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Understanding the BIM actor role: a study of employer and employee preference and availability in the construction industry

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Abstract

Purpose – The implementation of BIM in the construction industry requires the coevolution of the various aspects of the BIM ecosystem. The human dimension is a very important dimension of the ecosystem necessary for BIM implementation. It is imperative to study this aspect of the BIM ecosystem both from the employer perspective and employee availability to provide insights for stakeholders (job seekers, employers, students, researchers, policymakers, higher education institutions, career advisors and curriculum developers) interested in the labour market dynamics.

Design/methodology/approach – To understand the BIM actor roles through the employer lens and the actual BIM actors in the construction industry, this study employed data mining of job adverts from LinkedIn and Mncjobs website. Content analysis was employed to gain insights into the data collected. Also, through a quantitative approach, the existing BIM actor roles were identified.

Findings – The study identified the employers' expectations of BIM actors; however, it is noted that the BIM actor recruitment space is still a loose one as recruiters put out open advertisements to get a large pool of applicants. From the data analysed, it is concluded that the BIM actor role is not an entirely new profession. However, it simply exists as construction industry professionals with BIM tool skills. Also, the professional development route is not well defined yet.

Originality/value – This study presents a realistic angle to BIM actor roles hence enhancing BIM implementation from the human perspective. The findings present an insight into the preferred against the actual.

Keywords BIM actor Role, BIM diffusion, BIM ecosystem, Building information modelling, Construction industry, Employer perspective

Paper type Research paper

Introduction

The fourth industrial revolution ushered in diverse technological tools and platforms; this is revolutionising existing processes across sectors, including the construction industry. According to the world economic forum, the construction industry occupies a strategic position in the economy and has linkages with every sector of the economy (Castagnino *et al.*, 2016). However, the construction industry has continued with the same approach to its processes for the past 50 years (Santiago *et al.*, 2018) despite the changing demands of clients. In order to exit the labour-intensive process and meet up with the infrastructural demand

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from clients, the construction industry must key into the fourth industrial revolution. Different tools have been identified to achieve this and change the process and products in the construction industry. These include prefabrication and modular construction, autonomous construction, augmented reality, big data and predictive analytics, cloud and real time collaboration, 3D scanning and photogrammetry and Building information modelling (BIM) (Ejohwomu *et al.*, 2021).

This study focused on BIM as an emerging technology, however, from the actor perspective. This is due to the actors' critical role in the diffusion process (see Adekunle *et al.*, 2021). Literature reveals the emergence of new professional roles due to BIM uptake in the construction industry. Some of these roles are presented in Table 1.

Meanwhile, it is worthy of note that most of these roles overlap and there is no distinct demarcation between them. This corroborates Davies, Wilkinson and Mcmeel, (2017) position; thus there is a need for a regulation of the human resources roles and job description in the BIM ecosystem. Also, this alludes to the fact that the different guide specification on BIM roles is not adhered to in practice, but different employees define job roles and specifications. It is however worthy of note that existing published guides have different perspectives on the BIM roles depending on the source-client or industry-client coalition (Davies *et al.*, 2014). It becomes important to study employer requirements for BIM roles, the development trend of the BIM roles over time vis-a-vis a comparison with the roles in the existing literature. Ultimately, to investigate the perception of employers in terms of requirements for the various BIM roles. Furthermore, against the employer preferred roles and responsibilities, the study conducted a study to identify actual BIM actor roles.

Roles	Functions
BIM Manager	coordinating the team and the production and use of the model, implementation of BIM, development and delivery of the BIM execution plan and establishing BIM protocols for the project (Davies *et al.*, 2017), (LetsBuild, 2019)
Building Modeller	create, develop and extract 2D documentation from BIM models
Sequencing Modeller and Detailing Modeller	add sequencing to resources (Panushev and Pollalis, 2006)
Modelling manager/project model manager/model manager	He is responsible for assigning team leaders for each project stage and for managing the client relationship, develop modelling guides for specific building parts, with the cost modelling expert creates standard recipes, approves 3D model, approves 3D-cost model, facilitates information and data management, catalyst and facilitator of BIM, integrate the information supplied by different building actors into BIM, assist the project manager in the communication with the building actors and the clients by preparing 3D visualisations and maintaining clear protocols for information exchange, prepare as-built BIM (Panushev and Pollalis, 2006)–(Barison and Santos, 2010)
3D Modellers	review construction documents, content plan and modelling guidelines (Panushev and Pollalis, 2006) create the geometry in BIM model working in teams for developing different parts of the model (Barison and Santos, 2010)
Cost Modeller	Add methods and resources to the recipe database which increases the LoD of the cost model from low to medium (Panushev and Pollalis, 2006), inserts information about the construction process and resources required (Barison and Santos, 2010)
BIM analysts	Review, analyse and simulates the BIM model (Panushev and Pollalis, 2006)

Table 1.
Some BIM roles from literature

BIM actors in literature

There have been several studies on the different emerging roles due to BIM adoption. These studies investigated these emerging roles using different perspectives and different intents. These studies include Akintola *et al.* (2017), Davies *et al.* (2017), Uhm *et al.* (2017), Hosseini *et al.* (2018), Jacobsson and Merschbrock (2018), Bosch-Sijtsema *et al.* (2019) and Bosch-Sijtsema and Gluch (2019).

The study by Akintola *et al.* (2017) investigated the legitimacy of the new roles through a subjectivist philosophical perspective. The study was qualitative in nature as it interviewed industry professionals who have been involved with BIM implementation at the organisational level. The study posited that these new roles are in existence and will continue to exist due to the lack of expertise by core professionals. Thus it is implied that the acceptance of the new BIM roles is their apparent knowledge of BIM tools over the core professionals. Jacobsson and Merschbrock (2018) concluded that these new roles are not sustainable. This conclusion is similar to (Hosseini *et al.*, 2018). Hosseini *et al.* (2018) when they concluded through text mining of real-life job advertisements. The study implied that the role of BIM manager could be fully taken up by project managers if supported and fully nurtured to acquire BIM competence.

In the study by Bosch-Sijtsema and Gluch (2019), they focused on the development of the BIM actor role in the construction industry. Their findings presented insights through data gathered from BIM and non-BIM users. From this study, it is evident that the skill requirement for the BIM actor is not adequately captured and it is still evolving.

It is worthy of note that a study by Sebastian (2011) in the Netherlands adopted a case study of two healthcare building construction projects. In the two projects considered, one employed a BIM model manager while the other did not. The study highlighted the challenge faced during the project execution phase in terms of BIM software compatibility, dexterity of professionals with software, among others. Although the study did not articulate a direct comparison in terms of the outcome but based on the outlined roles of the BIM manager, it is evident that the project with a model manager experienced a better project administration compared to the other. Thus, the place of a designated BIM actor role is important in projects adopting BIM. This contrasts with (AGC, 2008) who opines that existing professionals can perform all required duties and does not require any special BIM actor in the implementation of BIM on projects. AGC offered detailed roles and responsibilities for existing professionals without any mention of BIM actor roles.

The study by Davies *et al.* (2014) investigated the current practice within BIM roles in New Zealand. The study was achieved through an interview of BIM specialists across disciplines. The study supported the BIM manager roles. Most of the study's findings dwell on the roles, expertise, skills and route to achieving the BIM manager status. It gives a comparison of the description of the BIM manager role in handbooks and guides as against what is obtained in practice. The study revealed that there was no formal BIM manager training for the respondents and most of them acquired the BIM knowledge through individual efforts. The study posited that most BIM managers were assigned as BIM champions. There are studies that adopted a systematic review of literature on BIM actors (Jacobsson and Merschbrock, 2018) (He *et al.*, 2017).

These existing studies border generally on the viability, sustainability, standardisation of the BIM actor roles. Although these studies reached different conclusions, it is, however, noteworthy that the BIM actor role exists and is receiving attention. The more attention this subject area in BIM enjoys, the more it achieves maturity and legitimacy. Also, these discourses point out that the BIM adoption space is continuously evolving and is yet to be fully formed. It is, however, important to note that these previous studies did not study the BIM actor role from the employers' perception. The study by (Davies *et al.*, 2014) and (Bosch-Sijtsema *et al.*, 2019) require that the role requirements are studied from the employer perspective.

Underpinnings

The study of the BIM actor role in the adoption of BIM is important because the effective implementation of technology requires human input. The BIM ecosystem requires the alignment and coevolution of process, people and the product (Gu *et al.*, 2014). Coevolution has been said to be at the heart of the dynamic analysis of innovation; it also explains the transformation and structural change inherent in it (Malerba *et al.*, 2007). Also, Malerba posits that a change in the knowledge base or demand for features in an industry may affect the characteristics of the actors. The introduction of BIM into the construction industry necessitated a demand for new actors suited to the innovation. BIM adoption, therefore, birthed a new set of actors with new capabilities and requirements to ensure its implementation. This gave rise to the different components affecting these actors like roles, competence, and professional pathway, among others. Competence or knowledge is one of the central drivers for change in a system (Malerba, 2006).

Although the actualisation of the dynamic capabilities inherent in innovations does not rely solely on the actors (Teece, 2017) however this aspect of the BIM ecosystem must evolve with the other aspects of the ecosystem. Innovation and industry evolution is tremendously shaped by the interaction of different actors (Malerba *et al.*, 2007). Thus, human actors must be properly aligned to discharge the required functions responsible for BIM implementation. Being properly aligned means they must possess the required skill set for each stage of BIM implementation. This aligns with the work of Nelson (1994), which posits that there is a constant development of new technology over time during its lifecycle and that firm and industries structures co-evolve with technology. It is thus necessary to discuss BIM actor competencies, job description and their commensurate development in the BIM ecosystem.

The constant development of the BIM ecosystem is in line with the posits of the activity theory. Activity theory states that there are usually contradictions and a constant state of development in an activity system (Engestro, 2000). The construction project process is an example of an activity system and the introduction of new technology like the BIM is a new development in the construction industry. These constant contradictions and development between elements of the system cause the change and alignment of the different objects, dimensions of the ecosystem.

To better understand the unit of analysis, the APDOT model (US Department of Labor, 1993) was adopted. Prior to 1999, job analysis was carried out using the Dictionary of Occupational title; however, this was replaced by the occupational information network (O*NET) framework (Fleishman *et al.*, 1995). This framework provides a comprehensive framework for job description and analysis. Although the O*NET framework consists of 6 domains, of interest to this study is occupation-specific requirements but from the workers perspective. This consists of occupation skills, knowledge, task duties and technology. However, the study by Reiter-Palmon *et al.* (2006) reveals that focussing on occupationally specific job requirements are important and O*NET only provides a broader context and not job-specific information. Occupationally specific job requirements provide a worker with tailored characteristics to a specific job. Thus to achieve an insight into the BIM actors roles the APDOT (US Department of Labor, 1993), was employed. According to Fleishman *et al.* (1995), the APDOT is a model that describes all necessary variables required in a comprehensive occupational information system. The APDOT model consists of two sets of variables which are attributes of the work to be done and attributes prospective workers must possess to be able to execute the work. The APDOT model has four domains: worker attributes, work context, labour market context and work content and outcomes. This study will adopt the worker attributes variables to achieve an in-depth understanding of the BIM actor roles.

Research method

This study analyses BIM job advertisements in the South African construction industry to gain occupationally specific requirements of these roles. Most employers fill vacancies through internal reallocation, task split and restructuring. Generally, vacancies are posted when there are no internal existing fit staff for the vacancy. Doing internal deployment and restructuring is considered faster and more cost-effective for employers. Meanwhile, vacancies are due to development in a sector and when the existing structure does not match the demand due to the developments (Kureková *et al.*, 2013). Secondly, the study conducted a survey to determine the existence of BIM actor roles in the South African construction industry. This presents an insight to determine if there are BIM actor roles in the South African construction industry. To achieve this, a total of 183 responses were gathered from various construction industry professionals.

The following steps as illustrated in Figure 1 were followed to achieve the aim of this study. BIM job-related advertisements were sought from Linkedin (linkedin.com) and MNCjobs site. Linkedin is a professional website mainly for professional networking, while MNCjobs (mncjobs.co.za) is a South African based job matching portal. Although other sites were visited through "GOOGLE.com', most postings were reposts of the same jobs. The search keywords employed on LinkedIn are "BIM jobs" and the location was set to "South Africa". On Mncjobs, the job search was done through the "search by designation" option. The same search words were applied. The search results from the LinkedIn search returned 106 results while Mncjobs returned 100 BIM-related results. These results were filtered, duplicated jobs that are not BIM-related based on the job description and internship placements were removed. A total of 70 listings were left after the filtering and 33 job titles were identified.

In recent times, there is a heavy reliance on the Internet to achieve many things. Most activities revolve around the Internet and this applies to the workplace also. Thus, to attract and recruit qualified hands to fill vacant roles. The online advertisement started in the 1990s and afforded employers more space to articulate all requirements unlike the space constraints experienced with print media (Carnevale *et al.*, 2014). Online advertisements provide access to better understand employer requirements (Kureková *et al.*, 2013) thus it is a valid data source. Online recruitment data were employed in Hosseini *et al.* (2018). Online job adverts data are objective, organic and naturalistic (Harper, 2012) and no based on respondents' bias or subjectivity unlike data obtained through surveys and interviews (Treisman, 2007). They provide good insight and understanding of the labour market dynamics for all

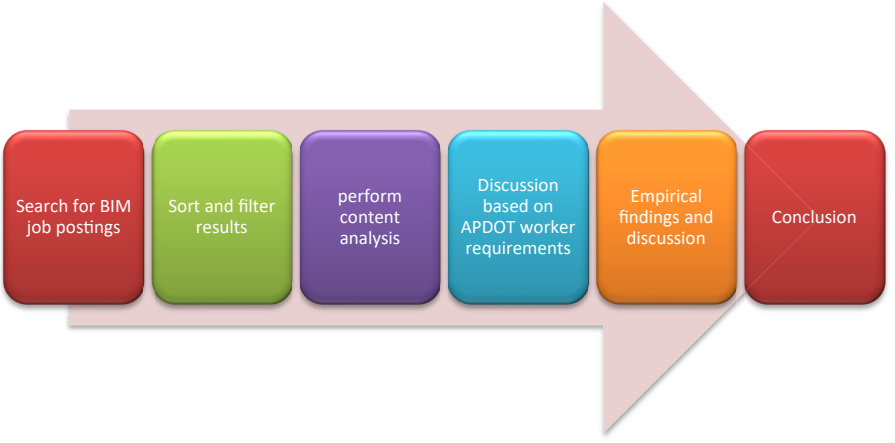

Figure 1.
Research method

stakeholders – job seekers, employers, students, researchers, policymakers, higher education institutions, career advisors and curriculum developers (Carnevale *et al.*, 2014). Thus, it was employed in this study to understand employers' perception and requirements for BIM actor roles.

Content analysis was employed to gain insights by using the APDOT worker requirements domain. According to (Bengtsson, 2016), content analysis can be used on all types of written texts irrespective of source. The content of the collected ads was divided up and condensed into meaningful units, the hermeneutic spiral was done among others as outlined (Erlingsson and Brysiewicz, 2017) (Kumar, 2011), to get meaning into the employer's requirement of BIM actor roles. The manifest analysis was employed as the analysis was very close to the collected data and the analysis discussed the obvious in the data (Bengtsson, 2016).

Different job postings contain irregular information for prospective applicants. The contents vary and are not comprehensive. This was analysed using different subheadings, see Table A1.

The study also conducted a South African construction industry case study through a quantitative survey of construction industry professionals. The study surveyed professionals in the South African construction industry to enhance understanding the BIM Actor roles in the South African construction industry. A total of 183 responses were collected for the study. The analysis of the collected data is presented in Table A2.

From Figure 2, the most popular and sought BIM role is that of a BIM modeller. This, when compared to the study of Uhm *et al.* (2017) where the position of the BIM manager. The BIM modeller role was presented in different variants (Figure 3) by the different employees. The basis for the variant is the need of the contractor. This implies that there exists no uniform nomenclature for this role.

As earlier stated, in order to gain more insights into the job adverts, one of the domains of APDOT, Figure 4, was adopted. One of the four domains of the APDOT model is the worker attributes variable. This domain was chosen because it provides the unit of analysis required for analysing the required attributes required of a prospective worker in performing the desired task. The different variables which represent the characteristics or qualifications

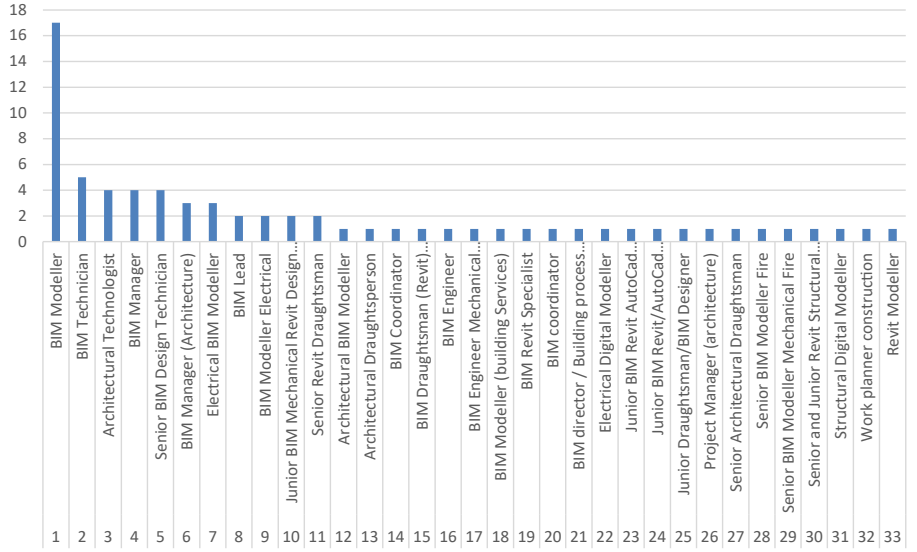

Figure 2.
BIM job roles from job adverts

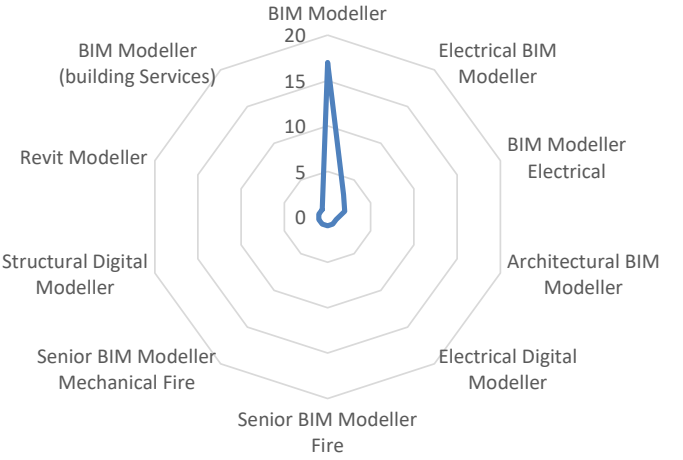

Figure 3.
BIM modeller role variants

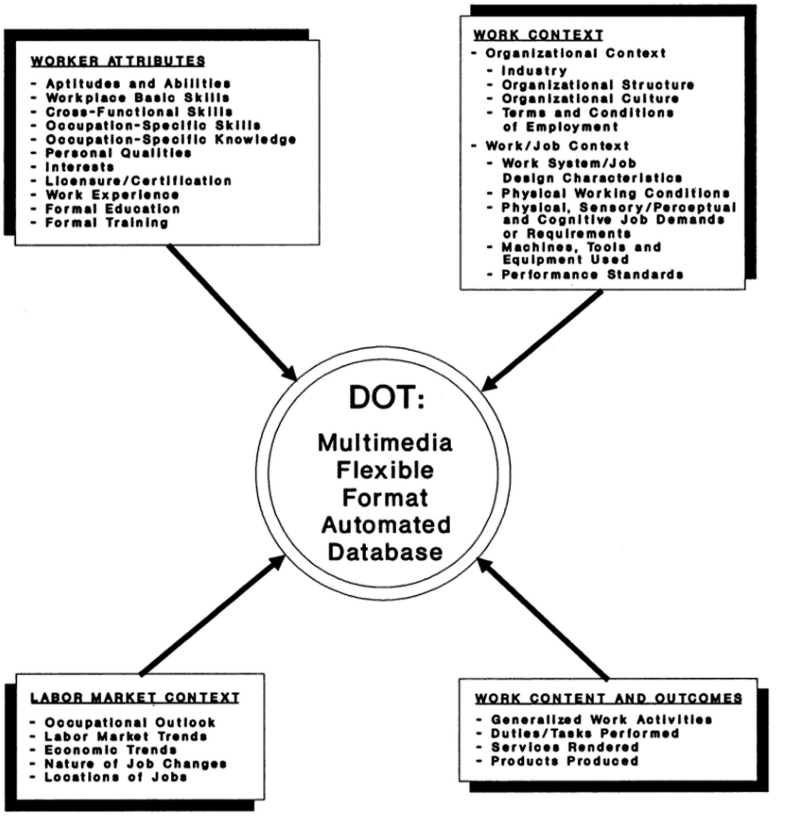

Figure 4.
DOT model

Source(s): US Department of Labor (1993)

expected of a worker (US Department of Labor, 1993) are employed as the themes for discussion of the adverts (Table A1).

(1) Aptitudes and Abilities: This is the capacity required to perform a range of physical and mental functions. It includes cognitive abilities, perpetual abilities, psychomotor abilities, sensory abilities and physical abilities.

(2) Workplace Basic Skills: are the required abilities developed over time and are required in virtually all jobs to some degree. They are reading, writing and arithmetic abilities.

(3) Cross-Functional Skills-these are generic skills that are required for the performance of broad categories of a work activity that occur over a relatively wide range of jobs. They include information gathering, oral communication, problem analysis, negotiating, organising and planning, coordinating with others and mentoring,

(4) Occupation-Specific Skills: these are developed abilities required to perform activity-specific and job duties or tasks. They include the ability to operate specific machines, among others.

(5) Occupation-Specific Knowledge: it is the degree of awareness of facts, processes, methods, techniques, subject area among others, as it applies to an occupation or job.

(6) Interests: this is an exhibited likeness for performing specific tasks, this includes realistic, investigative, artistic, social, enterprising and conventional.

(7) Personal Qualities – this defer in people; it defines an individual's peculiar characteristics like habit, ways of thinking, behaviour among others.

(8) Licensure/Certification-this includes state, professional and technical certification that is required for jobs. These certifications are usually given out by professional bodies, academies among others.

(9) Work Experience – job experiences are acquired over time on a job. It is most times made a prerequisite for employment for other jobs. Job experience can be acquired on a regular full time or part-time paid or unpaid volunteering job.

(10) Formal Education-this is the structured learning received in a formal setting or school, required of a worker or job seeker. Formal places of learning include secondary school, polytechnics, technical colleges, universities, among others.

(11) Formal Training-formal training is also received in a structured environment of learnership for instance, apprenticeship, certified programs, training programs etc., these are usually acquired in formal settings but not in an academic environment.

Identified BIM actor roles

BIM modeller

This is the most sought-after job by employers. The role of a BIM modeller has different variants: Electrical BIM modeller, architectural BIM modeller, Revit BIM modeller, BIM modeller building services, electrical digital modeller, structural digital modeller, BIM modeller fire and BIM modeller mechanical fire. Analysing the job descriptions of the modellers, the role of the modellers include optimising and elaborating architectural design using Revit, playing a technical advisory role to design teams, quality and timely delivery assurance functions, assessing and linking design models to cost implications, coordinating and communicating

with all building stakeholders, attending meetings and training functions. There seems not to be a consensus about the educational qualification because employers were concerned about industrial experience and proficiency in using Revit, AutoCAD and other BIM tools. Most of the responsibilities of the modeller are pre-tender stage and the modeller provides technical assistance ensuring the construction phase goes as designed. Thus, the role is referred to by some employers as the BIM knowledge manager responsible for the process and quality of output. It is like an overseer role, managing the entire process.

BIM manager

There are different nomenclatures for this position, this includes BIM manager Architecture, BIM director or Building process manager. Employers have no clear job description for this role in the adverts. Instead of the job description, employers listed worker's requirements they felt will deliver what they have in mind. This position requires a candidate with 5–10 years of experience as in a capacity incorporating BIM and Revit. Also, a Revit project management experience is a requirement. Professional body affiliation is an added advantage for prospective BIM actors. For formal education, employers specified a diploma in architecture or draughting. Revit (architecture, structural and interiors) and BIM knowledge. Interests required are self-motivation, proactiveness and eagerness. The role of the BIM manager is to meet with project teams, coordinate the BIM process throughout the building lifecycle, form a think tank with other professionals and to manage the BIM coordinators. (Davies *et al.*, 2017) describes the role of the BIM manager as a coordinator of the BIM process and ensures the implementation of the execution plan but evidently, employers require more and this includes organising training and preparing training materials.

BIM lead

The role and job description of this actor in the organisation was not stated by employers; however, the position requires a diploma in draughtsmanship. It also requires proficiency in Revit, MS office suite and AutoCAD. Employers seek 10–15 years of prior experience.

Although employers did not state the job description, it can easily be inferenced from the title that a BIM lead is an actor who leads all BIM endeavours of the organisation. Judging from the requirements and title, it can be said that the responsibility of the BIM manager and BIM lead are one and the same.

BIM technician

The role of a BIM technician includes analysis of information provided by other professionals on the project team, creation or modification of engineering designs, coordinating and communicating with stakeholders, taking responsibility for the timely delivery of designs, attending site meetings, drive BIM improvements, ensure day to day BIM workflows and mentoring and training. Employers generally require work experience in MEP, Revit and BIM environments. Revit and AutoCad proficiency with certifications are also an important requirement. Formal education requirement for this BIM actor role is not explicitly stated but tertiary education. As regards working experience, the minimum required is 2 years. The job requires that the actor exhibit high work ethics, self-motivation, meticulousness, oral and communication skills and ability to research and ensure the organisation is at par with the BIM trend.

BIM technologist

The outlined roles of a BIM technologist include working with the design professionals to produce designs in Revit and AutoCAD, site supervision, contract management, design, technical detailing and drafting, presentations, invoicing, networking, business development

and social media management. This actor role requires five-year prior experience with an architectural firm. Competence in Revit and exposure to BIM is required and professional body registration is required.

Draughtsman

The job posting has variants that include Revit draughtsman, Revit structural draughtsman, architectural draughtsman, BIM designer/junior draughtsman and BIM draughtsman. It is observed employers apply cadre recruitment to these postings. This role is a support role to the design team. However, it is involved in the design creation brainstorming process, Cad draughting and detailing, quality auditing of drawings, organising training; the role also creates BIM families and templates. Revit, AutoCAD and BIM 360 proficiency are required. The emphasis for this role is a certificate in Revit or draughting. Professional certification, previous experience in the built environment and BIM-enabled setting are also required. Employers like in other BIM actor roles stated require meticulousness, passion and ability to work in a team as important to the successful functioning of this role.

Revit designer

The variants in nomenclature for this role are BIM Revit specialist, BIM mechanical Revit design surveyor and BIM Revit/AutoCAD mechanical design engineer. The identified functions of this role include ensuring all designs are modelled in Revit; it is a support role to the design team and prior construction industry experience is required. Tertiary educational training is required.

BIM coordinator

This role works with the BIM manager in order to achieve BIM implementation. This actor is to act as a link between the BIM modellers and designers to enrich and optimise designs. The only requirement for this position is the knowledge of Naviswork or other equivalent software.

Discussion

The content of job adverts is a pointer to the state of an industry. It offers an insight into the labor market state. According to (Kureková *et al.*, 2013) employers are more open to generate sufficient applicants in a tight labour market while the opposite is the case in a high vacancy scenario where job ads are more likely to contain many filters so as to control the application rate. A study of the BIM advert shows an open approach to the adverts; many adverts are not fully populated with specific job requirements. This by implication means that the BIM job space is still developing and yet to reach maturity. Job adverts should have sufficient information and allow for decisions to be made, CVs to be tweaked among others (Furnham, 2012). There is much other crucial information missing on the job advertisements (Anastasiou, 2014). opines that salary and a detailed description of work are crucial elements of HRM communication policies for attracting ideal candidates. These elements are missing in the job adverts studied (Table A1).

The functions of the identified BIM actor roles are similar and most employers require them to serve as a contact point for BIM development, diffusion and implementation in their organisations. Most of the identified roles are observed to be tailored towards site supervisors. These adverts portray most BIM actors as a link between BIM implementation and the traditional approach. They are portrayed as "saviours" to save the organisations from remaining in the former state and ensuring BIM compliance. This is a pointer to the fact that the occupation-specific skills nor job descriptions are yet to mature and are not standardised yet.

Furthermore, unlike the existing professionals in the built environment, the BIM actor roles do not have a defined professional path yet. The job experience required is found in the

existing professionals' experience in the construction industry and professional membership of the existing professional bodies are considered as prerequisite requirements also. There is a heavy reliance on the existing professional experience as it gives the required construction industry experience. It allows BIM actors to understand the process.

Generally, the top five most sought BIM actor roles are BIM modeller, BIM technician, BIM technologist, BIM manager and BIM design technician. These jobs have different variants based on employee needs. BIM actor roles can broadly be divided into two buildings and services. The building actor role deals with normal building and services deals with the MEP aspect. This contrasts with Table 1 where the functions are BIM process tailored but job adverts show otherwise (see Figure 5).

Case study

To gain insight into the Actor roles in existence in the South African construction industry, the study surveyed professionals in the South African construction industry. A total of 183 responses were collected for the study. Table A2 presents an analysis of the collected data. The data shows that most respondents are mostly from consultancy (53.5%), followed by contracting (19.7%) and the government (12.6%). Respondents are mostly from the Gauteng province of South Africa. Regarding educational background, they possess different educational qualifications (PhD, Masters, Bachelor degree, honours and Matric); however, most of the respondents (29.5%) are BSc degree holders.

A critical study of the professional affiliation of respondents reveals that respondents are from the traditional construction industry professionals (Quantity surveyors, Architects, Engineers among others) and the evolving BIM actor roles. The identified BIM actor from the survey are: 3D Modeller, Modelling specialist, BIM Manager, BIM administrator, Building Modeller, Virtual Architect/Engineer, 4D specialist, Architectural Technologist, BIM coordinator, BIM Platform Resellers, BIM Technical Specialist (Civil Infrastructure), Digital project coordinator, project model manager, BIM champion, Cost Modeller, Virtual construction manager, Digital contractor, Sequencing Modeller and Detailing Modeller, BIM facilitator, Virtual construction manager and BIM researcher. A critical look at responses shows that Architects and Civil engineers appear to be more receptive to the new roles more than other traditional professions. This might be attributed to the adoption of BIM software for various functions.

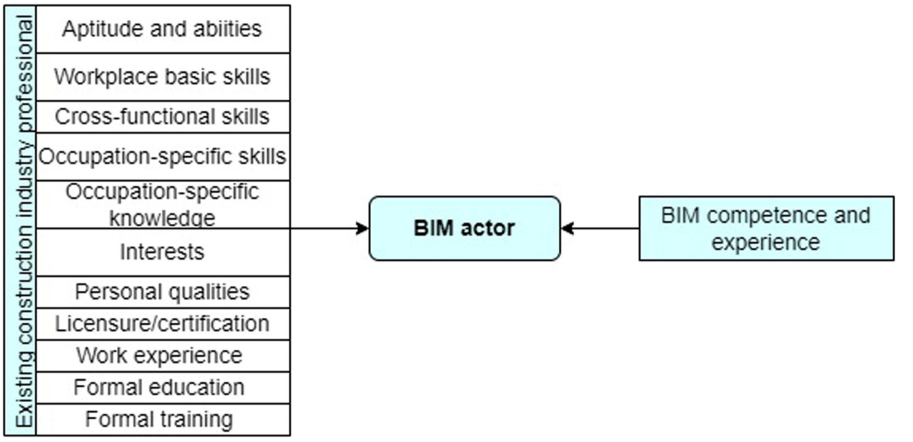

Figure 5.
The BIM actor general development pathway

A cross-tabulation of the BIM actor roles against the years of experience and educational qualifications (Tables A3 and A4) was done in order to gain more insight as regards the collected data. It can be inferred that professionals with 1–5 years of experience are observed to be aligning themselves with the professional roles created by BIM implementation in the South African construction industry.

Conclusion

The adoption of BIM brought the need for other components in the BIM ecosystem to coevolve to aid its successful implementation. The human factor is important in the diffusion of technology. Thus it is imperative to study the BIM actors. From the study, it is evident that the human dimension of the BIM ecosystem is not yet matured. Although this might be explained based on the location of the study. The South African construction industry is a BIM infant country, so the location might have influenced the study outcome. It can also be inferred that given the BIM actors identified in the study, standardisation and regularisation of the actor functions and connecting issues.

Also, the human resources department in construction organisations needs to make job adverts more detailed as this helps prospective employees and other stakeholders in the labour market space. Existing professionals are advised to improve their skills and achieve BIM tools competence. With this, the role of specialised BIM roles might not be needed. This is because the construction industry experience is a prerequisite for the BIM actors to function. Thus, it is a scenario of old wine in a new wineskin, it is the existing professionals occupying the position of the new roles created due to BIM adoption and this is conditional upon their acquisition of the required skills. Among other findings, the study identified the following:

(1) Although different roles have been identified in literature, it appears there might be duplication of roles for different names. These identified roles can be merged into one nomenclature.

(2) There exists a difference between identified BIM actor roles in job advertisements and those observed in the industry.

(3) This area is still developing and requires more research and acceptance and standardisation.

(4) Attaining the new BIM actor roles currently does not have a widely accepted standardised educational pathway however, it is deeply dependent on the knowledge of BIM software and tools.

(5) The findings reveal that the South African construction industry is promising and on the right track as regards the human aspects of BIM implementation.

This study offers an insight into the employer requirement for the BIM actor roles. It is important for the stakeholders in the BIM employment space in the construction industry. Thus, it is important for those interested in the labour market dynamics– job seekers, employers, students, researchers, policymakers, higher education institutions, career advisors and curriculum developers. The limitation of the study despite the addition to the body of knowledge are the infant nature of the study area and in extension the industry adopted for the study focus.

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Appendix

Role	Job description	Qualification	Skills
Revit Modeller	·		x
Architectural BIM Modeller	·	x	
Architectural Draughtsperson		x	x
Architectural Technologist		x	x
Architectural Technologist		x	x
Architectural Technologist	·	x	x
Architectural Technologist	x	x	
BIM coordinator		x	
BIM Coordinator	·	x	
BIM director/Building process manager	·	x	
BIM Draughtsman (revit) (mechanical)	x		
BIM Engineer	·	x	
BIM Engineer Mechanical Engineering	·	x	
BIM Lead			x
BIM Lead			x
BIM Manager			x
BIM Manager		x	x
BIM Manager	x		x
BIM Manager		x	
BIM Manager (Architecture)		x	
BIM Manager (Architecture)		x	x
BIM Manager (Architecture)			x
BIM Modeller	x		x
BIM Modeller			x
BIM Modeller		x	
BIM Modeller		x	x
BIM Modeller	·	x	
BIM Modeller	·		x
BIM Modeller	·		x
BIM Modeller	x	x	x
BIM Modeller	x	x	
BIM Modeller	x	x	
BIM Modeller	x		
BIM Modeller	x	x	x
BIM Modeller		x	
BIM Modeller	x	x	
BIM Modeller	x	x	
BIM Modeller	x	x	x
BIM Modeller (building Services)		x	
BIM Modeller Electrical	x	x	x
BIM Modeller Electrical	x		
BIM Modeller	·		x
BIM Revit Specialist		x	x
BIM Technician	·		x
BIM Technician	·		x
BIM Technician	x	x	x
BIM Technician	x	x	x
BIM Technician	x	x	
Electrical BIM Modeller		x	x
Electrical BIM Modeller			x

Table A1.
BIM job adverts content

(*continued*)

Role	Job description	Qualification	Skills
Electrical BIM Modeller	x	x	x
Electrical Digital Modeller	x	x	
Junior BIM Mechanical Revit Design Engineer		x	
Junior BIM Mechanical Revit Design Engineer		x	
Junior BIM Revit Autocad Mechanical Design Engineer	x	x	
Junior BIM Revit/Autocad Mechanical Design Engineer		x	
Junior Draughtsman/BIM Designer	x	x	x
Project Manager (architecture)	x		
Senior and Junior Revit Structural Draughtspersons	x	x	
Senior Architectural Draughtsman	·	x	x
Senior BIM Design Technician			x
Senior BIM Design Technician	·	x	x
Senior BIM Design Technician	x	x	
Senior BIM Design Technician	x	x	
Senior BIM Modeller Fire	x	x	
Senior BIM Modeller Mechanical Fire	x	x	x
Senior Revit Draughtsman	·		x
Senior Revit Draughtsman	·		x
Structural Digital Modeller	x	x	
Work planner construction			x

Table A1.

Characteristics	Features	Frequency	Percentage
Profession	3D Modeller, Modelling specialist, Structural designer	1	0.5
	Architect	40	21.9
	Architect, 3D Modeller	4	2.2
	Architect, BIM Manager, 3D Modeller, Modelling specialist	1	0.5
	Architect, BIM Manager, BIM champion, BIM administrator, Modelling specialist, BIM facilitator	1	0.5
	Architect, Building Modeller, 3D Modeller, Building modeller	1	0.5
	Architect, Building Modeller, Virtual Architect/Engineer, 4D specialist, Building modeller, Researcher	1	0.5
	Architect, Project manager	2	1.1
	Architect, Project manager, Sustainability Specialist	1	0.5
	Architectural Technologist	1	0.5
	Asset Manager	1	0.5
	BIM coordinator	1	0.5
	BIM coordinator, BIM leader	1	0.5
	BIM Manager, 3D Modeller	1	0.5
	BIM Platform Resellers	1	0.5
	Building Modeller	2	1.1
	Building services engineer	3	1.6
	Civil engineer	13	7.1
	Civil engineer, BIM champion	1	0.5
	Civil engineer, BIM champion, BIM leader, Modelling specialist, BIM Technical Specialist (Civil Infrastructure)	1	0.5
	Civil engineer, BIM Manager, 3D Modeller	1	0.5
	Civil engineer, Digital project coordinator, 4D specialist, Lead Reality Capture	1	0.5
	Civil engineer, Modelling manager/project model manager/model manager	1	0.5
	Civil engineer, Project manager	3	1.6
	Civil engineer, Project manager, 3D Modeller	1	0.5
	Civil engineer, Project manager, Structural Engineer	1	0.5
	Civil engineer, Structural Engineer	2	1.1
	Civil engineer, Structural Engineer, 3D Modeller, BIM leader	1	0.5
	Civil technician	1	0.5
	Engineering Surveyor	1	0.5
	Environmental Scientist	1	0.5
	Futurist	1	0.5
	Lecturer	2	1
	Project manager	30	16.3
	Project manager, BIM Manager, BIM champion	1	0.5
	Project manager, Building services engineer	1	0.5
	Project manager, Quantity surveyor	2	1.1
	Project manager, Quantity surveyor, BIM administrator	1	0.5
	Project manager, Quantity surveyor, Modelling manager/project model manager/model manager	1	0.5
	Project manager, Quantity surveyor, Property Developer	1	0.5
	Property developer	1	0.5
	Quantity surveyor	41	22.4
	Quantity surveyor, Construction manager	1	0.5
	Quantity surveyor, Cost Modeller, Virtual construction manager, Digital contractor, 4D specialist	1	0.5
	Sequencing Modeller and Detailing Modeller	1	0.5
	Sequencing Modeller and Detailing Modeller, 3D Modeller, Digital project coordinator, Building modeller, BIM coordinator	1	0.5
	Structural Engineer	2	1.1
	Structural Engineer, Building Modeller, BIM champion, Modelling specialist, BIM facilitator, BIM researcher	1	0.5
	Supply chain management	1	0.5
	Virtual construction manager	1	0.5
	Total	*183*	*100.0*

Table A2.
Empirical data analysis

(*continued*)

Characteristics	Features	Frequency	Percentage
Academic qualification	Bachelor's Degree	54	29.5
	Doctorate	10	5.5
	Honours' Degree	40	21.9
	Master's Degree	53	29.0
	Matric Certificate (Grade 12)	4	2.2
	Post-Matric Certificate or Diploma	22	12.0
	Total	*183*	*100.0*
Years of experience in the construction industry	less than 12 months	10	5.5
	1–5 years	66	36.1
	11–15 years	32	17.5
	6–10 years	38	20.8
	above 15 years	37	20.2
	Total	*183*	*100.0*
Type of organisation	Asset Manager/Developer	2	1.0
	Autodesk distributor	1	0.5
	Consultancy	99	53.5
	Engineering company	1	0.5
	Government	23	12.6
	Main Contractor	36	19.7
	National route concession company	1	0.5
	Property Fund	1	0.5
	Software Consultants	1	0.5
	Specialist contractor	8	4.4
	Sub contractor	8	4.4
	Academia	2	1.0
	Total	*183*	*100.0*
Organisation category	Medium (51–250 employees)	63	34.4
	Micro (0–10 employees)	66	36.1
	more than 250 employees	5	2.7
	Small (11–50 employees)	49	26.8
	Total	*183*	*100.0*
Location of organisation	Eastern Cape	9	4.9
	Eastern Cape., Gauteng	1	0.5
	Eastern Cape., Gauteng., KwaZulu-Natal., Limpopo., Northern Cape., North West., Western cape	1	0.5
	Eastern Cape., Gauteng., Northern Cape., Western cape	1	0.5
	Free State	6	3.3
	Free State., Gauteng., Limpopo	1	0.5
	Gauteng	103	56.3
	Gauteng., KwaZulu-Natal	2	1.1
	Gauteng., KwaZulu-Natal., Mpumalanga., North West	1	0.5
	Gauteng., KwaZulu-Natal., Western cape	1	0.5
	Gauteng., Western cape	1	0.5
	KwaZulu-Natal	16	8.7
	KwaZulu-Natal., Western cape	1	0.5
	Limpopo	6	3.3
	Mpumalanga	17	9.3
	North West	1	0.5
	Western cape	15	8.2
	Total	*183*	*100.0*

Table A2.

	Qualification					
	PhD	Master's degree	Bachelor's degree	Honors degree	Matric certificate (Grade 12)	Post-matric certificate or diploma
3D Modeller, Modelling specialist, Structural designer	0	0	0	0	0	1
Architect, 3D Modeller	0	0	1	3	0	0
Architect, BIM Manager, 3D Modeller, Modelling specialist	0	0	0	1	0	0
Architect, BIM Manager, BIM champion, BIM administrator, Modelling specialist, BIM facilitator	0	0	0	0	0	0
Architect, Building Modeller, 3D Modeller, Building modeller	0	0	1	0	0	0
Architect, Building Modeller, Virtual Architect/ Engineer, 4D specialist, Building modeller, Researcher	1	0	0	0	0	0
Architectural Technologist	0	0	0	0	0	1
BIM coordinator	0	0	0	0	1	0
BIM coordinator, BIM leader	0	0	0	0	1	0
BIM Manager, 3D Modeller	0	0	0	0	0	1
Building Modeller	0	0	0	0	1	1
Civil engineer, BIM champion, BIM leader, Modelling specialist, BIM Technical Specialist (Civil Infrastructure)	0	0	1	0	0	0
Civil engineer, BIM Manager, 3D Modeller	0	0	0	0	0	1
Civil engineer, Digital project coordinator, 4D specialist, Lead Reality Capture	0	0	0	0	0	1
Civil engineer, Modelling manager/project model manager/model manager	0	1	0	0	0	0
Civil engineer, Project manager, 3D Modeller	0	0	0	1	0	0
Civil engineer, Structural Engineer, 3D Modeller, BIM leader	0	0	0	1	0	0
Project manager, BIM Manager, BIM champion	0	0	1	0	0	0
Project manager, Quantity surveyor, BIM administrator	0	1	0	0	0	0

Table A3.
Cross tabulation of Actor roles and Educational qualification

(*continued*)

	Qualification						
	PhD	Master's degree	Bachelor's degree	Honors degree	Matric certificate (Grade 12)	Post-matric certificate or diploma	
Project manager, Quantity surveyor, Modelling manager/project model manager/model manager	0	0	1	0	0	0	
Quantity surveyor, Cost Modeller, Virtual construction manager, Digital contractor, 4D specialist	0	0	0	0	0	1	
Sequencing Modeller and Detailing Modeller	0	0	1	0	0	0	
Sequencing Modeller and Detailing Modeller, 3D Modeller, Digital project coordinator, Building modeller, BIM coordinator	0	0	0	0	0	1	
Structural Engineer, Building Modeller, BIM champion, Modelling specialist, BIM facilitator, BIM researcher	0	1	0	0	0	0	
Virtual construction manager	0	0	0	1	0	0	
	1	3	6	7	3	8	**Table A3.**

Profession	Years of experience in the construction industry				
	1–5 years	11–15 years	6–10 years	Above 15 years	Less than 12 months
3D Modeller, Modelling specialist, Structural designer	0	1	0	0	0
Architect, 3D Modeller	4	0	0	0	0
Architect, BIM Manager, 3D Modeller, Modelling specialist	0	0	1	0	0
Architect, BIM Manager, BIM champion, BIM administrator, Modelling specialist, BIM facilitator	0	0	1	0	0
Architect, Building Modeller, 3D Modeller, Building modeller	0	0	1	0	0
Architect, Building Modeller, Virtual Architect/Engineer, 4D specialist, Building modeller, Researcher	0	1	0	0	0
Architectural Technologist	0	0	0	0	1
BIM coordinator	0	0	0	1	0
BIM coordinator, BIM leader	0	0	0	1	0
BIM Manager, 3D Modeller	0	0	0	1	0
Building Modeller	0	0	2	0	0
Civil engineer, BIM champion, BIM leader, Modelling specialist, BIM Technical Specialist (Civil Infrastructure)	0	0	1	0	0
Civil engineer, BIM Manager, 3D Modeller	0	0	1	0	0
Civil engineer, Digital project coordinator, 4D specialist, Lead Reality Capture	0	1	0	0	0
Civil engineer, Modelling manager/project model manager/model manager	1	0	0	0	0
Civil engineer, Project manager	0	1	1	1	0
Civil engineer, Project manager, 3D Modeller	1	0	0	0	0
Civil engineer, Structural Engineer, 3D Modeller, BIM leader	0	1	0	0	0
Project manager, BIM Manager, BIM champion	1	0	0	0	0
Project manager, Quantity surveyor, BIM administrator	0	1	0	0	0
Project manager, Quantity surveyor, Modelling manager/project model manager/model manager	1	0	0	0	0
Quantity surveyor, Cost Modeller, Virtual construction manager, Digital contractor, 4D specialist	0	0	0	1	0
Sequencing Modeller and Detailing Modeller	1	0	0	0	0
Sequencing Modeller and Detailing Modeller, 3D Modeller, Digital project coordinator, Building modeller, BIM coordinator	0	0	1	0	0
Structural Engineer, Building Modeller, BIM champion, Modelling specialist, BIM facilitator, BIM researcher	1	0	0	0	0
Virtual construction manager	1	0	0	0	0
	11	6	9	5	1

Table A4. Crosstabulation of actor roles against years of experience

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