational commitment therein to enhance adoption of these technologies as well as the limited exposure of the staff to training opportunities to gain relevant skills required to use these technologies.

Although the results from this study cannot be generalized owing to the limited number of respondents- a significant limitation, they hold salient implications for the management of municipality councils in South Africa with regards to the need to upskill their staff to play salient roles in the imminent transition towards digitally enabled building inspection functions in South Africa. It is expected that further studies will be conducted using a variety of research methods and incorporating a broader spectrum of the relevant population to arrive at generalizable outcomes and associated theoretical advancements.

ACKNOWLEDGEMENT

We extend our deepest gratitude to the Wits CIDB Centre of Excellence for their generous funding support of this research. The centre’s support enabled the lead author to attend and present this work at the 2024 WABER SUDBE Conference in Johannesburg.

REFERENCES

Adepoju, O. O., & Aigbavboa, C. O. (2021). Assessing knowledge and skills gap for construction 4.0 in a developing economy. Journal of Public Affairs, 21(3). https://doi.org/10.1002/pa.2264

Al-Sabbag, Z. A., Connelly, J. P., Yeum, C. M., & Narasimhan, S. (2020). Real-Time quantitative visual inspection using extended reality. Journal of Computational Vision and Imaging Systems, 6(1), 1-3.

AlSaggaf, A., & Jrade, A. (2023). ArcSPAT: an integrated building information modeling (BIM) and geographic information system (GIS) model for site layout planning. International Journal of Construction Management, 23(3), 505-527.

Aliu, J., & Oke, A. E. (2023). Construction in the digital age: exploring the benefits of digital technologies. Built Environment Project and Asset Management, 13(3), 412-429.

Awuzie, B., & Moghayedi, A. (2024). Harnessing 4IR/5IR technologies for improved procurement and delivery. In Routledge Handbook of Construction Project Procurement and Delivery (pp. 371-390). Routledge.

Baiche, B., Walliman, N., & Ogden, R. (2006). Compliance with building regulations in England and Wales. Structural Survey, 24(4), 279–299. https://doi.org/10.1108/02630800610704427

Barbanente, A., & Maiellaro, N. (1998). An intelligent assistant for building inspection. Computers, environment, and urban systems, 22(3), 257-275.

Becker, S., Einizinab, S., Radanovic, S., Khoshelham, K., Mirzaei, K., & Fang, Y. (2023). Reality Capture Methods for Remote Inspection of Building Work. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 48, 275-281.

Bognot, J. R., Candido, C. G., Blanco, A. C., & Montelibano, J. R. Y. (2018). Building construction progress monitoring using unmanned aerial system (UAS), low-cost photogrammetry, and geographic information system (GIS). ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 4, 41-47.

Dias, I. S., Flores-Colen, I., & Silva, A. (2021). Critical analysis about emerging technologies for Building’s façade inspection. Buildings, 11(2), 1–19. https://doi.org/10.3390/buildings11020053

Einizinab, S., Khoshelham, K., Winter, S., Christopher, P., Fang, Y., Windholz, E., Radanovic, M., & Hu, S. (2023). Enabling technologies for remote and virtual inspection of building work. Automation in Construction (Vol. 156). ttps://doi.org/10.1016/j.autcon.2023.105096

Eiris, R., Albeaino, G., Gheisari, M., Benda, W., & Faris, R. (2021). InDrone: a 2D-based drone flight behavior visualization platform for indoor building inspection. Smart and Sustainable Built Environment, 10(3), 438-456.

Elghaish, F., Matarneh, S., Talebi, S., Kagioglou, M., Hosseini, M. R., & Abrishami, S. (2021). Toward digitalization in the construction industry with immersive and drone technologies: a critical literature review. Smart and Sustainable Built Environment, 10(3), 345–363. https://doi.org/10.1108/SASBE-06-2020-0077

Fobiri, G., Musonda, I., & Muleya, F. (2024). Unlocking the full potential of reality capture for construction project cost monitoring: a mixed review. Journal of Engineering, Design and Technology (article in press)

Freimuth, H., & König, M. (2018). Planning and executing construction inspections with unmanned aerial vehicles. Automation in Construction, 96, 540-553.

Ferraz, G. T., De Brito, J., De Freitas, V. P., & Silvestre, J. D. (2016). State-of-the-art review of building inspection systems. Journal of performance of constructed facilities, 30(5), 04016018.

Gazette, G., & Notice, G. (1977). National Building Regulations and Building Standards Act.

John Samuel, I., Salem, O., & He, S. (2022). Defect-oriented supportive bridge inspection system featuring building information modeling and augmented reality. Innovative Infrastructure Solutions, 7(4), 247.

Khairadeen Ali, A., Lee, O. J., Lee, D., & Park, C. (2021). Remote indoor construction progress monitoring using extended reality. Sustainability, 13(4), 2290.

Law, T., Yang, L., Vrcelj, Z., Miao, Y., Sandanayake, M., Gu, B., & Wang, X. D. (2023). The safety impetus for the adoption of reality capture for remote virtual site inspections. In Handbook of Construction Safety, Health, and Well-being in the Industry 4.0 Era (pp. 65-78). Routledge.

Liu, X., Wang, X., Wright, G., Cheng, J. C., Li, X., & Liu, R. (2017). A state-of-the-art review on the integration of Building Information Modeling (BIM) and Geographic Information System (GIS). ISPRS International Journal of Geo-Information, 6(2), 53.

Liu, D., Xia, X., Chen, J., & Li, S. (2021). Integrating building information model and augmented reality for drone-based building inspection. Journal of Computing in Civil Engineering, 35(2), 04020073.

Ma, L., & Hartmann, T. (2023). A proposed ontology to support the hardware design of building inspection robot systems. Advanced Engineering Informatics, 55, 101851.

Meno, T. (2020). An Assessment of Risk Associated with Digitalisation in the South African Construction Industry. (Master’s Dissertation). Johannesburg: University of Johannesburg. Available from: http://hdl.handle.net/102000/0002 (Accessed: 28 January 2024)

Pan, N. H., & Isnaeni, N. N. (2024). Integration of Augmented Reality and Building Information Modeling for Enhanced Construction Inspection—A Case Study. Buildings, 14(3), 612.

Rachmawati, T. S. N., & Kim, S. (2022). Unmanned Aerial Vehicles (UAV) Integration with Digital Technologies toward Construction 4.0: A Systematic Literature Review. Sustainability Vol. 14, Issue 9. https://doi.org/10.3390/su14095708

Shafei, H., Radzi, A. R., Algahtany, M., & Rahman, R. A. (2022). Construction 4.0 Technologies and Decision-Making: A Systematic Review and Gap Analysis. Buildings Vol. 12 (12) https://doi.org/10.3390/buildings12122206

Tekin, H. (2022). Assessment of Risks in Building Inspection Services during and Post-COVID-19 Pandemic. ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, Part A: Civil Engineering, 8(2). https://doi.org/10.1061/ajrua6.0001214

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

100
1922
2022