

Exploring Individual Functional Competency in Organisational Building Information Modelling Environments: Architects' Experiences and Perspectives

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Abstract: The recent National Building Information Modelling (BIM) Roadmap 2030 in Malaysia repositions BIM as a core organisational capability embedded within existing professional roles, rather than relying on external BIM specialists. Architects, traditionally seen as natural leaders, are now expected to integrate BIM into daily practice, making project success increasingly dependent on internal organisational readiness. However, most studies remain project-focused, overlooking how functional competencies—the application of cognitive and personal skills in practice—are enacted within organisations, particularly from the perspective of individuals experiencing them firsthand. Therefore, this study aims to gain an in-depth understanding of architects' functional competency in specific BIM-related tasks within organisational settings. This qualitative study employed written account exercises and in-depth, semi-structured interviews to unpack the subjective experiences of architects within such an environment. Thematic analysis revealed five key functional competency themes: business management, process management, people management, technology management and knowledge management. These findings advance the competency literature by providing a grounded understanding of how architects enact functional competencies in organisational BIM environments. They also provide a foundation for developing theoretical frameworks that link individual BIM competencies to broader organisational capabilities. Practically, the findings support organisations in anticipating market trends, designing change management strategies and fostering a culture of continuous BIM improvement. Additionally, the identified themes can inform the development of benchmarking tools to assess and enhance organisational BIM capability.

Keywords: BIM, Digital transformation, Individual competency, Organisational capability, Architectural practice

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INTRODUCTION

The construction industry plays a crucial role in Malaysia's economy, growing by an overall rise of 10.1% despite the impact of the COVID-19 pandemic and accounting for almost 3.5% of the country's gross domestic product in 2022 (Ramly, Mohamad and Noor, 2023). Building information modelling (BIM) is transforming the architecture, engineering and construction (AEC) business globally and in Malaysia, particularly through the initiation of Construction 4.0 Strategic Plan 2021–2025 (CR4.0) by the Construction Industry Development Board Malaysia (CIDB, 2020). This digital shift has gained further momentum through two recent federal mandates: the enforcement of Treasury Circular PK 1.15 (Kementerian Kewangan Malaysia, 2025), which makes BIM implementation compulsory across all ministries and project phases beginning 1st July 2025 and the 13th Malaysia Plan (2026–2030), which requires BIM adoption in all public projects valued at RM10 million and above under its project and fiscal reform strategy (Kementerian Ekonomi Malaysia, 2025). These national directives signal the need for a systemic change within organisational workflows and competencies.

However, despite increasing institutional support, the construction workforce remains largely dominated by low-skilled labour. The shortage of competent and highly skilled personnel continues to be one of the major obstacles hindering effective BIM implementation in Malaysia (CIDB, 2020; Musarat et al., 2024). A similar issue has been observed in the Australian BIM industry, where graduates were expected to demonstrate competencies that extend beyond technical software proficiency to encompass organisational process integration (Alieh et al., 2025). This challenge is further compounded by the outmigration of local BIM professionals in search of better employment prospects abroad (Ibrahim, Esa and Mustafa Kamal, 2019). In response, the CR4.0 highlights the need to build future-ready talent under its first strategic thrust, “building capacity”.

Addressing this talent shortage requires more than simply hiring additional employees. This effort demands a fundamental rethinking of organisational capability. In the context of BIM, successful project implementation depends heavily on such capability, which involves multiple elements including individual employee competencies, business processes and technology, all focused on reaching organisational objectives (Ahuja, Sawhney and Arif, 2018). Central to this organisational capability are individual competencies, namely, the ability to apply cognitive, personal and functional skills in specific work settings, which shape both project outcomes and long-term organisational readiness (Shahrudin, Zairul and Haron, 2021). In fact, the tendering of public BIM-based projects by the Malaysian Public Works Department (Jabatan Kerja Raya [JKR]) requires potential consultants to have adequate BIM personnel within their own organisations rather than hiring third parties to deliver BIM-

related tasks (JKR, 2021). Moreover, a key proposition from Malaysian AEC experts during the recent National BIM Roadmap 2025–2030 was to make BIM a standard practice by the year 2030 (Implementation Coordination Unit, 2024). The reasoning behind this is that BIM responsibilities such as modelling, coordination, quantification and data management should ideally be delivered by existing professionals, rather than by BIM specialists to retain business sustainability and maintain the competitive edge in this dynamic environment (Shahrudin, Zairul and Haron, 2021). In such an environment, BIM specialists would be anticipated to serve merely as data analysts or facilitators throughout the construction process (Adekunle, Aigbavboa and Ejohwomu, 2024). This mandate and vision indirectly demand the AEC business practices to proactively reconstruct their organisational capability towards meeting the increasing demand for BIM-required projects.

Among the various professional roles, architects are often to take the lead in embedding BIM within the architectural projects. However, architects who have traditionally been perceived as natural leaders have been criticised for their inadequacy in keeping pace with the continuously evolving digital requirements of the industry, rendering them ill-equipped to effectively navigate contemporary construction challenges (Martin, Watson and Brooks, 2025). Harzani (2021), former president of the Malaysian Institute of Architects, cautions that local architects may risk being surpassed by foreign counterparts if they do not quickly adapt to a borderless working environment. To stay competitive in a digitally mediated environment like BIM, Malaysian architects must improve their business value unlocking, consulting team leadership, communication and problem-solving skills (*Berita Arkitek*, 2021). The increasing complexity of modern projects has also diminished the conventional leadership position of architects, resulting in a scarcity of practitioners proficient in BIM (Frimpong and Dansoh, 2018; Shahrudin et al., 2022). This situation has left architects with no alternative but to equip themselves with the necessary functional competencies to re-establish their identity and regain trust for the profession within the community of practice.

Despite these professional pressures, the academic literature has not sufficiently addressed how such challenges are navigated within organisations. Two main shortcomings were identified in relation to the focus of the present study: the research context and the methods adopted. First, most of the previous studies appear to focus on project rather than organisational context (Shahrudin, Zairul and Haron, 2021). Only a few studies sought to discuss internal organisational changes (such as architectural organisational work, personal motivations and values of architects, manpower planning, information management and social-cultural aspects) triggered by BIM adoption (Abbasnejad et al., 2021a; 2021b; Phung and Tong, 2021; Makabate et al., 2022). The tendency to focus on project context may be due to BIM being made mandatory across new public procurement projects, causing a

significant revamp in project organisational structure, procurement strategy, contractual administration and the professional authority. Yet, competence demonstration is very much context dependent. Previous scholars offered no explanation on the distinction between the competencies needed within internal organisation and those needed across individual projects specifically from the architects' perspective. Individuals can only be regarded as competent to practice in a BIM environment once they are capable of fulfilling the requirements of a typical BIM project per se and contributing to improve the organisational culture, systems and work processes internally.

Second, difficulty may arise in gaining a deeper understanding of how the interlocking cognitive, personal and functional activities are experienced by individuals in an organisational BIM environment. This problem fundamentally stems from the quantitative methods used to identify the competencies required from BIM personnel (Olatunji, 2019; Sinoh, Othman and Ibrahim, 2020; Shahrudin, Zairul and Haron, 2021; Zhang et al., 2022). For instance, research by Sinoh, Othman and Ibrahim (2020) and Shahrudin, Zairul and Haron (2021) has primarily used systematic reviews and statistical analyses to highlight essential BIM competencies and success factors. While these studies have contributed to defining skill requirements and assessing organisational readiness, they offer limited insight into the day-to-day practices and situated experiences of individuals operating in BIM environments. Another significant gap is the lack of focus on the interlocking cognitive, personal and functional activities experienced by individuals in a BIM setting. Studies such as those by Olatunji (2019) and Zhang et al. (2022), which used quantitative methods to assess learning outcomes and motivational drivers in BIM education, may overlook the subtle and situated nature of competency adaptation as it occurs in routine workflows.

Considering the contextual and methodological limitations of previous studies, the present study, therefore, aims to gain an in-depth understanding of architects' functional competency in specific BIM-related tasks within organisational settings. The next section examines the existing knowledge structure of individual competence and BIM organisational context, synthesises a new perspective and reveals the research gaps.

LITERATURE REVIEW

Interlocking Dimensions of Individual Competence

There is a lack of common ground in the discussion of what constitutes a competent individual in the context of a specific achievement environment. In the USA, academics typically relate competency terminology to a behavioural-based approach. Prominent American scholars including Boyatzis (1982)

and Spencer and Spencer (1993) evaluate competency from the individual's perspectives and associate it with a core characteristic of that person. The characteristics and perspectives of an individual are the cornerstone of excellent performance and effective behaviour, particularly in the workplace. Such characteristics are however intangible; they are connected to the cognitive ability, motives, self-concept, values and traits demonstrated by individuals (Pimenta and Piato, 2016; Van Doorn and Raz, 2023). The tendency to adopt the behavioural approach by American researchers is justifiable given that success in the future and the competencies needed to achieve it are dependably indicated by past behaviour (Sampaio et al., 2022; Shahrudin et al., 2025). Nevertheless, finding a person who demonstrates specified outcomes and performance criteria may be difficult, especially when looking at it from the perspective of the behavioural-based approach.

In contrast, academics in the UK believe that competency terminology is best described using the functional-based approach. Mansfield and Mitchell (1997) conceptualise competence as an individual's demonstration in specific situations of either a work description, purpose, or outcome. Makhambetova and Magauova (2023) also explored their study with the support of a function-based approach within the context of competency. The approach, emphasising on the results of work that is obtained both within and across organisational settings, has the advantage of accuracy over the ambiguity of the behavioural approach. Nonetheless, a significant drawback of the functional-based approach is its excessive constraint caused by assumptions about the job descriptions of those who are always recognisable in advance. Lester (2017) argues that the aim of the functional approach in making a generalisation about practice is controversial because defining an individual's competent actions requires situational interpretation and judgement.

A significant amount of research attempts to integrate or hybridise the elements of the functional-based and behavioural-based approaches to construct a model that comprehensively identifies, characterises and assesses an individual's competence in a variety of professional work environments. A holistic model of a professional individual's competence was put forward by Cheetham and Chivers (1998); this model consists of four associated elements: (1) cognitive competence, (2) personal competence, (3) ethical competence and (4) functional competence. In a recent systematic review study of competence demonstration in a BIM environment, Shahrudin, Zairul and Haron (2021) clustered "ethical competence" under "personal competence" because an individual's moral values (ethics) are also affected by his/her attitude, behavioural and personal traits (personal) in the workplace. In the same work, Shahrudin, Zairul and Haron (2021) conceptualised that the competence of an individual can be divided into three interlaced dimensions as follows:

1. Cognitive competence: The ability to apply conceptual, disciplinary, procedural and contextual related knowledge into practice settings.
2. Personal competence: The ability to successfully exhibit and control attitude, conduct and personal traits in work-related settings.
3. Functional competence: The ability to apply a cognitive and personal set of competence in performing the occupation- and organisation-specific range of work.

Nevertheless, the present study will only emphasise functional competencies over cognitive and personal competencies, considering the nature of individual performance in BIM implementation contexts. While cognitive competence involves applying knowledge in practical situations and personal competence relates to displaying and managing attitudes and traits, functional competence integrates both cognitive and personal competencies into practical application within specific occupational and organisational tasks. Furthermore, the study is constrained to the organisational BIM context recognising that each team member's competency directly influences organisational capability, thereby, laying the foundation for successful BIM execution at the project level.

BIM Functional Competencies: Organisational Context

The transition from conventional to architectural BIM-based practices is not as straightforward as changing the technology infrastructure. It may be argued that the organisational ongoing leadership support and strategic business vision are the only ways BIM practices can be sustained. Trenerry et al. (2021) emphasised the need for coordinating an organisational business model and culture with the BIM methodology and foreseeing the needs of the workforce to educate, support and prepare employees to adapt to a transformation in the traditional work culture. Other researchers claim individuals may be discouraged from returning to the more outdated 2D-based methods if they understand the benefits of BIM and adapt their procedures to meet BIM requirements (Lee et al., 2023). Such findings suggest that to impact their workforce's daily BIM experience at the operational level, senior executives must effectively coordinate business management-related matters.

Questions also arise with regard to the process management, including the communication and collaboration procedures and quality control and assessment in architectural design following the changes in organisational business workflows in a BIM environment. Papadonikolaki (2020) discovered three primary patterns of BIM collaboration processes, namely, distributed among supply chain partnerships, ad hoc and linear. Effective distributed cooperation may depend on having a sufficient number of competent people from various departments who can make fast decisions regarding BIM-related issues. Regardless of the type of collaboration opted for, having information

being stored, updated and managed transparently in a single repository solution (referred to as common data environment [CDE]) may break the rigid lines of communication in a linear-based structure (Matthews et al., 2018). Therefore, architects must be able to customise their communication techniques to suit their organisation-specific needs in a BIM environment.

Despite the tenets of BIM that revolve around collaborative processes and human-based collaboration, such an endeavour is possible only through continuous technological advances, hence, the need to establish the tool ecologies within an internal organisation (Abdirad and Dossick, 2021). Architects usually deploy several tools and related plugins to simulate sustainability and spatial planning analyses and investigate architectural façade concepts before developing a federated BIM model, especially in the exploration design stage (Ataman and Dino, 2022). According to Daymond et al. (2023), it is consequently inevitable that the tool ecosystem is established throughout the architectural design process. Failing to do so may lead to double-handling tasks.

In terms of knowledge management, scholars are typically in favour of viewing the BIM model as a container for gathering and keeping track of asset data, which involves the facility as a whole as well as the zoning, spaces, system and all of its products (Patacas, Dawood and Kassem, 2020). The management of unstructured data and tacit knowledge, which includes organisational data, BIM policies and procedures and BIM learning resources that are not part of the BIM model, runs counter to this viewpoint. However, the study contends that handling such a scenario may benefit from the use of the same idea of storing, extracting and distributing data from a single point of reference, which is why the CDE was used (Lee, Kim and Choi, 2022). However, without the firm's strategic knowledge containers, ongoing reflective practices and socialisation strategies during the process of capturing tacit knowledge, the CDE by itself is insufficient for knowledge management (Wethyavivorn and Teerajetgul, 2020). Table 1 summarises the guiding themes and their descriptions of BIM functional competencies discussed in the literature, which served as a framework for developing the present study's interview questions.

Thus far, the study has conceptualised the interlocking dimensions of individual competence and reviewed the state of the art of BIM functional competencies literature within the organisational context. The following section discusses the methodological procedures adopted to elicit the experiences of architects working in a BIM environment.

Table 1. Guiding themes and descriptions of BIM functional competencies from the literature

Guiding Theme	Description
Business management	Aligning an organisational business model and culture towards the BIM methodology.
Process management	Developing and maintaining communication and collaboration procedures in a BIM environment; managing CDE.
People management	Managing individuals' wellbeing and professional development in a BIM environment.
Technology management	Establishing the tool ecology across the architectural design process.
Knowledge management	Managing structured and unstructured information as well as tacit knowledge within the organisation.

METHODOLOGY

This research adopted an interpretive phenomenological methodology (Lindseth and Norberg, 2004) for its ability to unpack the subjective experiences of architects in applying the cognitive and personal competencies into practical application within a specific organisational BIM environment. Informants in this study were recruited from the Malaysian architectural professional community, who are currently struggling with challenges like limited talent diversity, dependency on foreign expertise and a resistance to change, which impede the progress of CR4.0 implementation in the Malaysian construction industry (CIDB, 2020). Recognising the importance for local architects to adapt to digital construction environments (*Berita Arkitek*, 2021), informants were chosen based on specific criteria: practitioners ranging from assistant architects to architectural directors in registered architectural consultancy practices (ACPs), possessing BIM fundamental understanding and technology skills, effective communication abilities and willingness to participate. The phenomenological approach prioritises in-depth exploration of individual experiences, providing rich insights into how functional competencies are manifested in an organisational BIM environment. Despite a small sample size of 10 informants (as shown in Table 2), multiple rounds of interviews, prolonged engagement with the informants and diverse data collection methods ensured comprehensive coverage, achieving thematic saturation without new themes emerging.

Table 2. Profiles of key informants

Informant Number	Position and Role	Years in Industry	Type of ACP	Types of BIM Projects Involved in
K1	Architectural director	16	Partnership	Commercial and healthcare facilities
K2	Project architect	8	Architectural body corporate	Commercial
K3	Architectural director	25	Architectural body corporate	Commercial and healthcare facilities
K4	Senior architect	7	Architectural body corporate	Residential and infrastructure
K5	Project architect	15	Multi-disciplinary	Commercial and healthcare facilities
K6	Project architect	12	Architectural body corporate	Residential
K7	Assistant architect	5	Architectural body corporate	Commercial and infrastructure
K8	Project architect	9	Architectural body corporate	Healthcare facilities
K9	Design technology specialist	6	Architectural body corporate	Cultural architecture
K10	Design architect	6	Architectural body corporate	Residential and infrastructure

The initial data collection involved inviting informants to engage in expressive writing exercises (Langdridge, 2007), allowing them to freely document their experiences in a self-reflective manner. Informants were encouraged to provide detailed accounts of their actions, thoughts and emotional responses for any types of experiences they preferred within the constraints of an A4-sized paper. Subsequently, in-depth semi-structured interviews were conducted using a predefined set of open-ended questions tailored to align with the content of the informants' written accounts. Sample interview questions included inquiries about business management practices, processes, people, technology and knowledge management BIM related activities (as shown in Table 3). Conducted at the informants' workplaces, these interviews facilitated discussions on real-time scenarios within the digital construction environment's physical and social contexts. Audio recordings of the interviews were transcribed for detailed analysis.

Table 3. Examples of interview questions and probes

Guiding Theme	Interview Questions and Probes
Business	1. Can you describe a situation where you had to make a critical business decision related to a BIM project? 2. How do you assess the business value of implementing BIM in your organisation? 3. What strategies do you use to manage the financial aspects of BIM integration?
Process	1. How do you ensure that BIM processes are efficiently integrated into your project workflows? 2. Can you discuss any challenges you have faced in aligning BIM processes with traditional architectural practices?
People	1. How do you manage team dynamics and collaboration when working on BIM projects? 2. Can you provide an example of how you resolved a conflict within your team during a BIM project? 3. What leadership skills do you find most important for managing a team in a BIM environment?
Technology	1. Can you describe a time when you had to troubleshoot a technical issue related to BIM? 2. What criteria do you consider when selecting BIM software and tools for your projects?
Knowledge	1. How do you capture and share BIM-related knowledge within your organisation? 2. Can you give an example of how knowledge management practices have improved a BIM project? 3. What strategies do you employ to ensure continuous learning and development in BIM?

Thematic analysis (Braun and Clarke, 2006) was employed to explore the architects' demonstrated soft skills in navigating the digital construction environment and the analysis was supported using ATLAS.ti 8 (ATLAS.ti Scientific Software Development GmbH, Berlin, Germany). This involved coding meaningful units in the data, grouping similar codes into categories and constructing central themes through peer debriefing and member checking sessions. The process of thematic analysis was compiled in a form of thematic analysis matrix (Mohd Noor, 2021) (as shown in Table 4). The final constructed themes as tabulated in the thematic analysis matrix unpacks the complexity of functional competencies demonstration comprehensibly. Finally, the constructed themes (including that of business management, process management, people management, technology management and knowledge management) were discussed alongside relevant literature to deepen the understanding of informants' experiences using a comprehensive understanding method (Lindseth and Norberg, 2004).

Table 4. Thematic analysis matrix

Research Objective: To Examine the Functional Competency Showcased by Architects Working in an Organisational BIM Environment			
Deductive Code	Initial Coding	Sub-Theme	Final Theme
Functional competency	Solidifies the project brief by translating the input/needs from the users into design brief, which in turn translates into BIM objectives; Analyses the implication of budget constraint a client has towards the exploration of design intent; Facilitates the client in assessing and identifying the project team's capability; Captures and records all feedback, queries and outcome of the virtual design review session in a form of BIM coordination report; Develops a resourcing strategy through inter-organisational BIM training; Advocates the culture of self-leadership across the organisational team members; Explores the respective strength and limitations of various architectural and non-architectural software; Develops project information container into the following state of information: work in progress, shared, published and archived; Creates content creation guidelines for each BIM families	1. Anticipating the future market 2. Developing partnership and alliance strategy	Theme 1: Business management
		1. Managing communication and collaboration workflows 2. Managing quality control and quality assurance 3. Automating work processes	Theme 2: Process management
		1. Managing workforce planning 2. Facilitating and coaching team members 3. Adapting and developing the organisational work culture	Theme 3: People management
		1. Assessing and exploring the capability of BIM solutions 2. Developing tool ecologies	Theme 4: Technology management
		1. Developing structure of organisational information container 2. Capturing and storing product information via BIM model	Theme 5: Knowledge management

DISCUSSION

This section discusses the five central themes and associated categories that represent the experiences of architects in showcasing functional competencies in organisational BIM environments, in relation to the existing body of knowledge.

Theme 1: Business Management

As narrated by K1, working towards high-value projects is the only way forward to develop and sustain the credibility of architectural business practices in a BIM environment. Yet, achieving such an aim is possible only by anticipating the many interlocking factors including type of future projects, type of data (Godager, Onstein and Huang, 2021) and type of future workforce (Alieh et al., 2025) that may disrupt the current architectural market:

How do these conventional roles transformed and how do I, as a business leader, anticipate the types of projects that I am going to get, the types of data that I am going to manage and the key personnel to manage such data. Then only I can get high value jobs. (K1)

Anticipation of future markets is also evident from the experience of K3. The adoption of the BIM methodology was always central to his architectural practice to facilitate better information sharing and collaborative decision-making, leading to enhanced design quality, even before the methodology was mandated for all public construction projects in Malaysia. K3 has voluntarily extended traditional architectural liabilities by providing specific BIM services across a range of projects, from small projects like a police station to mixed development projects: “Most of the project that I use BIM is based upon our own initiative is not a requirement by the client”.

As such, the study infers that failing to showcase such anticipatory set of competence such as recognising change agents, anticipating potential obstacle points and developing strategies to avoid such problems may lead to obsolescence by automation in a built environment for ACPs.

Developing partnership and alliance strategies with other organisations was another sub-theme that emerged from those practising in a BIM environment. Small and medium architectural practices often struggle to bid for a high value BIM project due to limited capital to invest in expensive hardware, software and cloud-based sharing platform subscriptions or even hire a large pool of BIM personnel (Majzoub and Eweda, 2021; Waqar, Qureshi and Alaloul, 2023). K3, therefore, recommended that practice leaders develop an effective partnership across organisations and with government agencies to leverage

efficiency in capital expenditure. The shared resources, according to K3, may not only be in the form of manpower, equipment and software but also grants and loans:

We can share resources including the manpower, hardware and software or even the grants and loan. Especially in a BIM environment, it is very beneficial where the usage of software or cloud-based subscriptions can be shared in a collaborative team to leverage on efficiency in capital expenditure. (K3)

Following the same line of argument, a successful partnership effort as recounted by K1 boils down to two factors: complementary skill sets in a BIM environment and a teamwork process. First, the collaborators should be familiar with the BIM environment to work effectively and are able to complement K1's skill sets to solve any design and technical related problems effectively. Second, the teamwork process, which includes the dedication, commitment and patience demonstrated across the team members, especially amid the COVID-19 pandemic, has inspired great confidence in K1's collaborators. K1 narrated such experiences as follows:

So, to work effectively, even our collaborators have to be familiar with the BIM environment. Then only I can set goals, solve any design or technical problem and achieve the programme to ensure all parties are happy. Second, basically it is a teamwork process where input is provided back and forth to achieve the best outcomes. (K1)

Based on the aforementioned experiences, this present study confirms that sharing investment, knowledge, experience and resources through inter-organisational collaboration (Chen et al., 2022; Ferreira et al., 2022) is the only way forward for architects to enhance their competitive edge and capacity to take on larger, more complex BIM-based projects.

Theme 2: Process Management

The study discovered that a successful implementation of BIM within the ACPs is as much about communication and collaboration as it is about producing BIM products (Mehrbod et al., 2020; Chen et al., 2022). Simply put, the inquiries in BIM practices need to seek not only “what”, but, importantly, “how”. The “how” inquiry is one about workflows. Taking the experience of K10 in managing the intra-collaboration design workflows, he once faced model ownership issues of not establishing a work-sharing file in a BIM system during the design preparation stage. Ever since then, he would make sure that a work-sharing file and its associated strategy were all in place before developing a BIM model collaboratively:

Previously, I faced some issues in coordinating internally with the other three BIM modellers in my team. Initially, I worked without having a proper work set, which in turn lead to many ownership issues. So, the lesson here is that I should decide first the work-sharing set file properly for each work task alongside the master file. (K10)

The informants also narrated the ability to apply the theoretical concept of CDE workflows to achieve an effective line of communication within an organisation. For example, K5 always ensured that the structural organisation of every BIM project folder is in accordance with the four states of information prescribed by the ISO 19650 standard (Lee, Kim and Choi, 2022). K5 always verified that each information container is tagged with a specific naming convention:

I will even make sure that the naming for the Revit files is in aligns with the ISO BIM standard. In ISO, the naming has to be associated with certain level. So, my team members left with no choice. They have to organise and manage the BIM model by level even only for the four storey buildings. (K5)

The BIM environment also involves interactions to review, check and coordinate a vast amount of information. The architect in this environment needs to ensure that the information is always consistent, credible and reliable before being shared internally and externally to other project stakeholders, hence, the need for managing the quality assurance and quality control (QA/QC) processes (Badran, AlZubaidi and Venkatachalam, 2023). With respect to the QA/QC processes, K1 opted for a macro-management approach by managing his employees' work from distance rather than micromanaging them. In such a situation, having well-established BIM office standards, digital platforms and communication procedures eventually helped K1 to control the quality of the design products and work processes without him needing to be in every step of the way. K1 recounted the experience:

The office culture should be in place supported through office standards, digital platform and good communication. So, the product can be continued, without myself being there every step of the way and obviously my time is also spent outside of the office, advocating for architecture and the industry. (K1)

Apart from managing the QA/QC processes, the informants also invested time and resources to automate their daily repetitive and manual processes, hence, increasing their productivity at work. Informants shared their experiences in leveraging the availability of various parametric plugins to expedite the repetitive processes of door numbering, room numbering, sheets

creation, data transfer across platforms and typical modelling related tasks (Wu et al., 2022):

For instance, door numbering, room numbering, create sheets based on excel list, transferring data from excel to Revit (vice versa). In a nutshell, things that are tedious and consumes a lot of time. So, I use it to expedite our production. (K2)

In contrast, K9 optimised the parametric workflows and their associated plugins to resolve the intricate problem of façade design. Both the physical mock-ups and the virtual BIM model developed by K9's team members were unsuccessful in performing a constructability study of multi-curvature façade faces. Being well versed in the use of the Grasshopper plugin, K9 therefore stepped forward by developing parametric scripting to solve the problem:

This last piece of the puzzle took them months to figure out the dimensions even wasting the first 1:1 visual mock-up as it turns out wrong, straight and not undulating. I came in to write the script for a couple of days which then the project finally completed early 2020. (K9)

Taken together, the present study confirms that the architects involved in a BIM environment must be able to optimise the capabilities of parametric solutions not only in automating their daily repetitive processes but also in resolving specific intricate design problems (Khamis et al., 2022).

Theme 3: People Management

Managing workforce planning emerged as one of the critical themes experienced by the informants in their daily BIM practices. The informants conducted a demand analysis by understanding the implications of changes in the tender requirements of a new public construction project on workforce planning (Alieh et al., 2025). The requirements of having an internal BIM infrastructure and the specific role of BIM personnel were among the factors considered by K3 in restructuring the workforce:

There was one project they needed 12 BIM personnel with a proof of qualifications and certifications. So those are the projects that if I did not have BIM with a specific requirement, then I would not even qualify to bid the tender. So, it is no option in that sense for your survival. (K3)

Implementing appropriate workforce interventions would be the next key step after an analysis of the demand for future workforce requirements (Wu et al., 2021). In this regard, K2 proposed to the directors and the top management that equipping the existing staff with BIM capabilities should be

done in stages, rather than having the whole organisation converted instantly: “So, I identify which project is the most critical or which project that has BIM requirements. Based on that, I should come out with a proper number and how many manpower that we should expand”.

Moreover, facilitating, training and coaching organisational team members informally, as highlighted by Shahrudin, Zairul and Haron (2021), were also among the activities that go almost instantaneously with what the informants performed daily. K1, for instance, recounted that new graduates need to gain a certain level of BIM project experience to be fully functional in the organisation, regardless of whether they are equipped with BIM technical skills: “They require a lot of coaching during the first six months of employment. Throughout that period, there has to be constant handholding and coaching to ensure the discipline required to contribute successfully within the BIM environment”.

K4 demonstrated a similar approach by continuously coaching and explaining to the team members about the innovation workflows in a BIM environment. K4 acted mostly as a “firefighter” or “fixer” who resolved any technical-related problems during the project delivery process. The situation was like in a classroom wherein K4’s organisational members just raised their hands, asking for assistance: “I had been moving around from one place to another just to assist and explain to them. The situation was like in a classroom. They just raised their hand calling for assistance”.

Adapting and developing the organisational work culture was also evident among the informants to achieve effective performance in a BIM environment. From the perspective of K4, each individual has to regard him/herself as a “manager” of his/her work. That is to say, whatever K4 had taught them on a personal level, they had to demonstrate and share similar approaches to others in front of K4. Such a self-leadership culture (Graham, Nikolova and Sankaran, 2020) is reflected by K4 as follows: “Everyone must see themselves as a BIM manager to their own work or even to the team in which they work for. Each of them must experience how it feels managing and training other team members”.

Following the same line of narration, K1 advocated for an open culture at work by encouraging the employees to voice their concerns and dispositions comfortably, regardless of their hierarchical positions in the organisation: “They can just rise from their seat and we can talk and openly discuss. Rather than making an appointment, now it becomes very direct”.

Reflecting the experiences across different organisational BIM contexts, the present study therefore affirms that organisational culture and performance is very much anticipated by the collective self-leadership of individuals in their daily practices (Shahrudin et al., 2022).

Theme 4: Technology Management

The study uncovered that being open-minded to the diverse perspectives and ways of working is pivotal in catching up with the rapid advancement in BIM technologies. Committing oneself to a particular set of methodology and tools may likely hinder the growth of an individual as an architect (Shahrudin et al., 2022). To go beyond the Revit-based application, K2 once introduced new technology called “TestFit” to the managing director that could actually assist the designers in analysing the feasibility of a project in terms of the plot ratio, parking allocation and residential unit’s optimisation in a shorter period of time. The managing director was quite impressed with K2’s demonstration, as he thought that this new approach could be used to pitch for a project:

If I constrained myself with Revit, it is really difficult for me to develop... So, what I did was I proposed some new technologies to my boss. Have you heard about TestFit? My boss was quite impressed with the proposal... (K2)

Similarly, K9 was inspired by a personal experimental desire to uncover a more productive architectural production approach. K9 has worked with a variety of architectural and non-architectural platforms, ranging from a simple mesh base platform like “sketchUP” to more powerful topo-manipulation platforms like “Blender” and “Maya”. By evaluating the system, the constraints and the strengths of each platform, K9 believes that the frontiers of design value in architecture may be pushed farther: “Understanding the computer system and limitations only teach me that every software has their respective strength only for us to take advantage of them all to push our design further”. Overall, the informants seemed to concur that being open-minded, explorative and investigative are decisive towards optimising the capabilities of BIM technologies to their maximum potential.

The informants appeared to commonly explore multifaceted BIM solutions and the associated plugins during the stage of design exploration and development. Such exploration demands a shift from just supporting a singular software to supporting the whole architectural work processes, hence the need for the tool ecologies within the organisation (Abdirad and Dossick, 2021). The development of tool ecologies was not just about the translation of information from one software to another with a minimum loss of data. It was also about understanding the types of information required for a different range of works along with the information hierarchical structure embodied in a specific native software. In this regard, K2 narrated, “Again, when I talk about transferring information and interoperability, I need to understand what kind of information that I need to extract from that model even before I try to find a way to actually transfer that information”.

Taken together, the study concludes that if an organisation or individual project requires various BIM applications across the construction supply chain, one should critically consider the types of information needed, the information hierarchical structure embodied in a native software, the project coordinate and the modelling practices before developing the tool ecologies.

Theme 5: Knowledge Management

The informants developed an information container structure to optimise the amount of time to retrieve, store and manage information. Having a well-developed container structure in place helped them to extract relevant information quickly, hence improving their work performance (British Standards Institution, 2018). In K5's experience, the structure of the project container (folder) is arranged into the following four states of progress: work in progress, shared, published and archived. Each state of progress is further broken down into the sub containers of input data, 3D models, 2D sheets, families and templates and temporary. However, no single container structure can fit across organisations because of the diversity in vision, culture and values. In K1's organisation, the information container structure is primarily structured into project and office standards containers. The project container is further broken down into the following sub containers: Revit e-transmit, mark-up, structural drawings, trade literature and PDF set for review.

BIM object families were also perceived by the informants as a container for capturing and storing typical product specifications (including architectural, interior and medical furniture elements) that may be reused for future projects (Daniotti et al., 2020). Considering the lack of buy-in from Malaysian manufacturers and suppliers in digitising their product technical specifications into BIM objects, extensive modelling needed to be created for each item, particularly during the pioneering stage of BIM implementation. In K8's experience, a lot of time was invested towards creating hundreds of BIM object families following the lack of existing resources:

There is hardly any manufacturer or supplier that has their product in 3D or BIM models at this current moment. I left with no choice, I got to deal with the challenges and keep on updating our BIM library along the way. (K8)

CONCLUSION

In conclusion, this study gained an in-depth understanding of functional competency experienced by architects in organisational BIM environments. The results revealed five critical themes: business management, process management, people management, technology management and knowledge

management. Business management includes anticipating the future market and developing partnership and alliance strategy, while process management includes managing communication and collaboration workflows, managing quality control and quality assurance and automating work processes. Next, people management consists of managing workforce planning, facilitating and coaching team members and adapting and developing the organisational work culture, while technology management consists of assessing and exploring the capability of BIM solutions and developing tool ecologies. Finally, knowledge management involves developing structure of organisational information container and capturing and storing product information via a BIM model.

Academics and researchers can benefit from the study findings including but not limited to enhancing research focus and developing theoretical frameworks. The elicited experiences of architects can be used to develop frameworks such as those that explain the relationship between individual BIM competencies and organisational capabilities. Researchers may also leverage the study findings to develop frameworks for training programmes and educational curricula by mapping the competencies required for successful BIM implementation. Furthermore, the study findings open new avenues for exploring the underlying factors influencing each theme, such as specific challenges in quality control or barriers to effective communication and collaboration in BIM projects. Ultimately, the study findings can drive research that fosters more organisational BIM capability.

In addition to academics and researchers, industry practitioners can also benefit from the study findings in several ways. These findings can be translated into practical guidelines for architects and project managers, helping them focus on critical areas such as communication workflows, quality control and technology assessment to enhance organisational BIM capability. Furthermore, practitioners can develop benchmarking tools based on the identified themes to assess organisational BIM capabilities. Additionally, policymakers can use the study findings as recommendations for developing industry standards and regulations related to BIM. Organisations can leverage the standards and regulations to anticipate future market trends, develop change management strategies and foster a culture of continuous improvement in BIM.

Nevertheless, this study was limited to informants from a single type of stakeholder (i.e., architects). This narrow focus may limit the generalisability of the study findings to other stakeholders in the construction industry, such as engineers, project managers and contractors. However, this limitation does not diminish the validity or importance of the results. By concentrating on architects, who play a pivotal role in BIM implementation and coordination, the study provides deep insights into the critical functional competencies required for successful BIM integration. These insights are essential for developing targeted training programmes and enhancing overall organisational

BIM capabilities. Moreover, the findings offer a solid foundation for future research to explore similar competencies among other stakeholders, thereby, gradually building a comprehensive understanding of organisational BIM capabilities across the industry and setting the foundation for successful BIM implementation at both organisational and project levels.

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