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Author(s)	Kabemba Steve Ngoy, Abimbola Windapo, Olugbenga Timo Oladinrin and Muhammad Qasim Rana
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Article

Digital Platforms, Structural Barriers and Gender Inclusion: A Systemic Model for the South African Construction Industry

Kabemba Steve Ngoy ^{1,*}, Abimbola Windapo ¹, Olugbenga Timo Oladinrin ², João Alencastro ²
and Muhammad Qasim Rana ³

¹ Department of Construction Economics and Management, Faculty of Engineering and the Built Environment, University of Cape Town, Rondebosch, Cape Town 7700, South Africa; abimbola.windapo@uct.ac.za

² School of Art, Design and Architecture, Faculty of Arts, Humanities and Business, University of Plymouth, Plymouth PL4 8AA, UK; olugbenga.oladinrin@plymouth.ac.uk (O.T.O.); joao.alencastro@plymouth.ac.uk (J.A.)

³ Construction Management, University of the Built Environment, Horizons, 60 Queen's Road, Reading RG1 4BS, UK; m.rana@ube.ac.uk

* Correspondence: kabembasteve7@gmail.com or kabemba.ngoy@uct.ac.za; Tel.: +27-63-339-4148

Abstract

This study examines the systemic structures that limit inclusivity, diversity, equality, and accessibility (IDEA) in South Africa's construction industry. It develops an empirically grounded framework, linking digital platform/tool (software tools and systems that facilitate construction processes) adoption to the institutional changes needed to advance gender equity. Building on a literature review, an online survey of 112 Construction Industry Development Board (Cidb)-registered practitioners was analyzed in SPSS v26 using descriptive and inferential statistics and principal component analysis (PCA). Results show that gender differences in mastery of core digital tools were not statistically significant ($p > 0.05$ across tool categories). The regression model predicting perceived career growth showed weak explanatory power and was not statistically significant ($R^2 = 0.068$; $F(10,100) = 0.734$; $p = 0.691$). Accordingly, the non-significant model is interpreted as indicating that the predictors included are insufficient to explain perceived career growth in this sample, and that other organizational and structural factors may be more influential. PCA produced a three-component digital inclusivity ecosystem composed of operational fairness, technical empowerment, and integrative leadership, demonstrating 62.84% variance explained and a three-pillar systemic architecture for equity composed of legislative frameworks, socioeconomic support, and organizational practice. Leadership representation remained skewed (73.83% male overall; 78.64% at the director level). The study concludes that progress toward IDEA is more likely to result from combining digital adoption with multi-level institutional reforms. Practical implications include integrated policy interventions and organizational practices that address structural barriers while leveraging digital platforms for inclusion.

Keywords: digital equity; gender equality; career progression; structural barriers; construction industry; inclusivity; diversity; accessibility (IDEA)



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1. Introduction

The pursuit of equality remains a defining challenge of our time, with inequality and the marginalization of minorities ranking among the most significant political issues [1]. Within this global context, the construction sector stands out as a persistently male-

dominated field with limited representation for women and other minorities. Alarming, despite women making up only 13% of the workforce, evidence suggests that discrimination has been exacerbated by the COVID-19 pandemic [2]. This disparity is particularly pronounced across the entire construction supply chain, including specialized contractors, suppliers, and heavy construction firms, where the lack of diversity and equity is most acute [3]. Furthermore, even though large companies have begun to implement principles of inclusivity, diversity, equality, and accessibility (IDEA), the effects remain less noticeable, particularly within medium-sized and small construction firms [4].

Concurrently, the industry is undergoing a profound transformation. The contemporary construction industry, specifically in South Africa, is being reshaped by the Fourth Industrial Revolution (4IR), structuring its planning, design, construction, and operation phases around new digital paradigms. The development of artificial intelligence (AI) has been a key driver of this transformative change, leading to a fundamental reorientation in how construction processes are planned, designed, and executed [5,6]. However, the integration of these advanced technologies faces its challenges. Research into the obstacles to sustainable practices has identified significant barriers related to system integration, security, data quality, and organizational issues [7]. Critically, while these challenges are acknowledged, it is evident that there remains considerable space for integrating inclusivity and equity into this digital transition. With few exceptions, most of the issues raised in the literature are not gender-oriented, representing a significant gap in understanding. Despite growing attention to digital transformation in construction, there remains a significant knowledge gap regarding how digital platform adoption interacts with structural barriers to either mitigate or reproduce gender exclusion in promotion and leadership pathways. Specifically, the lack of empirical evidence on whether digital skill parity translates to career progression equity in male-dominated industries like South African construction.

This paper examines whether gender is related to the level of mastery of core digital tools among construction professionals in South Africa. It also explores how proficiency in different categories of digital tools influences perceived professional career growth. In addition, the study identifies which groups of digital tools most strongly support inclusivity, diversity, equality, and accessibility (IDEA) in the construction sector. Finally, the paper investigates the institutional factors, including policy and organizational conditions, required to advance gender equity in the industry. This research contributes to knowledge by developing and empirically validating a systemic model that derives a component-based framework that organizes digital platform adoption with multi-level institutional reforms, moving beyond individual skill deficits to address structural determinants of gender inequality in construction. It is justified by the practical and policy need of improving gender equity in construction at the same time as the sector digitizes. In South Africa, construction remains central to infrastructure delivery and employment, yet the persistent under-representation of women in decision-making roles can constrain talent utilization, innovation, and organizational resilience.

Therefore, cultivating a more sustainable and resilient construction ecosystem in South Africa demands a deliberate focus on moving from theory to practice. Exploring digital-enabling platforms is of paramount importance, as it illuminates the intricate interplay between technological adoption barriers and long-term developmental goals. Ultimately, the way work is organized is a primary indicator of the accessibility of a profession, and this research posits that digital platforms present a critical opportunity to the construction profession in a way that fosters genuine inclusivity, diversity, equality, and accessibility (IDEA) for all stakeholders.

2. Literature Review

The following literature review is structured around workforce and pipeline conditions that shape women's entry and progression, highlighting the role of digital equity-enabling platforms as potential enablers of inclusive participation, and ends with consideration related to institutional and structural barriers that condition whether digital adoption translates into IDEA outcomes.

2.1. Strengthening Pathways into Employment

Women hold fewer than 4% of executive leadership roles in engineering and construction companies in developed countries, according to Hickey and Cui [8]. This means that female employees have limited opportunities to find role models of their gender in the workplace. It is worth noting that this finding is also mentioned in the South African context by Olugbenga et al. [9] and Windapo [10]. In addition, it has been predicted that the construction industry will have a shortage of qualified professionals in the next decade [11]. It proves that there is enough space for inclusivity and equity to fill in the space to promote innovation and benefit from the economic impact it comes with. Antoine [12] stated the imperativeness of achieving gender parity in STEM and highlighted its role for social justice and its economic significance in this day and age. Given that STEM fields are known for their ability to increase career opportunities and provide goods, services, and innovations for everyone, women represented 42% of the workforce in 2021, but held only 22% of positions in the STEM field [3,12]. This trend has remained almost unchanged from 19% in 2005 in the G20 countries [3] and is alarming because it could point to the idea that the disparity is much more severe in developing nations. Strengthening pathways into employment while promoting gender equality in career progression can rely on the key points that were suggested by Ottmann [13]. These action points include promoting equal work conditions; promoting work-life balance; promoting gender equality in international mobility; promoting gender balance in leadership roles; establishing institutions for gender equality and professional certifications; and promoting equal access to job opportunities and recruitment processes. Furthermore, it is crucial to support gender equality in science and technology-based entrepreneurship and innovation activities by promoting gender parity in funding access, ensuring equitable access to public support for women-owned businesses [9,13]. These increase the visibility of women entrepreneurs, facilitating women's access to mentorship and training, encouraging women's networking, advocating for gender-responsive innovation, recognizing women-led innovations, championing gender equality in technology access, and advancing gender balance in start-up workforces [4].

Women's integration and career advancement within the construction industry is closely tied to the disparities between education and real-world professional practice [12]. To combat this evidence of the disadvantages for women in the construction industry, three key areas were identified by Carrasco and Perez Lopez [14] to bridge disparities between education and professional practices in the construction industry. Firstly, these key areas of concern are factors influencing women's careers in the construction industry, including obstacles spanning individual, interpersonal, and organizational factors. Secondly, the education approaches perpetuate gender disparities and contribute significantly to the gaps between education and professional practices. These include education-practice gaps driven by gender exclusion in the architecture, engineering, and construction (AEC) industry, with physical environment and university culture; a lack of gender-oriented educational approaches; and misalignments between academic training and industry demands. Lastly, we discuss enablers for advancing gender equity in education and professional practice in the construction industry, which include opportunities for change

in the construction industry, linking education and professional practices, and driving long-term structural transformation.

According to Lewis and Shan [15], bringing the construction industry more in line with principles related to inclusivity, diversity, equality, and accessibility is more about the impact on the bottom line and equal representation than about a purely economic choice. Nonetheless, it has been demonstrated that businesses with a higher proportion of women in corporate leadership positions perform better financially than those with a lower gender diversity [16]. Therefore, strengthening pathways into employment while promoting diversity in the construction sector and all its sub-sectors is essential to its long-term growth and development, but it does not guarantee higher profits as a result. This investigation draws on the technological acceptance model (TAM) developed by [17] to contextualize technological adoption and use on institutional theory to explain why, even where digital mastery is comparable, institutional barriers can prevent digital capability from translating into equitable career outcomes. TAM was used in this study to contextualize technology use and adoption by practitioners. Institutional theory was used to explain why comparable digital mastery may not translate into equitable career outcomes when institutional barriers remain influential, such as organizational norms, promotion practices, professional gatekeeping, and unequal access to advancement opportunities. Together, these frameworks support the study's design by pairing measures of digital tool mastery and perceived career influence with measures of institutional and structural conditions that shape inclusion and progression. Interpreted through this lens, digital capability may be necessary for participation in a digitized workspace, but institutional conditions claim its pivotal and central position in determining whether such capability can be recognized and rewarded in career progression.

2.2. Digital Equity-Enabling Platforms in the Construction Industry

Construction industry digital-enabling platforms are showing their ability to improve inclusivity and diversity, workforce safety and well-being, training and skill development, policy and regulatory support, and cross-disciplinary collaboration [13]. They have the potential to impact directly eight of the seventeen sustainable development goals (SDGs) (including SDG 4 (Quality Education), SDG 5 (Gender Equality), SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure), SDG 10 (Reduced Inequalities), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action)) of the United Nations which are all results of decent infrastructure delivery, with a particular emphasis on SDG11, which aims to achieve sustainable cities and communities and is directly related to deliverables from the construction industry. As a result, to operate digital-enabling platforms and accomplish the aforementioned targets, diverse and inclusive human resources are needed, highlighting the industry's need for equity.

Technological tools such as advanced building technology, autonomous construction, building information modeling (BIM), augmented reality, virtual reality, 3D printing, and unmanned aerial vehicles have significantly impacted the stakeholders' relationships in the construction industry [6]. This power dynamic shift has opened more opportunities for women to get involved in the construction industry as these digital-enabling platforms have proved their ability to mitigate barriers, including fear of heights, work-life balance, musculoskeletal disorders, and exposure to harmful gases on-site, among others, which were identified as significant obstacles for women to participate fully and in an equitable way in the construction industry [18]. These tools or digital-enabling platforms challenge the traditional gender roles assigned to women in the workspace, often associated with administration rather than engaging in hands-on construction work, as expressed by

Watt [19]. It is crucial to examine at this point whether the construction profession is changing to a more managerial role due to digital tools, which would encourage more women to work in the industry, given its current nature, or whether these tools should be viewed as mitigating factors.

Digital-enabling platforms have the potential to improve construction industry education, training, and, more importantly, practice, which in turn could contribute to accessibility, equality, diversity, and inclusivity in the South African construction industry [20]. However, the gap in the literature between theoretical learning and practical application is highlighted by the need for a structured framework to facilitate the integration of these tools for construction professionals without discrimination. Optimizing the construction process, including material fabrication, planning, design, construction, operation, and maintenance, requires, in this era, the use of digital-enabling platforms such as artificial intelligence (AI). It was described by Regona et al. [5] as the cornerstone that reshapes the entire industry and can positively influence all stages of construction project life cycles, and the integration of AI. The construction industry can gain digital-enabling platforms that have a considerable technical impact on the construction project life cycle, such as predictive maintenance, safety monitoring, resource optimization, quality control, data integration, machine learning models, edge computing, and human–AI collaboration. Furthermore, Internet of Things (IoT), artificial intelligence (AI), analytics, robotics, human–machine interaction, cloud computing, big data (like BIM data), connectivity, and digital technology were described by the Chartered Institute of Building (CIOB) [20] and Omrany et al. [21] as the core components of the construction Industry 4.0, or the rapid technological advancements of the 21st century. The nature of the mentioned digital-enabling platforms shows that technological infrastructure might be less accessible to some groups of construction professionals, especially women and disabled persons; however, their operation can foster inclusivity, diversity, equality, and accessibility, as some barriers seem to be mitigated by their nature. Therefore, they form the broad scope covered by digital-enabling platforms in this study. Obstacles to their adoption in the construction industry include a lack of knowledge about contemporary technologies; a failure on the part of construction workers to embrace changes; a challenge in communicating the results of the technology to the client; the complexity of construction projects; a lack of technical expertise; and the cost of Construction 4.0 in terms of training and technology maintenance [22]. As mentioned above, these barriers are general issues faced by all and are not particularly gender-oriented.

In the construction industry, achieving digital equity through digital-enabling platforms necessitates solutions related to growing network infrastructure for universal accessibility [23]. According to the International Telecommunications Union (ITU), 75% of people in urban cities worldwide have access to a computer, compared to 50% of people worldwide, with Africa having the lowest percentage, respectively, 17 and only 2% [1]. Comparing the accessibility discrepancy level across social and economic levels increases its significance. Providing a solution to this should be one of the initial issues to be addressed for a more inclusive, diversified, equal, and accessible society for women, people with disabilities, and historically disadvantaged ethnic, indigenous, or racial groups, especially in a country like South Africa.

In preparation for the future, despite the acknowledged global challenges in implementing the AEC Industry 6.0 (architecture, engineering, construction as an extension of Industry 4.0/5.0 in the built environment, which integrate advanced computation, automation, human-centered and sustainability oriented design, and cyber–physical systems across the asset life cycle), considered as the next step from the AEC sector, built on Industry 4.0 and 5.0, the volume of career prospects in the construction industry is a chance to be seized by construction professionals to establish a more balanced environment in terms of

inclusivity, diversity, equality and accessibility to the industry in South Africa [3]. Digital-enabling platforms associated with the AEC Industry 6.0 facilitate the design, building, and maintenance process, improve efficiency, accuracy, and sustainability according to Almusaed et al. [24]. The repertoire of digital-enabling platforms identified by Almusaed et al. [24] is expanded tenfold, with increased level of complexity opening space for advanced paradigms like quantum computing, nanotechnology, artificial intelligence, and cloud-based energy solutions, all shaped by AI, robotics, additive manufacturing (AM) technology, paradigm, 3D printing, blockchain, metaverse, big data, building information technology and the Internet of Things (IoT). These technologies are categorized in packages, each linked to an important number of sub-technologies useful to the construction industry. Table 1 summarizes the constructs and variables identified and operationalized in the instrument.

Table 1. Summary of constructs and variables.

Construct	Variables
Digital Tool Mastery	
	BIM proficiency
	Structural analysis and design
	Project management and scheduling
	Construction site management
	Design and drafting
	Quantity takeoff and estimating
	Accounting and financial management
	Surveying, mapping, and GIS
	Facility and asset management
	Cloud collaboration and document management
	Sustainability and energy analysis
Digital Skill Acquisition	
	Method of skill acquisition
	Duration of digital tool use
	Gender as a determining factor in learning
Perceived Career Growth	
	Influence of digital mastery on career growth
Barriers to Women's Participation	
	Glass ceiling
	Gender roles and work culture
	Industry exposure
	Job satisfaction
	Maternity leave
	Caregiving support policies

Table 1. *Cont.*

Construct	Variables
Policy and Legislative Frameworks	
	Equal pay legislation
	Gender equality policies
	Legislation and policies (general)
	Economic policy
	Workforce policy
	SDGs/international policies
	Gender balance requirements
Organizational Practice Career Development	
	Manager interactions
	Peer interactions
	Women managers (role models)
	Mentorship
	Hiring strategies
	Flexible working hours
	Caregiver leave and reintegration
	Childcare support
	Assessment procedures and metrics
	Management trusts in recruiting women
Health, Safety, and Well-being Supports	
	Infrastructure suited to women's bodies
	Mechanisms against gender-based violence
	Programs for women's health
Educational Pathway Factors	
	Preventing gender bias in student admission
	Preventing gender bias in student financial aid
	Promoting retention via mentoring
	Promoting retention via workshops
	Promoting retention via networks
	Preventing discrimination at all levels (including MSc/PhD)
	Preventing sexual harassment at all levels
	Promoting gender equality in international mobility
	Childcare facilities

Table 1. *Cont.*

Construct	Variables
Contextual and Demographic Variables	The level of women's segregation in accessing the construction field
	Gender, age, profession, employment type, education, professional registration, experience, company services, company size, current position

3. Methodology

This study is grounded in a deductive research philosophy, which prioritizes the research problem and enables the selection of methods that best facilitate a practical solution. To systematically investigate the systemic structures that hinder equity in the male-dominated South African construction industry and to develop a comprehensive framework linking digital platform adoption to the multi-level institutional changes necessary for sound inclusivity, diversity, equality, and accessibility (IDEA), the research employed a quantitative research design.

An initial phase of the research involved a literature review to establish the state of the art and frame the investigation. From this review, a set of heterogeneous variables was collected. The identified variables were structured around key internal and external factors shaping the digital equity-enabling platform for IDEA, as well as systemic and multi-level barriers, with their categorical classifications. These variables directly informed the development of the quantitative research instrument. A structured online questionnaire of 45 items was developed across four sections (demographics, main factors addressing digital-enabling platform, main factors addressing gender inequality in the construction field, and main factors strengthening women's pathway into employment) (see Appendix A). From these were retrieved demographics, digital tool mastery, career growth perceptions, and institutional barriers. Scales included 5-point Likert items for mastery and perceptions. Face and content validity were ensured via expert review ($n = 4$) and a pilot test. Consistent with TAM and Institutional Theory, the instrument captures both the technology-use dimension (digital tool mastery and perceived influence) and the institutional constraint dimension (policy, organizational practices, and structural supports shaping gender inclusion and progression).

Quantitative data were collected from South African construction professionals and contractors via a questionnaire survey administered via the online platform SurveyMonkey. Data collection occurred between August 2025 and November 2025. The sampling frame targeted Construction Industry Development Board (CIDB) registered entities to ensure respondents were active industry practitioners, including construction professionals, technical officers, middle-level managers, directors, and others. The sample size was determined based on established research principles [25,26]. This study estimated the sample size using a 5 percent margin of error to describe the precision of the sampled population with a 95 percent level of certainty. Based on Kothari's [27] repertoire, the 112 valid responses electronically collected were deemed sufficient for analysis. Non-response bias was assessed by comparing early and late respondents on key demographics, with no significant differences found ($p > 0.05$). This dataset forms the basis from which conclusions were drawn.

Given that the collected data were essentially quantitative, the analysis was conducted in three stages using SPSS (Version 26). Initially, descriptive statistics were used to summarize and categorize the sample characteristics and responses, providing a profile of

the respondents and the sector. Following this, inferential statistics were applied to test relationships and hypotheses. This phase included chi-square tests to examine associations between gender and digital tool mastery, independent and paired *t*-tests to compare means, and multiple regression analyses to predict perceptions of career growth based on digital mastery, gender, education, and experience. Finally, factor analysis (principal component analysis (PCA) was utilized for data reduction to create clear and analyzable groups from many items regarding digital tools for IDEA and institutional factors for gender equity. PCA was chosen due to the exploratory aim of reducing data dimensionality and clustering observed indicators into interpretable dimensions. It does not account for measurement error nor offer confirmatory measurement validation. Consequently, confirmatory factor analysis or structural equation modeling is recommended for future phases to confirm the measurement structure and examine construct-level relationships.

The Kaiser–Meyer–Olkin (KMO) measure and Bartlett’s test of sphericity were used to verify sampling adequacy and model suitability [27–29]. Suitability was confirmed via KMO (>0.747) and Bartlett’s test ($p < 0.001$). Extraction used Principal Components with Varimax rotation. Factors were retained using the eigenvalue > 1 criterion and scree plot analysis, with significant loadings at (0.40) [27]. Component labeling was conducted deductively by the research team.

4. Results

4.1. Descriptive Statistics

The survey results presented in Table 2 show that the construction industry respondents are predominantly male professionals (73.83%) with substantial experience, most of whom occupy managerial or leadership roles within their organizations. They are engaged mainly in civil engineering (57.84%) and building works (64.71%), reflecting the dominant activities driving the South African construction industry. The presence of seasoned professionals with over a decade of industry experience highlights a mature workforce capable of overseeing complex projects and mentoring younger practitioners.

Table 2. Demographic characteristics of respondents.

Nature of Investigation	Alternatives	Responses (%)	Frequency
Gender	Male	73.83	79
	Female	26.17	28
	Prefer not to say	0.00	0
	Other	0.00	0
Age (Years)	18–24	0.93	1
	25–34	8.41	9
	35–44	26.17	28
	45–54	30.84	33
	55–64	23.36	25
	65+	10.28	11

Table 2. Cont.

Nature of Investigation	Alternatives	Responses (%)	Frequency
Profession	Architect	1.83	2
	Quantity Surveyor	2.75	3
	Engineer	15.60	17
	City Planner	0.92	1
	Land Surveyor	0.00	0
	Construction Manager	39.45	43
	Other	39.45	43
Employment Type	Developer	0.93	1
	Contractor	48.60	52
	Subcontractor	13.08	14
	Consultant	11.21	12
	Government	3.74	4
	Educational Institution	4.67	5
	Other	17.76	19
Education Level	Diploma/Certificate	52.88	55
	Bachelor's Degree	8.65	9
	Honors Degree	12.50	13
	Master's Degree	8.65	9
	PhD	3.85	4
	Other	13.46	14
Professional Body Registration	None of the above	34.86	38
	ASAQS	2.75	3
	ECSA	11.01	12
	ACPM	9.17	10
	SACPCMP	8.26	9
	SAIA	0.92	1
	Other	33.03	36
Experience in the Construction Industry	Less than 5 years	14.29	15
	6–10 years	23.81	25
	11–15 years	20.00	21
	16–20 years	15.24	16
	Over 21 years	26.67	28
Services Provided by the Company	General Civil Engineering	57.84	59
	Buildings	64.71	66
	Design	14.71	15
	Government Regulatory Body	5.88	6
	Professional Body	4.90	5
	Other	15.69	16

Table 2. Cont.

Nature of Investigation	Alternatives	Responses (%)	Frequency
Company Size (Employees)	Micro (<10)	51.89	55
	Small (10–49)	29.25	31
	Medium (50–249)	11.32	12
	Large (250+)	7.55	8
Current Position	Technical Officer	2.91	3
	Middle-level Manager	10.68	11
	Director Level	78.64	81
	Other	7.77	8

With: ASAQs: Association of South African Quantity Surveyors; ECSA: Engineering Council of South Africa; ACPM: Association of Construction Project Managers; SACPCMP: South African Council for the Project and Construction Management Professions; SAIA: South African Institute of Architects.

Most of the participants were affiliated with small (29.25%) or micro enterprises (51.89%), which form the backbone of the construction industry in many developing economies, emphasizing the sector's reliance on smaller, often owner-managed firms. Educationally, the majority hold technical diplomas or certificates (52.88%), indicating a strong practical foundation; however, relatively fewer hold advanced academic degrees, such as master's degrees (8.65%) or doctorates (3.85%). Notably, a significant segment of respondents reported no registration with any professional body (34.86%), underscoring a gap in professional affiliation and compliance. This suggests the need for capacity-building initiatives, upskilling programs, and professional registration drives to enhance standards, accountability, and recognition within the South African construction workforce.

4.2. Inferential Statistics: Digital Adoption, Gender Parity, and Career Predictors

4.2.1. Digital Tool Adoption Across Professions

Digital tool engagement is specialized, with Architects, Engineers, and Quantity Surveyors demonstrating the broadest tool engagement as seen in Figure 1. This adoption aligns with professional specialization, rather than uniform sector-wide adoption. Quantity surveyors, for example, recorded the highest use (100%) in Quantity Takeoff and Estimating tools, reflecting their core tasks. Construction managers display balanced adoption across most tools.

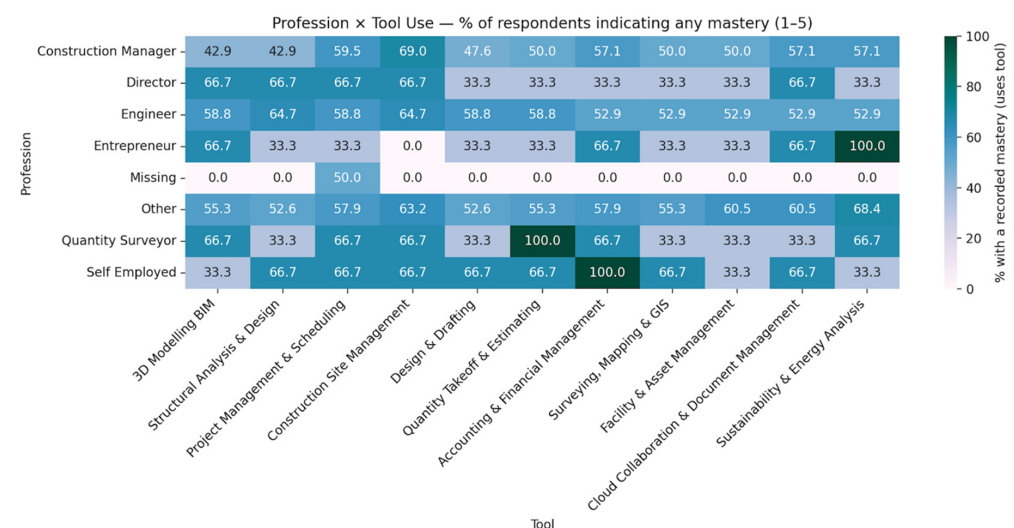


Figure 1. Digital adoption and level of mastery across construction professions in South Africa.

4.2.2. Mastery of Core Digital Tools

The analysis revealed no statistically significant gender-based disparity in the mastery of core digital tools across the South African construction sector. This finding was true for a wide range of competencies, from highly technical engineering software and digital processes/tools such as BIM ($\chi^2 = 2.920$, $p = 0.404$) and Cramér's $V = 0.162$ and Structural Analysis ($\chi^2 = 4.908$, $p = 0.297$) and Cramér's $V = 0.210$ to project management and operational tools such as Site Management ($\chi^2 = 3.056$, $p = 0.549$) and Cramér's $V = 0.166$ and Quantity Takeoff tools ($t = -0.615$, $p = 0.540$), Cohen's $d = -0.13$, 95% CI $[-0.53, 0.28]$. The lack of significant p -values (all > 0.05) across all tests. This indicates that the observed differences in proficiency levels between male and female respondents are likely due to chance rather than a systematic gender effect, as shown in Table 3.

Table 3. Statistical analysis of gender and digital tool mastery.

Digital Tool Category	Specific Tools Examples	Statistical Test	Value	p -Value	Key Finding and Interpretation
Building Information Modeling (BIM)	Revit, ArchiCAD, Tekla, Civil 3D	Pearson Chi-Square	$\chi^2 = 2.920$	0.404	No significant association. Gender is not a determinant of BIM mastery, indicating parity in this critical digital competency.
Structural Analysis and Design	ETABS, SAP2000, STAAD.Pro	Pearson Chi-Square	$\chi^2 = 4.908$	0.297	No significant association. Women show comparable mastery in advanced engineering software, challenging stereotypes in a male-dominated discipline.
Project Management and Scheduling	MS Project, Primavera, Procore	Pearson Chi-Square	$\chi^2 = 5.141$	0.273	No significant association. Competence in high-level project management tools is equivalent across genders.
Construction Site Management	Fieldwire, PlanGrid, Bluebeam	Pearson Chi-Square	$\chi^2 = 3.056$	0.549	No significant association. Mastery of on-site digital coordination tools is not gender dependent.
Design and Drafting	AutoCAD, SketchUp, Rhino 3D	Pearson Chi-Square	$\chi^2 = 7.150$	0.128	No significant association. No evidence of a gender gap in core design and drafting software proficiency.
Quantity and Financial Tools	CostX, Bluebeam, QuickBooks	Independent t -test	$t = -0.615$	0.540	No significant difference. Women report similar levels of mastery in estimation and financial management tools.
Education vs. Company Size	N/A	Paired t -test/Correlation	$r = 0.015$	0.873	No significant correlation. Higher education does not guarantee a position in a larger firm, highlighting structural mobility barriers.

This demonstrates that women who are active in the industry have achieved skill parity with their male counterparts. Therefore, the central problem of gender inequality shifts from a question of individual capability or training to an alleged problem of structural integration and career mobility.

4.2.3. Predicting Professional Career Growth

A regression analysis examining predictors of general professional career growth found that the overall model was not statistically significant ($F(10,100) = 0.734, p = 0.691$) and had very weak explanatory power ($R^2 = 0.068$). The corresponding effect size was also small (Cohen's $f^2 = 0.073$). A post hoc power (sensitivity) analysis for the omnibus regression ($N = 111$; 10 predictors; $\alpha = 0.05$; $R^2 = 0.068$) indicates low achieved power (≈ 0.40) to detect effects of this magnitude. The non-significant model is therefore interpreted cautiously, and larger samples and/or additional explanatory variables are recommended for future work. Similarly, diagnostic tests were conducted. Variance Inflation Factor (VIF) values for all predictors were below 2.5, indicating no critical multicollinearity. An inspection of residual plots showed no severe violations of homoscedasticity or normality, supporting the model's appropriateness despite its limited explanatory power. This means that an individual's technical digital skills, educational background, gender, or years of experience do not reliably predict their professional advancement in this context. Digital competency appears to be a necessary baseline but is insufficient on its own for career growth, underscoring the influence of unmeasured systemic factors. Although no predictors were statistically significant ($p > 0.05$), two showed meaningful trends: accounting and financial management tools had a negative coefficient ($B = -0.184, p = 0.105$), 95% CI $[-0.408, 0.040]$, suggesting these back-office skills may be less valued in career progression. Sustainability and energy analysis tools exhibited a positive trend ($B = 0.120, p = 0.222$), 95% CI $[-0.074, 0.314]$, implying that emerging green building competencies may be growing in relevance, as shown in Table 4.

Table 4. Regression analysis for perceived professional career growth predictors for gender, education, years of experience, and all digital tool categories.

Predictor	B	Std. Error	Beta	t	p-Value
Model Summary	$R^2 = 0.068$; Adj. $R^2 = -0.025$		$F(10,100) = 0.734$		$p = 0.691$
(Constant)	3.028	0.558	-	5.423	0.000
Gender	-0.248	0.250	-0.099	-0.992	0.324
Education Level	0.008	0.054	0.014	0.143	0.886
Years of Experience	0.012	0.022	0.054	0.548	0.585
Design and Drafting Tools	0.103	0.112	0.137	0.924	0.358
Quantity Takeoff Tools	-0.057	0.131	-0.068	-0.433	0.666
Accounting and Financial Tools	-0.184	0.113	-0.214	-1.635	0.105
Surveying, Mapping, and GIS Tools	-0.024	0.115	-0.033	-0.212	0.833
Facility and Asset Management Tools	0.046	0.093	0.058	0.496	0.621
Cloud Collaboration Tools	0.072	0.086	0.096	0.836	0.405
Sustainability and Energy Tools	0.120	0.098	0.138	1.228	0.222

4.3. Factor Analysis: Digital Inclusivity and Structural Barriers

4.3.1. Digital Tools and Inclusivity Framework

A Principal Component Analysis (PCA) identified how different digital tools facilitate Inclusivity, Diversity, and Equality (IDEA). The model was statistically sound ($KMO = 0.747$; Bartlett's Test $p < 0.001$). Results revealed a three-component structure explaining 62.84%

of the total variance, confirming that digital inclusivity is a multidimensional pattern also seen in Table 5.

Table 5. Factor analysis for the digital inclusivity framework.

Component/Factor	% of Variance Explained	Key Digital Tools (with Factor Loadings)	Interpretation and Role in Promoting IDEA
1. Digital Operations and Organizational Inclusivity	38.87%	Site Management Tools (0.755) Accounting and Finance Tools (0.720) Quantity Estimating Tools (0.683) Cloud Collaboration Tools (0.623) Sustainability Tools (0.608)	Promotes institutional fairness through transparency, standardized workflows, and reduced hierarchical gatekeeping, ensuring a level playing field and greater accountability.
2. Technical and Analytical Empowerment	13.09%	Structural Analysis Tools (0.762) GIS/Surveying Tools (0.731) Facility and Asset Management Tools (0.644) Design and Drafting Tools (0.492)	Fosters STEM participation and inclusion by equipping women with technical mastery in precision-driven domains, enabling influence over core design and analytical decisions.
3. Integrative Project Leadership and Innovation	10.88%	Project Management Tools (0.846) BIM Tools (0.640) Design and Drafting Tools (0.621)	Supports strategic leadership and cross-disciplinary coordination. Mastery here bridges the pathway to managerial roles and enhances project integration and innovation capacity.
Total Variance Explained	62.84%		

The first and most substantial component was digital operations and organizational inclusivity, which accounted for 38.87% of the total variance. This dimension is characterized by tools such as site management, accounting and finance, and cloud collaboration, which promote institutional fairness through transparency and standardized workflows. The second component, identified as technical and analytical empowerment, explained 13.09% of the variance and encompassed tools such as structural analysis, GIS/surveying, and facility and asset management, with the core function of fostering STEM participation and inclusion by equipping women with technical mastery. Finally, the third component, integrative project leadership and innovation, accounted for 10.88% of the variance and is defined by strategic tools such as project management and BIM. These tools are pivotal as they support strategic leadership and cross-disciplinary coordination, bridging the pathway to managerial roles and enhancing overall project integration.

4.3.2. Institutional Gender Equity Index

A PCA was conducted to uncover the underlying structure among institutional and socio-cultural factors influencing women's underrepresentation in leadership. The results revealed a single dominant component. This single construct accounted for nearly all variance (97.94%) and had an Eigenvalue of 8.814, confirming its strength and dominance, and is presented in Table 6 and Figure 2. All nine variables loaded highly on this single component (loadings 0.912 to 0.999), with communalities ranging from 0.832 to 0.998. The

correlation matrix showed extremely high intercorrelations ($r = 0.89$ to 1.00) among all items, such as preventing discrimination, maternity leave, and addressing the glass ceiling.

Table 6. Factor analysis for institutional gender equity (unidimensional structure).

Statistical Metric	Result	Interpretation
Total Variance Explained	97.94%	An exceptionally high indicating that one overarching construct accounts for nearly all variance in responses.
Eigenvalue	8.814	Far exceeds the threshold of 1, confirming the strength and dominance of the extracted component.
Correlation Range	~0.89 to 1.00	Shows extremely high intercorrelations among variables, meaning they reflect the same core issue.
Component Loadings	0.912 to 0.999	Each variable contributes strongly and consistently to the composite factor.

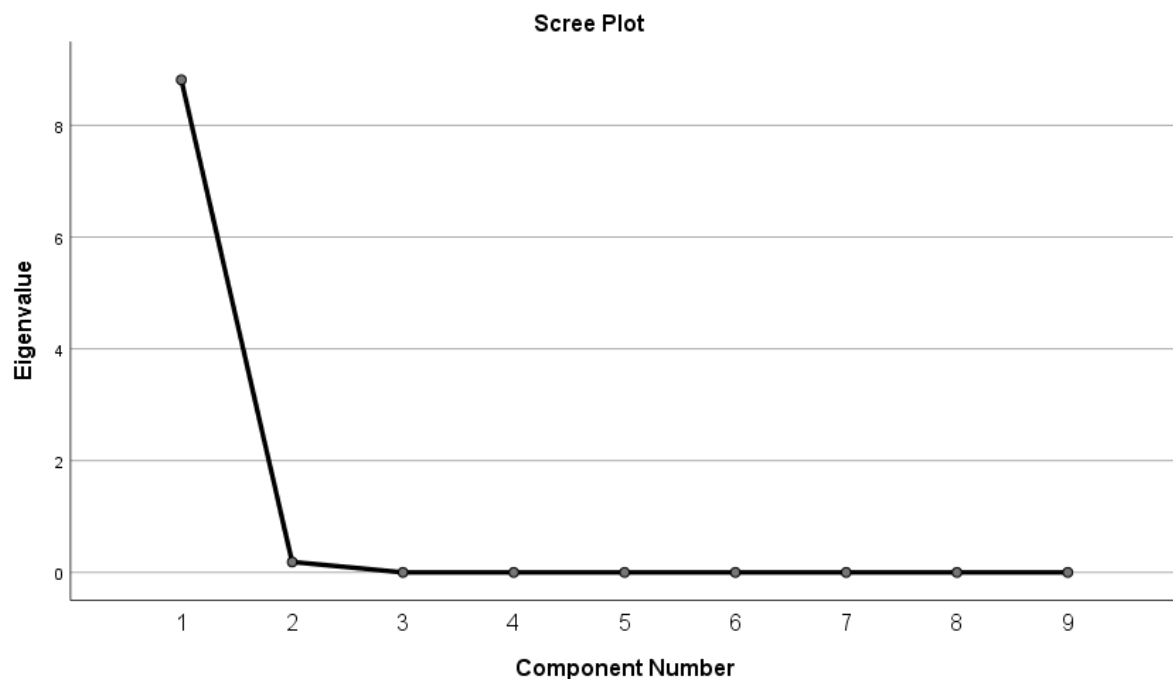


Figure 2. Scree plot of eigenvalues from PCA indicating a one-component solution.

This composite factor is the Institutional Gender Inclusivity Index, underscoring that institutional, cultural, and policy variables are found to converge into one combined dimension. Variables loading highly on this index included policy and protection, such as preventing discrimination, structural support, such as childcare facilities, opportunity and mobility, like industry exposure, and cultural and attitudinal factors, like gender roles and the glass ceiling. The emergence of a single dimension explaining almost all variance likely reflects two interrelated phenomena: a respondent perception of institutional gender equity as a unified, systemic construct where all aspects are seen as critically interdependent; and a potential measurement effect where the high thematic coherence and positive framing of all items may have limited discriminant validity in this survey context.

4.4. The Three-Pillar Architecture of Gender Equity

A final PCA uncovered the underlying structure of legislative, organizational, and policy-level factors driving gender inclusivity. The analysis revealed a robust three-component structure, explaining 99.91% of the total variance. This analysis also used Principal Component extraction with Varimax rotation, retaining factors with eigenvalues > 1. These three pillars represent the systemic architecture of gender equity interventions as seen in Table 7 and Figure 3.

Table 7. The three pillars of systemic gender equity.

Component/Pillar	% of Variance Explained	Key Contributing Factors (with Loadings)	Level of Intervention	Core Function
1. Legislative and Structural Equality Frameworks	46.85%	Caregiving support policies (0.990) Equal pay legislation (0.990) Gender equality policies (0.990) Women managers (0.990) Manager/Peer interactions (0.990)	Macro Level (Formal Architecture)	Establishes the foundation for inclusion through laws, institutional commitments, and visible leadership representation.
2. Socioeconomic and Health Support Mechanisms	37.04%	Programs for women's health (0.986) Flexible working hours (0.986) Mechanisms vs. gender-based violence (0.986) Infrastructure suited to women's bodies (0.974)	Meso Level (Enabling Environment)	Provides the practical supports that sustain participation, ensuring safety, well-being, and work-life integration.
3. Organizational Practice and Career Development	16.01%	Childcare support (0.965) Mentorship in employment (0.965) Hiring strategies (0.965) Caregivers leave and re-integration (0.965)	Micro Level (Operational Systems)	Implements daily practices that influence career progression, connecting institutional policy with lived workplace experience.

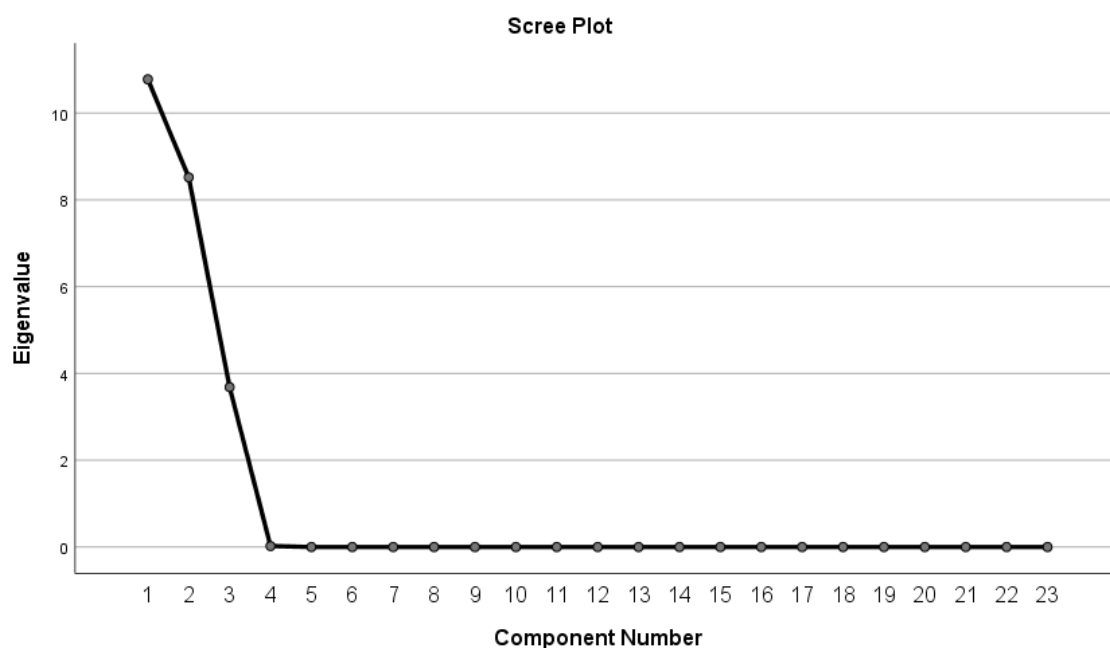


Figure 3. Scree plot of eigenvalues indicating a three-component solution.

The first pillar is legislative and structural equality frameworks (46.85%), which presents a macro-level intervention that establishes the formal legal foundation through

laws, institutional commitments, and visible leadership representation, such as equal pay legislation (0.990) and women managers (role models) (0.990). The second pillar, socio-economic and health support mechanisms (37.04%), functions as a meso-level intervention designed to provide practical supports sustaining participation, ensuring safety, well-being, and work–life integration, like flexible working hours and mechanisms against gender-based violence. Finally, the third pillar, organizational practice and career development (16.01%), constitutes a micro-level intervention that implements daily practices influencing career progression, like childcare support (0.965), mentorship (0.965), and hiring strategies (0.965).

5. Discussion

Interpreted through TAM and Institutional Theory, the findings suggest that digital capability may be necessary but insufficient for equitable career outcomes where institutional constraints remain. They, similarly, clearly reframe the arrangement of gender inequality in the South African construction industry. South Africa was used as the empirical setting, offering potentially transferable insights for other Global South contexts and for advanced economies where construction digitization is also uneven. However, affirming broader applicability would require relevant empirical evidence. The absence of a statistically significant gender gap in digital tool mastery fundamentally challenges the persistent stereotype of technology as a masculine domain, aligning with recent studies showing skill parity in technical domains [30]. Rather than providing a definitive explanation, results reject the hypothesis that gender differences in digital mastery are a key determinant in this dataset and point to the need to examine alternative explanatory factors. The empirical evidence confirms that the central issue is more about structural integration and career mobility, creating a paradox where skilled women are present in the workforce but are likely hindered from advancing into influential roles.

The regression analyses provide critical insights into this understanding. They insist that digital skills, while necessary, are not a unique determinant for career advancement. The modest-to-weak explanatory power of the presented models strongly points to the dominance of unmeasured systematic factors, such as organizational culture, mentorship, professional networks from which women are most of the time excluded, as supported by [31], and biased promotion practices in shaping professional career trajectories [32]. In this context, the perceived negative association of the design and drafting tools with career growth perceptions is particularly informative. It assumes the existence of a technical ceiling on top of the assumed glass ceiling, where deep operational proficiency may compartmentalize professionals into technical tracks that are often undervalued in the industry's leadership hierarchy, also mentioned by Lamola et al. [33]. In contrast, the positive trend associated with BIM proficiency is supported by the literature, positioning it as a platform for collaboration and managerial oversight, skills that are crucial for leadership roles [2]. This demonstrates a critical need to steer women towards high-impact digital specializations while concomitantly challenging the systematic undervaluation of technical proficiency in career progression.

The factor analysis provided a strong, evidence-based framework for systemic intervention to achieve IDEA through a digital equity platform in the South African construction industry. The three-component digital ecosystem demonstrates that tools foster inclusivity not as separate instruments but as a connected system, including operational fairness, technical empowerment, and leadership pathways. It therefore offers a well-defined procedure for targeted digital adoption strategies. At the same time, the three-pillar equity model and the one-dimensional institutional gender inclusivity index empirically authenticate that effective change requires a holistic, multi-level approach. As the literature suggests, isolated

initiatives, be it introducing a new digital tool or implementing a maternity leave policy within an organization, are destined for limited impact if implemented without synchronizing changes across the legal, supportive, and practical domains of the workplace [34]. Complementary domains of intervention include progressive legislation (Pillar 1), which is ineffective without the enabling infrastructure of flexible work and anti-harassment mechanisms (Pillar 2), and the equitable daily practices of mentorship and unbiased hiring (Pillar 3).

6. Conclusions

This study concludes that the gender gap in the South African construction industry is not uniquely attributable to variations in technical skills or literacy. The major challenges are unequivocally structural and systemic, rooted in the tightly interlinked web of cultural norms, institutional policies, and organizational practices. Therefore, the research contributes a novel, empirically grounded framework that identifies and organizes the strategic adoption of digital-enabling platforms to a comprehensive, multi-level institutional strategy for achieving gender equity. It moves the narrative beyond individual-level explanations and training deficits to institutional accountability and system-wide transformation.

Practical Implications: This study offers several practical implications for policymakers, industry associations, and organizational managers. For policymakers, the three-pillar model suggests that gender equity requires integrated interventions across legislative domains, including enforcing equal pay law, supporting childcare infrastructure, and, on the organizational level, promoting mentorship programs. Industry associations should develop digital competency frameworks that emphasize not only technical skills but also leadership-oriented digital tools like BIM and project management software. Construction firms should implement transparent promotion pathways, establish mentorship and sponsorship programs for women, adopt flexible work arrangements, and actively work to eliminate biased hiring and promotion practices. On another dimension, digital platform developers should design tools with inclusive features that support collaboration and remote work, thereby reducing traditional barriers to women's participation.

Limitations: The study relies on an online SurveyMonkey sample, which may introduce self-selection and coverage biases. The design is cross-sectional, limiting causal inference. Measures are self-reported and may be affected by social desirability and common-method variance. Leadership representation in the sample might have a non-negligible role, which might not fully reflect the broader industry distribution. These limitations may reduce generalizability; therefore, findings should be interpreted as a strong foundational step. Future research should employ longitudinal designs, incorporate stratified samples of professionals, and examine cross-cultural comparisons.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the University of Cape Town—Faculty of Engineering & the Built Environment Ethics Committee (EBE/01901/2025) on [15 August 2025].

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author.

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Appendix A

Questionnaire on Digital Equity-Enabling Platform for Inclusivity, Diversity, Equality and Accessibility (DEEP-IDEA) in The South African Construction Industry

Please answer the following questions by crossing (x) in the relevant box or by writing down your response in the provided space.

Section A: Demographic Characteristics

1. What Is Your Gender?

1. Male	2. Female	3. Prefer not to say	4. other
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2. How Old Are You (Years)?

1. Below 25 years	2. 26–35	3. 36–45	4. 46–55	5. 55–65	6. Over 65 years
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3. What Is Your Profession?

1. Architect	2. Quantity Surveyor	5. Engineer	4. City Planner	5. Land Surveyor	6. Construction Manager
Other, please specify					

4. Are You Working For?

1. Developer	2. Contractor	3. Subcontractor	4. Consultant	5. Government	6. Educational Institution
Other, please specify					

5. Indicate Your Highest Level Of Education?

1. Diploma/Certificate	2. Bachelor's Degree	3. Honors Degree	4. Master's Degree	5. PhD
Other, please specify				

6. Please indicate which professional body you are registered with.

1. None
2. Association of South African Quantity Surveyors
3. Engineering Council of South Africa
4. Association of Construction Project Managers
5. South African Council for the Project and Construction Management Professions
6. South African Institute of Architects
7. Other, please specify

7. Please indicate the number of years of experience you have in the construction industry.

1. Less than 5years	2. 6–10 years	3. 11–15 years	4. 16–20 years	5. Over 21 years
8. Please indicate the services your company provides in the construction industry (tick all applicable services).				
1. General Civil Engineering (roads, bridges, major sewage/drainage, etc.)	2. Buildings	3. Design	4. Government Regulatory Body	5. Professional Body
6. Educational Institution				
Other, please specify				
9. Please indicate the size of your company in terms of the number of employees.				
1. Micro enterprise		Fewer than 10 employees		
2. Small enterprise		10 to 49 employees		
3. Medium-sized enterprise		50 to 249 employees		
4. Large enterprise		250 or more employees		
10. For how long has your company (Institution) been in the construction business since its registration?				
please specify				
11. Please state your current position in the organization				
1. Technical officer		2. Middle-level manager		3. Director level
Other, please specify				

Section B: Main Factors Addressing Digital-Enabling Platform

12. On a scale of 1 to 5 (1: very low and 5: very high), what is your perceived level of mastery of the digital tool(s) you often use in your profession? Please rate your mastery as your ability to use the tool independently and effectively to complete work-related tasks (Tick even if you only master one in each line).

Options		1	2	3	4	5
3D Modeling, Data Integration, & Coordination	BIM (Building Information Modeling) (Revit, ArchiCAD, Tekla Structures, Civil 3D, Allplan, Vectorworks Architect)					
Structural Analysis & Design	Structural modeling and simulation (ETABS, SAP2000, STAAD.Pro, SAFE, Robot Structural Analysis)					
Project Management & Scheduling	Planning, scheduling, cost/resource control (Primavera P6, MS Project, Buildertrend, Asta Powerproject, CoConstruct, Procore)					
Construction Site Management	On-site coordination, reporting, inspections (PlanGrid, Fieldwire, Bluebeam Revu, BIM 360, Raken, Bridgit Bench)					
Design & Drafting	2D/3D drawing and conceptual design (AutoCAD, SketchUp, Rhino 3D, BricsCAD)					
Quantity Takeoff & Estimating	Cost estimation, quantity calculation (CostX, Bluebeam Revu, WinQS, Planswift, Candy CCS, STACKCostX, Bluebeam Revu, WinQS, Planswift, Candy CCS, STACK)					
Accounting & Financial Management	Budgeting, accounting, financial reporting (Sage 300 CRE, QuickBooks, CMiC, Jonas Construction Software)					

Options		1	2	3	4	5
Surveying, Mapping & GIS	Site measurement, topography, geolocation (Trimble Business Center, Leica Geo Office, DroneDeploy, ArcGIS, Civil 3D)					
Facility & Asset Management	Maintenance, operations, asset tracking (Archibus, Planon, FM:Systems, IBM Maximo, EcoDomus)					
Cloud Collaboration & Document Mgmt	Data sharing, cloud storage, model/document access (Autodesk Construction Cloud, Trimble Connect, Asite, Procore, Aconex)					
Sustainability & Energy Analysis	Energy modeling, carbon impact, LCA (IES VE, DesignBuilder, Sefaira, One Click LCA, Tally (Revit plugin))					
Other, please specify						

13. Indicate On A Scale Of 1 To 5, Where 1 Is Not At All And 5 Is To A Very Large Extent, The Extent To Which The Following Digital Tools Facilitate inclusivity, Diversity, Equality, And Accessibility In The South African Construction Industry.

Options		Extent of Influence				
		Not At all	Some Extent	Moderate Extent	Large Extent	Very Large Extent
		1	2	3	4	5
3D Modeling, Data Integration, & Coordination	BIM (Building Information Modeling) (Revit, ArchiCAD, Tekla Structures, Civil 3D, Allplan, Vectorworks Architect)					
Structural Analysis & Design	Structural modeling and simulation (ETABS, SAP2000, STAAD.Pro, SAFE, Robot Structural Analysis)					
Project Management & Scheduling	Planning, scheduling, cost/resource control (Primavera P6, MS Project, Buildertrend, Asta Powerproject, CoConstruct, Procore)					
Construction Site Management	On-site coordination, reporting, inspections (PlanGrid, Fieldwire, Bluebeam Revu, BIM 360, Raken, Bridgit Bench)					
Design & Drafting	2D/3D drawing and conceptual design (AutoCAD, SketchUp, Rhino 3D, BricsCAD)					
Quantity Takeoff & Estimating	Cost estimation, quantity calculation (CostX, Bluebeam Revu, WinQS, Planswift, Candy CCS, STACKCostX, Bluebeam Revu, WinQS, Planswift, Candy CCS, STACK)					
Accounting & Financial Management	Budgeting, accounting, financial reporting (Sage 300 CRE, QuickBooks, CMiC, Jonas Construction Software)					

	Options	Extent of Influence				
		Not At all	Some Extent	Moderate Extent	Large Extent	Very Large Extent
		1	2	3	4	5
Surveying, Mapping & GIS	Site measurement, topography, geolocation (Trimble Business Center, Leica Geo Office, DroneDeploy, ArcGIS, Civil 3D)					
Facility & Asset Management	Maintenance, operations, asset tracking (Archibus, Planon, FM:Systems, IBM Maximo, EcoDomus)					
Cloud Collaboration & Document Mgmt	Data sharing, cloud storage, model/document access (Autodesk Construction Cloud, Trimble Connect, Asite, Procore, Aconex)					
Sustainability & Energy Analysis	Energy modeling, carbon impact, LCA (IES VE, DesignBuilder, Sefaira, One Click LCA, Tally (Revit plugin))					
Other please specify						

14. Please Indicate and Specify How You Acquired Your Top Five Construction-Related Digital Skills, If Applicable.

Skill	Method of Skill Acquisition			
	1. Formal Education	2. On the Job	3. Informally	4. Self-taught
1. Skill 1				
2. Skill 2				
3. Skill 3				
4. Skill 4				
5. Skill 5				

15. For How Long Have You Been Using the Identified Digital Tools in Your Professional Service, If Applicable?

Digital Tool	Utilization Period				
	1. Less than 5 Years	2. 6–10 Years	3. 11–15 Years	3. 16–20 Years	4. Over 21 Years
1. Digital Tool 1					
2. Digital Tool 2					
3. Digital Tool 3					
4. Digital Tool 4					
5. Digital Tool 5					

16. Kindly Indicate Whether Your Gender Was a Determining Factor in Learning and Mastering the Identified Digital Tool(S).

Digital Tools	Options	
	Yes	No
1. Digital Tool 1		
2. Digital Tool 2		
3. Digital Tool 3		
4. Digital Tool 4		
5. Digital Tool 5		
17. Please Indicate the Extent to Which the Mastery of The Identified Digital Tool(S) Influences Your Professional Career Growth on A Scale Of 1 To 5. Where		
1.	Not At All—No Observable Impact.	
2.	Some Extent—Minor Improvements in Daily Tasks Or Recognition.	
3.	Moderate Extent—Enabling You to Take on New Responsibilities and Receive Positive Feedback;	
4.	Large Extent—Promotions, New Job Offers, Or Important Professional Recognition;	
5.	Very Large Extent—Major Career Advancements, Leadership Positions, Or A Significant Change in Career Trajectory.	

Digital Tools	Options				
	1	2	3	4	5
	Not at All	Some Extent	Moderate Extent	Large Extent	Very Large Extent
1. Digital Tool 1					
2. Digital Tool 2					
3. Digital Tool 3					
4. Digital Tool 4					
5. Digital Tool 5					

Section C: Main Factors Addressing Gender Inequality In The Construction Field

18. In which line of construction-related services do you believe that mastery of the identified digital tools can influence women's career growth in South Africa?

Construction Services	Extent of Influence				
	Not at All	Some Extent	Moderate Extent	Large Extent	Very Large Extent
	1	2	3	4	5
Architecture					
Engineering					
Construction Management					
Project Management					
Interdisciplinary collaboration					
Precision and Error Detection					
Data Analysis					
Small-scale Projects					
Virtual Reality					
Construction Site Layout					
Construction Automation					

Construction Services	Extent of Influence				
	Not at All	Some Extent	Moderate Extent	Large Extent	Very Large Extent
	1	2	3	4	5
Facility Management (FM)					
Digital Representations for Stakeholders					
Eco-friendly Construction and Sustainability					
HVAC (Heating, Ventilation, and Air Conditioning) Management					
Land Surveying					
Quantity Surveying					
Energy Efficiency					
Resource Optimization					
Data-driven Decision-making					
Integration with Urban Systems					
Lifecycle Management					
Enhanced Indoor Environment					
Other Please Specify					

19. How Would You Rate the Level Of girls' And Women's Segregation in Accessing the Construction Field in South Africa?

1	2	3	4	5
Not Acceptable	Acceptable	Average/Fair	Good/Satisfactory	Very Good

20. Kindly Indicate On A Scale Of 1–5 (Where 1 Is not At All, And 5 Is To A Very large Extent), The Extent To Which The Following Factors Attract, Promote Access To, And Retention Of Women In All Levels Of Education.

Options	Extent of Influence				
	Not at All	Some Extent	Moderate Extent	Large Extent	Very Large Extent
	1	2	3	4	5
Preventing gender bias in student admissions					
Preventing gender bias in student financial aid					
Promoting retention of women in the construction-related field through gender-sensitive mentoring					
Promoting retention of women in the construction-related field through workshops					
Promoting retention of women in the construction-related field through networks					
Preventing gender-based discrimination at all levels of education, including Master's and Ph.D.					
Preventing sexual harassment at all levels of education, including Master's and Ph.D.					

Options	Extent of Influence				
	Not at All	Some Extent	Moderate Extent	Large Extent	Very Large Extent
	1	2	3	4	5
Promoting gender equality in the international mobility of students.					
Promoting day care/childcare facilities for students, particularly in Higher Education Institutions that offer construction-related courses.					
Other please specify					

Section D: Main Factors Addressing strengthening Women's Pathway into Employment

21. Below Is a List of Factors That strengthen Women's Pathway into Employment. Based on Your Experience and Knowledge, indicate on a Scale of 1 To 5 The Extent to Which the Identified Factors Strengthen Women's Pathway into Employment in the South African Construction Industry.

Factors Enhancing Women's Access to Employment in the South African Construction Industry	Extent of Influence				
	Not at All	Some Extent	Moderate Extent	Large Extent	Very Large Extent
	1	2	3	4	5
Industry exposure					
Gender roles and work culture					
Glass ceiling					
Job satisfaction					
Maternity leave					
Caregiving support policies					
Equal pay legislation					
Gender equality policies					
Legislation and policies					
Mass and social media					
Gender balance requirements					
Manager interactions					
Peer interactions					
Women managers					
Mentorship					
Hiring strategies					
Flexible strategies					
Caregiver leave and reintegration					
Childcare support					
Assessment procedures and metrics					
Use of infrastructure and materials suited to women's bodies					
Mechanism against gender-based violence					

Factors Enhancing Women's Access to Employment in the South African Construction Industry	Extent of Influence				
	Not at All	Some Extent	Moderate Extent	Large Extent	Very Large Extent
	1	2	3	4	5
Economic policy					
Workforce policy					
SDGs/international policies					
Management trust in recruiting women					
Flexible working hours					
Institution of programs for women's health					
Other please specify					

Thank you for taking the time to fill out this questionnaire. Please do not hesitate to contact the research team if you have any questions about this survey or the research project in general. Kindly see the contact details below.

Contact details:

Kabemba Ngoy Steve, Ph.D.
 Department of Construction Economics and Management
 Faculty of Engineering and the Built Environment
 University of Cape Town
 Mobile Number: +27-(064)-057-9824
 Email: kabemba.ngoy@uct.ac.za
 Email: kabembasteve7@gmail.com

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