

Digital Skills and Women's Career Advancement in the South African Construction Industry

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Abstract

The South African construction industry remains male-dominated, with women facing barriers to education, entry, retention, progression and leadership. At the same time, the industry is becoming more digital through tools such as Building Information Modelling, project management software, quantity take-off systems, digital collaboration platforms, sustainability tools, surveying technologies and construction site management applications. This paper examines how digital skills influence women's professional growth in the construction industry. The study adopted a quantitative research approach, using a questionnaire to collect data from 113 randomly selected construction professionals in the South African construction industry. The data collected was analyzed using descriptive statistics. The findings show that mastery of digital tools is perceived to support professional growth through improved work efficiency, access to new responsibilities, recognition, promotion opportunities, and wider participation in technical construction services. Digital tools were also perceived as useful for improving inclusivity, diversity, equality and accessibility in areas such as project management, design, quantity surveying, construction management, data-driven decision-making and sustainability. However, the findings also show that digital skills alone cannot address women's under-representation. Supportive education systems, mentoring, anti-discrimination measures, childcare support, flexible work arrangements, equal pay, gender-sensitive hiring and safer work environments are also required. The paper concludes that digital skills can enhance women's career pathways, but only when supported by wider institutional and workplace reforms.

Keywords: Construction industry, digital skills, gender equality, professional growth, women

1. Introduction

The construction industry is central to economic development, infrastructure delivery and sustainable cities (Sesele, 2022). It provides buildings, roads, water systems, energy infrastructure and other facilities needed for social and economic life (Department of Public Works and Infrastructure, 2022). However, the industry is one of the least gender-balanced sectors globally. Women are under-represented in construction employment, technical roles, site-based work and leadership positions (Hickey and Cui, 2020; Stride et al., 2021).

In South Africa, this challenge is linked to wider social and economic inequalities (StatsSA, 2024). Women's participation in construction is affected by educational access, gender stereotypes, limited role models, workplace culture, safety concerns, caring responsibilities, unequal career opportunities and limited access to professional networks (UNESCO, 2024). These barriers are not only social problems; they

also affect the industry's ability to attract skilled people, innovate and respond to future labor needs (CETA, 2025).

At the same time, construction work is changing. The fourth industrial revolution has increased the use of digital technologies in planning, design, construction and operation. These tools include Building Information Modelling (BIM), structural analysis software, project management and scheduling tools, construction site management systems, design and drafting tools, quantity take-off and estimating software, cloud collaboration platforms, sustainability and energy analysis tools, and digital surveying systems (Windapo, 2021). These tools can reduce some traditional barriers to participation by enabling remote work, improving collaboration, reducing reliance on physical strength, increasing transparency and creating new technical career paths (Al Salaheen et al., 2024).

Digitalization, therefore, raises an important question: can digital skills support women's professional growth

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in the construction industry? This question is important because digital transformation may either reduce inequality or reproduce existing exclusion. If women do not have equal access to digital training, tools and work opportunities, digitalization may deepen the gender gap (Bailey and Nyabola, 2021). However, if digital skills are made accessible, they can help women enter, remain and progress in construction careers. Therefore, this paper examines how digital skills influence women's professional growth in the South African construction industry.

2. Literature Review

2.1. Gender inequality in the construction industry

The construction industry is widely recognized as male dominated. Women are under-represented in site roles, technical occupations, ownership positions and senior leadership. Stride et al. (2021) note that women constitute a small proportion of the construction workforce and that the COVID-19 period exacerbated existing inequalities. Nieto et al. (2024) further argue that although larger companies may have formal diversity and inclusion policies, their effects are often less visible in small- and medium-sized construction firms.

Women's under-representation is not caused by one factor. It is linked to education, social expectations, workplace culture, hiring practices, lack of role models, poor retention strategies, limited flexibility and weak implementation of equality policies (United Nations, 2016; UNESCO, 2024; Nieto et al., 2024). In construction, these challenges may be more pronounced because the industry is often associated with physical labor, long hours, site-based work, mobility demands, and masculine work cultures (Windapo, 2021). The lack of women in leadership is also a major barrier. Hickey and Cui (2020) report that women occupy fewer than 4% of executive leadership roles in engineering and construction companies in developed countries. This limits the visibility of women role models and can reduce younger women's confidence in pursuing careers in construction.

2.2. Education, STEM and women's career pathways

Women's participation in construction is linked to access to Science, Technology, Engineering, and Mathematics (STEM) education. UNESCO (2024) notes that women are under-represented in STEM education, research, innovation and leadership. Barriers include stereotypes, gender bias, lack of mentoring, limited flexible work structures, poor career management, and inadequate parental or caregiving support policies. The United Nations (2016) proposes action areas for improving women's participation in STEM. These include changing social stereotypes, engaging girls in STEM education, attracting women

into higher education, promoting equal career progression, preventing harassment, supporting work-life balance, ensuring gender-sensitive policy design and promoting women's access to technology and innovation.

These ideas are relevant to construction because many construction professions depend on STEM knowledge. Architecture, engineering, quantity surveying, construction management, project management, facilities management and sustainability consulting all require technical knowledge. Therefore, improving girls' and women's pathways into construction must begin with education and continue into employment.

2.3. Digital transformation in the construction industry

The construction industry is being reshaped by digital technologies. Artificial intelligence, BIM, cloud computing, robotics, big data, internet of things, digital surveying, 3D modelling, virtual reality and sustainability analysis tools are increasingly used across the project lifecycle (Wang et al., 2023; Regona et al., 2024; Omrany et al., 2024). These technologies improve design quality, project coordination, cost estimating, scheduling, safety monitoring, resource optimisation, lifecycle management and sustainability assessment.

However, digital adoption is not automatic. Barriers include a lack of knowledge, resistance to change, the cost of training, technical complexity, poor communication of benefits, weak organisational support, and limited technical expertise (Windapo, 2021; Mazurchenko and Zelenka, 2022). These barriers affect all construction professionals, but they may have a stronger impact on women, who already face unequal access to training, networks, tools, and professional opportunities.

2.4. Digital equity inclusion and women's professional growth

Digital equity means that people have fair access to digital tools, digital infrastructure, training and opportunities to benefit from technology. Bailey and Nyabola (2021) highlight global digital access gaps, especially in Africa. If digital access is unequal, digital transformation may increase existing inequalities rather than reduce them. Digital tools can also create new opportunities for women in construction. Windapo (2021) and Al Salaheen et al. (2024) argue that technologies such as BIM, augmented reality, virtual reality, autonomous construction, 3D printing, and drones can reduce barriers associated with site work, including physical strain, safety risks, fear of heights, and work-life balance challenges. These tools may also

challenge traditional views that women belong mainly in administrative roles rather than technical construction work.

3. Research Methodology

The study adopted a quantitative research approach. A questionnaire was used to collect data from 112 randomly selected registered with the Construction Industry Development Board (Cidb)-registered in the South African construction industry. The survey was appropriate because the study aimed to gather perceptions from a range of professionals on digital tool mastery, career growth and women's inclusion in the industry. The questionnaire was administered electronically via Survey Monkey. The survey captured 112 recorded responses. However, the number of valid responses varied across questions because some respondents did not complete all sections. Therefore, the findings are interpreted descriptively and with scientific rigor.

The data were analyzed using descriptive analysis. Responses were examined to identify patterns in digital mastery, perceived career influence, perceived support for women's growth and factors affecting women's education and employment pathways. Inferential statistical claims were not made but the conclusions are drawn from observed patterns in the survey data.

The survey used categorical questions and Likert-type response scales. Digital mastery was measured using categories such as very low, low, moderate, high and very high. Perceptions of inclusivity and career influence were measured using categories such as not at all, some extent, moderate extent, large extent and very large extent. The digital tools investigated are shown in Table 1.

The study has two main limitations. First, the sample is not claimed to represent all construction professionals in South Africa and second, the study is based on perceptions and does not directly measure actual career outcomes such as promotions, salaries or job changes.

Future research should use a larger dataset and may apply inferential analyses to test relationships among digital mastery, gender, and career outcomes.

4. Findings and Discussion

4.1. Profile of respondents

The dataset includes respondents from different construction-related roles. These include construction managers (40%), engineers (15%), quantity surveyors (3%), architects (2%), and other built environment participants, including project managers and facilities management practitioners (39%). Several respondents work as contractors (49%), subcontractors (13%), consultants (11%), government (4%), educational institutions (5%), and other organisations (18%).

The dataset also includes both male and female respondents, although male respondents are more visibly represented (74%). This reflects the wider male dominance of the construction industry. Respondents also came from different age groups, education levels and experience categories. Many had more than 6 years of construction experience, with several reporting over 21 years (26%). Many respondents were directors or business owners (78%), which suggests that many responses came from people with decision-making experience in construction organizations. Respondents worked for companies ranging in size from microenterprises (51%) to large enterprises (8%). This is important because small firms may face stronger barriers to adopting digital technologies due to costs, limited training budgets, and limited digital infrastructure.

4.2. Perceived mastery of digital tools

The data show different levels of mastery across digital tool categories. Some respondents reported high or very high mastery of tools for project management 3.3 weighted average on a scale of 5), design and drafting (2.63), construction site management (2.88), quantity take-off (3.03), and cloud collaboration (2.68). Other respondents reported low or very low mastery, especially in more specialized areas such as

Table 1: Construction-related digital tool categories investigated

Digital tool category	Examples
3D modelling and BIM	Revit, ArchiCAD, Tekla Structures, Civil 3D
Structural analysis and design	ETABS, SAP2000, STAAD.Pro, SAFE
Project management and scheduling	Primavera P6, MS Project, Procore
Construction site management	PlanGrid, Fieldwire, Bluebeam Revu, BIM 360
Design and drafting	AutoCAD, SketchUp, Rhino 3D, BricsCAD
Quantity take-off and estimating	CostX, WinQS, Planswift, Candy CCS
Accounting and financial management	Sage, QuickBooks, CMiC
Surveying, mapping and GIS	Trimble, Leica Geo Office, DroneDeploy, ArcGIS
Facility and asset management	Archibus, Planon, IBM Maximo
Cloud collaboration and document management	Autodesk Construction Cloud, Trimble Connect, Aconex
Sustainability and energy analysis	IES VE, DesignBuilder, One Click LCA, Tally

sustainability and energy analysis (2.14), facility and asset management (2.71), structural modelling (2.3), and some advanced BIM functions (2.39).

This pattern suggests uneven digital readiness in the construction industry. Some professionals are already using digital tools effectively, while others remain at low levels of mastery.

The data also shows that respondents acquired digital skills through several routes. These include formal education (21.25%), on-the-job learning (42.62%), self-teaching (25.66%) and informal learning (10.48%). On-the-job learning and self-teaching appear frequently in the dataset. This suggests that digital skills are often developed through practice rather than only through formal education. This is useful because it shows that digital skill development can happen at different career stages. However, it also means that people without access to digital work tasks, mentors or supportive employers may be disadvantaged.

4.3. Digital tools and inclusivity, diversity, equality and accessibility

Respondents were asked the extent to which digital tools facilitate inclusivity, diversity, equality and accessibility in the South African construction industry. The responses indicate that many participants see digital tools as supportive of inclusion, particularly when they improve collaboration, communication, accuracy, planning, and access to information. Digital tools such as BIM, cloud collaboration platforms, project management systems and digital document management were found to improve access to project

licenses, training, digital devices, project experience or supportive mentors, they cannot benefit equally. Digital inclusion, therefore, requires both technology access and organizational support.

4.4. Digital skills and women's professional career growth

The study sought to know whether mastery of digital tools influences professional career growth. Responses show that digital mastery is perceived to influence career growth through the ability to take on new responsibilities, positive feedback and recognition, promotion opportunities, new job offers, important professional recognition, and major career advancement. Several respondents rated digital mastery as having a large or very large influence on career growth (32%). This supports the view that digital skills are no longer optional in construction. They are becoming part of professional competence.

For women, digital skills can support growth in at least four ways. First, they can improve employability by making women more competitive for technical and managerial roles. Second, they can increase visibility, as professionals who can use digital tools may be recognized as capable and innovative. Third, they can open access to less physically demanding but highly technical roles such as BIM coordination, planning, cost management, sustainability analysis and digital project controls. Fourth, they can support entrepreneurship, especially for women-owned firms that use digital tools to improve tendering, estimating, design, coordination and reporting as shown in Table 2.

Table 2: Main ways digital skills can support women's professional growth

Career growth pathway	How digital skills may support women
Employability	Improves technical competence and job readiness
Promotion	Supports performance, recognition and responsibility
Entrepreneurship	Helps women-owned firms improve estimating, planning and reporting
Technical participation	Opens roles in BIM, design, scheduling, cost control and data analysis
Flexible work	Supports remote coordination, cloud collaboration and digital communication
Professional confidence	Enables independent and effective task completion

information. This may reduce the exclusion of people who are not physically present on site or who work from different locations. It can also support flexible work, remote coordination and better communication among project teams.

Design and drafting tools, quantity take-off software and project management tools were also perceived as relevant to career growth. These tools can help professionals demonstrate technical competence, manage tasks more efficiently and participate in higher-value work. For women, this may be important because digital competence can help challenge stereotypes that women are less suited to technical construction roles. However, digital tools do not automatically produce equality. If women are not given access to software,

The findings support the literature suggesting that digitalization can create new pathways into construction, but only when women have access to training and practical experience.

4.5. Construction services where digital skills can influence women's growth

Respondents identified numerous construction service areas in which digital mastery can support women's career growth. These include architecture, engineering, construction management, project management, interdisciplinary collaboration, precision and error detection, data analysis, virtual reality, construction site layout, construction automation, facilities management, quantity surveying, sustainability, energy efficiency, resource optimization, data-driven decision-

making, lifecycle management and enhanced indoor environments. These areas demonstrate that digital skills can support women's growth throughout the entire construction lifecycle. They are not limited to design offices. They extend to site management, sustainability, asset management and project delivery.

Particularly important areas include:

1. Project management and scheduling: Digital planning tools can support women's participation in management and leadership roles.
2. Quantity surveying and estimating: Digital estimating tools can improve cost accuracy and support commercial career pathways.
3. BIM and digital design: BIM can support coordination, modelling and interdisciplinary collaboration.
4. Sustainability and energy analysis: These tools link women's participation to green construction and sustainable development.
5. Cloud collaboration: These tools can support flexible work and wider access to project information.
6. Construction site management tools: These tools can help women participate more fully in site coordination, inspection and reporting.

This is important because women's inclusion should not be restricted to administrative work. Digital tools can help widen women's participation in technical and leadership roles.

4.6. Gender and digital skills acquisition

The study sought to know whether gender was a determining factor in learning and mastering digital tools. The responses were mixed. Some respondents indicated that gender was not a determining factor (64.35%), while others answered "yes" to one or more digital tools (35.65%). This suggests that gender may not affect all respondents equally, but it remains a relevant issue for some. The open-ended comments also show different views. Some respondents suggested that gender is not an issue, while others pointed to the need for women's empowerment, better support structures, proper uniforms, training programmes and formal or informal education. These comments show that gender inclusion is experienced differently across the industry.

The finding suggests that digital skills policy should avoid two extremes. It should not assume that all women experience the same barriers. It should also not assume that gender does not matter. A balanced approach is needed; digital skills programmes should be open to all, but they should also recognise the specific barriers women may face.

4.7. Segregation and access to the construction field

Respondents rated the level of segregation of girls and women in accessing the construction field on a 1-5 scale, with categories such as not acceptable, acceptable, average/fair, good/satisfactory, and very good. The responses vary, but many respondents rated the situation as average/fair (44.21%), acceptable (20%) or not acceptable (15.79%). This indicates that women's access to construction is still seen as a concern to people. This finding agrees with the literature that women's under-representation begins before employment. It is linked to education, subject choice, social expectations, career guidance, admission systems, financial aid, mentoring and safety. Therefore, improving women's digital skills in construction must begin before entry into the labour market. Schools, colleges, universities, and training institutions need to expose girls and women to digital construction technologies early on.

4.8. Education factors supporting women's access and retention

The survey asked respondents to rate factors that attract, promote access to and retain women in education. The factors included preventing gender bias in student admissions and financial aid, gender-sensitive mentoring, workshops, and networks, preventing discrimination and sexual harassment, promoting gender equality in international mobility, and providing childcare facilities for students. The responses show support for many of these factors. Mentoring, workshops, networks, anti-discrimination measures, anti-harassment measures and childcare support were commonly rated as important to some extent, a large extent or a very large extent.

These findings support UNESCO (2024) and the United Nations (2016), which emphasise that gender equality in STEM requires more than access. Retention is equally important. Women need safe, supportive and enabling learning environments. Digital construction education should therefore include mentoring, peer networks, practical tool training, role models and clear anti-harassment systems.

4.9. Education factors strengthening women's career pathways

The study also examined factors that strengthen women's pathways into employment. These included 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 and peer interactions; women managers; mentorship; hiring strategies; flexible strategies; caregiver leave and reintegration; childcare support; assessment procedures and metrics; infrastructure and materials suited to women's bodies; mechanisms against gender-based

violence; workforce policy; management trust in recruiting women; flexible working hours; and programmes for women's health.

The responses show that respondents perceive women's employment pathways to be shaped by many workplace and policy factors. This supports the argument that digital skills alone are not enough. A woman may master digital tools but still face barriers if recruitment is biased, site culture is hostile, childcare support is absent, pay is unequal, or promotion systems are unclear.

Digital skills must therefore be integrated into a wider inclusion strategy. This strategy should combine training, fair hiring, mentoring, workplace safety, flexible work, gender-sensitive performance evaluation, and leadership development.

5. Discussion of Findings

The findings show that digital skills can support women's professional growth in construction. They can increase employability, improve technical participation, support promotion and enable access to new roles (Al Salaheen *et al.*, 2024). They can also support inclusion by improving collaboration, flexibility and access to project information (Windapo, 2021). However, the findings also show that digital skills are not a complete solution. Digital transformation can only support equality if women have fair access to tools, training, work experience and supportive workplaces (Bailey and Nyabola, 2021). Without these, digitalisation may benefit those already privileged in the industry. This finding is consistent with the view that digital transformation does not automatically produce equity. Where digital skills development is informal, self-directed or dependent on unpaid personal time, it can reproduce existing gender inequalities because women may have less access to time, networks and organisational support for advanced technology learning (Gardner, 2019). Therefore, digital skills development should be formally embedded in workplace training, mentoring and career-development systems rather than treated as an individual responsibility.

The key contribution of this paper is that it frames digital skills as a pathway within a wider system of inclusion. Digital skills can strengthen women's professional growth, but they must be supported by inclusive education, affordable and accessible training, mentoring and role models, safe learning and work environments, fair recruitment and promotion, flexible work arrangements, childcare and caregiving support, equal pay and anti-discrimination policies, and management trust in recruiting and promoting women (UNESCO, 2024). The findings also suggest that inclusion must be addressed at organisational and site level. Recent work on gender inclusion in construction

shows that workplace safety, career progression, top-management commitment and inclusion at leadership level are essential attributes for improving gender inclusion in construction environments (Husam *et al.*, 2024). This supports the argument that digital skills must be accompanied by institutional measures that make construction workplaces safer, fairer and more supportive for women.

Digital equity enabling platform for inclusivity, diversity, equality and accessibility should not only provide access to software (Bailey and Nyabola, 2021). The platform should also avoid symbolic or superficial forms of inclusion (Hickey and Cui, 2020). Evidence from the AEC sector shows that increased numerical representation does not always translate into genuine participation, influence or equity, particularly where women are placed in limited roles or do not have equal power to shape organisational decisions (Hong, 2024). Therefore, this study proposes a solution that include measurable indicators of access, participation, promotion, leadership and retention. It should connect digital skills training with education, employment, professional registration, career support, entrepreneurship and policy reform.

6. Conclusion and Further Research

This paper examined how digital skills influence women's professional growth in the South African construction industry. Using questionnaire data from construction industry professionals, the paper found that digital tool mastery is perceived to support career growth through improved technical competence, new responsibilities, recognition, promotion opportunities and wider participation in professional services. The findings show that digital tools can support women's growth in architecture, engineering, construction management, project management, quantity surveying, facilities management, sustainability, energy data analysis, site management and digital collaboration. However, the study also shows that digital skills alone cannot resolve gender inequality. Women's professional growth also depends on access to education, mentoring, anti-discrimination measures, safe workplaces, flexible work, childcare support, fair hiring, equal pay, leadership opportunities, and a supportive organizational culture.

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