Journal of Engineering, Project, and Production Management
2025, 15(3), 0016

Digital Leadership Competency Framework in Construction: The Case of Entry-Level Positions

Risath Athamlebbe[1] and Rahimi A. Rahman[2]
[1]Ph.D. Student, Faculty of Civil Engineering Technology, Universiti Malaysia Pahang Al-Sultan Abdullah, Kuantan, Malaysia; Senior Lecturer, Department of Civil Engineering, South Eastern University of Sri Lanka, Oluvil, Sri Lanka, E-mail: risath2011@seu.ac.lk
[2]Associate Professor, Faculty of Civil Engineering Technology, Universiti Malaysia Pahang Al-Sultan Abdullah, Kuantan, Malaysia; Visiting Professor, Faculty of Graduate Studies, Daffodil International University, Dhaka, Bangladesh, E-mail: arahimirahman@umpsa.edu.my (corresponding author).

Project Management
Received December 20, 2024; revised January 7, 2025; accepted January 8, 2025
Available online June 30, 2025

Abstract: The construction industry, which is vital to the global economy, stands poised to enhance its impact through digitalisation in the Construction 4.0 era. However, the pace of digital transformation is hindered by employee competency gaps and ineffective leadership. Developing digital leadership (DL) competencies within its workforce is crucial if the construction industry is to navigate this transformation effectively. Entry-level positions in the construction industry play a crucial role, and DL competencies in these positions are necessary to support digital transformation. Despite this importance, the specific DL competencies required for entry-level positions in the construction industry have not been explored in the literature. This study aimed to develop a DL competency framework that is tailor-made for entry-level positions in terms of knowledge, skills, and attributes. Data were collected through semi-structured interviews with construction industry professionals from Malaysia and Sri Lanka. Thematic analysis was used to analyse the data. The framework developed includes three main knowledge themes: digital, technical, and sustainable project management, along with eight sub-themes. Skills comprises three main themes: managerial, technical, and interpersonal, together with six sub-themes. Finally, attributes have two main themes, professional and personal, with six sub-themes. Furthermore, the analysis suggests that these identified themes and sub-themes are common across Malaysia and Sri Lanka. The findings indicate that it would be possible to develop a DL competency framework aligned at a global scale. This is the first study to develop a DL competency framework that is tailor-made for entry-level positions in construction, so it offers foundational insights for research, practical applications, educational upgrades, organisational readiness, and policy formulation to enhance digital transformation.

Keywords: Competency, Construction, Digitalisation, Leadership, Workforce

DOI 10.32738/JEPPM-2025-0016

1. Introduction

The construction industry is a crucial feature of the global economy and holds a significant place in positively influencing the world in which we live (Li and Wang, 2021). Despite its complexity, the industry is constantly growing with the emergence of new technologies, materials, and methods (Hannan Qureshi et al., 2023). However, the industry is experiencing increasing pressure to meet the growing demand for more efficient and expedient construction processes, particularly in the context of digitalisation (Kasim et al., 2021). The industry's slow adoption of digital transformation is a critical concern because this transformation substantially impacts the design, construction, and operation of built assets. Referred to as Construction 4.0, this digital transformation is beneficial by enabling connectivity between people and technology, as well as the effective use of organisational process assets (Gledson and Greenwood, 2017). Despite these benefits, digital transformation within the construction industry is progressing slowly (Aghimien et al., 2022). This slow pace creates an uncertain situation in which the industry may fall behind in the global shift towards digitalisation, risking its competitive edge and innovation potential (Opoku et al., 2021). Effective leadership in the construction industry is crucial to effectively tackling this situation and adopting Construction 4.0 practices (Zulu and Khosrowshahi, 2021). In the literature, leadership is positioned as a key enabler of innovation, highlighting the critical role of innovative leaders in accelerating digitalisation (Ernstsen et al., 2021). Leadership is also critical in supporting organisational change

management (Michaelis et al., 2009). Consequently, construction industry leadership must remain at the forefront of the digitalisation process (Zulu et al., 2023).

Recent research highlights frameworks like the Digital Transformation Maturity Model (Han et al., 2024) and the Digital Transformation Maturity Evaluation Model (Zhu et al., 2024), which are tailored to the construction industry. However, these frameworks often overlook the digital leadership (DL) competencies essential for effective digital transformation and rarely emphasise leadership as a central factor in success. These competencies are vital for navigating the complexities of digitalisation in construction. The industry still relies on traditional leadership competencies, which are proving increasingly inadequate in the rapidly evolving digital landscape (Gledson and Greenwood, 2017). Although Chan et al. (2019) and Liao and Teo (2019) acknowledge leadership's role in the adoption of digital technology, it remains just one of many influencing factors. Moreover, DL is often neglected in the construction industry's digitalisation process (Morgan and Papadonikolaki, 2022). This oversight highlights the industry's failure to address the critical need for DL competencies, contributing to its slow progress in terms of digital transformation.

To address the challenge of its sluggish digital transformation, the construction industry requires individuals with DL competencies. Understanding the differences between traditional leadership and DL settings is timely and can help professionals derive the necessary DL competencies in construction. This highlights the need to develop DL competencies among the workforce in order to effectively navigate digital transformation, improve project outcomes, and remain competitive in the rapidly changing industry. However, limited research has focused on DL competencies for entry-level positions in construction, unlike other domains such as construction management, project management, and site management (Bakht, 2018; Mohd Affandi et al., 2016; Toyin and Mewomo, 2023). Importantly, Moloi (2021) highlights the need for a DL competency framework and measurement scale, emphasising the interest among employers in hiring entry-level employees with essential DL competencies. Thus, noticeable gaps remain in the understanding of the essential DL competencies required for entry-level positions in construction.

This study aimed to develop a DL competency framework for entry-level positions in the construction industry, focusing on the sector's digitalisation process. The following specific question was addressed: What DL competencies are essential for entry-level positions in construction? This framework bridges a knowledge gap in the literature and provides valuable insights for entry-level roles. Construction organisations, academic institutions, and policymakers can use the framework to prepare and equip the current and future workforce for digital transformation. Additionally, it can serve as a foundation for reviewing and revising recruitment and promotion criteria to support ongoing digital transformation. Notably, this is the first study to develop a DL competency framework for entry-level positions in construction.

2. Literature Review

Digital transformation involves using digital and information technology to convert traditional business practices, products, and services into digital formats. The aims are to improve efficiency, reduce costs, and enhance customer experience and innovation capabilities (Niu et al., 2023). To achieve effective digital transformation, the focus should extend beyond technology to encompass management practices, leadership, business models, and customer relationships, all of which drive change within construction organisations (Zhang et al., 2023). However, the literature reveals that despite the ongoing digital transformation efforts of organisations, they continue to face significant challenges such as resistance to change, a shortage of digital skills, and persistent data silos (Opoku et al., 2021). Furthermore, beyond technological adoption, cultural change and leadership development are vital for successful digital transformation in the construction industry (Han et al., 2024). Although DL is recognised as a key component of successful digital transformation, limited attention has been directed to DL characteristics in the construction industry. Therefore, further research on DL and its associated competencies in the construction industry would be greatly beneficial (Zulu and Khosrowshahi, 2021).

DL is defined as "executing the right things for a successful digitalisation of the organisation" (Sawy et al., 2016, p. 142). Larjovuori et al. (2016, p. 1144) defined DL as “the ability to create a clear, meaningful vision for the digitalisation process and execute strategies to actualise it”. Although there is no single definition, the essence of DL is executing the right strategies for the digitalisation success of the organisation and its business ecosystem (Zulu and Khosrowshahi, 2021). However, Morgan and Papadonikolaki (2022) stated that DL has been overlooked in construction industry digitalisation. The adaptation of digital technology in construction has been slower than in other industries (Naji et al., 2024), such as manufacturing (De Carolis et al., 2017) and education (Sheikhshoaei et al., 2018). This slow pace is due to a lack of workforce competencies and understanding (Siddiqui et al., 2023). Additionally, insufficient knowledge, skills, expertise, and experience hinder digital transformation in construction, affecting progress at both the individual and organisational levels (Tayeh et al., 2020). Therefore, DL competencies must be developed across all organisational levels to enable construction to succeed alongside other industries.

Different researchers have defined “competency” based on its specific context. Parry (1996, p. 50) stated that “competencies are a set of interrelated knowledge, skills, and attitudes that represent key components of a job role, linked to performance, measurable against standards, and reinforced through training”. The International Project Management Association defines competencies as knowledge, skills, and abilities (IPMA, 2015). Mistarihi (2021) emphasised strategic leadership competencies, including knowledge, awareness, skills, and abilities/behaviours/other characteristics. Recent research in construction project management has utilised knowledge, skills, and abilities/attributes (KSA) as the basis for competencies (Bademosi and Issa, 2022; Pathuri et al., 2022).

Few researchers have emphasised sufficiently the importance of adequate DL in Construction 4.0, with research in the construction industry being limited. The existing literature mainly focuses on DL competencies or those required by senior leaders and middle-level managers to guide organisations through digital transformation. Yang et al. (2022) identified and

structured key leadership competencies for organisations in Construction 4.0, summarising 22 of these into four domains: cognition, business, interpersonal communication, and strategy. However, the research did not analyse knowledge, skills, and attributes separately, despite these being key components of competencies. A systematic review by Maruthuvellu et al. (2022) focused on DL competencies for managerial positions within the local context of Malaysia. Munsamy (2022) developed a DL competency framework for engineering and technology organisations in Industry 4.0, identifying six competencies: embracing digital, leadership for the digital drive, digital adaptiveness and resilience, cultivating a digital culture, digital skills, and digital competitiveness intelligence. Johari and Hendra (2023) examined DL dimensions in Malaysia's construction industry, concluding by formulating four dimensions: digital leader competency, capacity, organisational structure, and strategy. Gledson et al. (2024) developed a DL framework for construction organisations, including general competency requirements.

2.1. Knowledge Gap and Study Positioning

This sub-section highlights the knowledge gap justifying this study. Research on DL competencies in the construction industry is limited, while DL evolves in the literature. The existing research focuses mainly on DL competencies for engineering organisations in general. Limited research has addressed the competencies needed for various positions in the construction industry, even though different roles require different competencies to handle digital transformation. In contrast, other construction domains, such as construction management, project management, and site management, have identified the competencies needed for entry-level positions. Therefore, a gap exists in the literature regarding DL competencies across positions, from entry-level to senior roles. Bakht (2018) emphasised the need to explore leadership competencies for entry-level engineers to enhance their career prospects and contribute to organisational and project sustainability. Additionally, prior research has not mapped DL competencies onto knowledge, skills, and attributes as key components of competencies. This gap challenges professionals and organisations because targeted training for digital transformation is difficult if the competencies have not been categorised according to these components. Understanding these knowledge gaps requires acknowledging the critical role that construction workforce competencies play in driving digital transformation. The workforce requires particular knowledge, skills, and traits to become digitally sound (Dahlström et al., 2017). Each position requires distinct DL competencies to support digital transformation as each role in the hierarchy plays a different part in digitalisation (Portnova and Peiseniece, 2020; Yang et al., 2024). Knowledge in the workforce, including technical expertise and the ability to facilitate knowledge transfer, would ensure informed decision-making and contribute to effective digitisation (Mohajan, 2016; Sima et al., 2020). Sunindijo (2015) noted that the necessary skills encompass leadership qualities, digital landscape adaptability, and communication and problem-solving proficiency. Personal attributes like adaptability, openness, and a positive mindset foster resilience and support digital transformation efforts (Ghorbani, 2023; Turner and Müller, 2005). This balance of competencies ensures that leaders can manage teams, mitigate risks, and optimise resources, especially in the context of the construction industry's digital transformation (Kissi et al., 2024). This study, therefore, aimed to develop a DL competency framework for entry-level positions in the construction industry; it is the first study to develop such a framework.

3. Methodology

DL in the construction industry is a relatively underexplored subject. Hence, a qualitative research strategy was used to collect data from construction industry professionals as this method is suitable for a "little-understood phenomenon". (Neuman, 2006; Punch, 2005). Other recent researchers (Zulu et al., 2023) also used a qualitative research strategy to identify challenges to enacting DL in the construction industry. Fig. 1. illustrates an overview of the methodology. The detailed methodology for each step is described below.

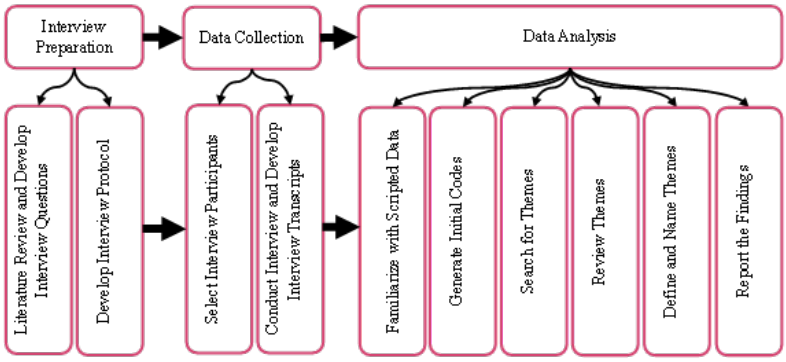

Fig. 1. An overview of the research methodology (developed by the authors)

3.1. Interview Preparation

For this study, qualitative data were collected through semi-structured interviews with construction industry professionals. This method was chosen for its effectiveness in clarifying, understanding, and exploring the participants' perspectives. Interviews help researchers use existing theories, generate granular knowledge, and validate knowledge within a specific context (Creswell, 2014). Based on a thorough literature search, three open-ended questions were developed to gather insights on the DL competency components of knowledge, skills, and attributes: 1) What knowledge should entry-level positions possess in order to lead in a digitally-driven construction industry? 2) What skills should entry-level positions possess in order to lead in a digitally-driven construction industry? 3) What attributes should entry-level positions possess in order to lead in a digitally-driven construction industry? An interview protocol was then developed, including an

invitation letter, interview methods, participant selection, interview questions, and participant information. The protocol was the guiding framework for the interview's objectives (Papadonikolaki et al., 2022). Our university did not require formal ethical clearance for this study as it involved interviewing professionals without reference to sensitive personal data. According to the Economic and Social Research Council (ESRC, 2007), professional-based research involving non-personal data typically does not need ethical approval due to its low risk. However, we followed the ethical practices consistent with leading research institutions (e.g., Harvard University Area IRB, 2015). Participation was voluntary, with the interviewees having the right to withdraw or skip questions. A consent letter was used to inform the participants of the study aim, methodology, benefits, interview process, and future use of the information. Interviews were scheduled during non-office hours to minimise disruption, and participants were allowed to reschedule. The researcher was available to address any concerns. Participants' identities were kept confidential, and data was securely stored in encrypted, password-protected files. Copies were sent to the participants for verification. This study followed ethical guidelines despite not requiring formal ethical clearance.

3.2. Data Collection

Data collection involved semi-structured interviews with construction professionals from Malaysia and Sri Lanka. These countries were chosen due to their rapidly developing construction industries, with Malaysia known for its fast digital transformation and Sri Lanka increasingly emphasising digitalisation in construction (Musarat et al., 2024; Perera et al., 2023). Table 1 presents the respondent profile. Participants were selected based on their extensive experience and involvement in digitalisation efforts within their organisations. The sample included professionals from middle to senior levels in order to gather diverse, contextual data. The participants had expertise in project management, construction IT, structural engineering, and water engineering, with engagement in planning, design, cost control, policy development, consultancy, and construction. A purposive sampling method was adopted to select the study participants. Purposive sampling methods are widely prevalent in qualitative research due to their ability to target a specific group of participants within a population. Researchers can select the sample based on the criteria that suit the study aim (Ames et al., 2019). A total of 22 participants took part in the data collection. In terms of sample size adequacy, Creswell (2014) recommended a sample size of 20-30 interviews for qualitative research, and Marshall et al. (2013) suggested that a typical sample size should fall within this range. All the interviews were conducted via videoconferencing and recorded, with the participants' consent, for accurate transcription (Wahyuni, 2012). Each interview lasted about 45 minutes and included follow-up questions. After each interview, a summary was sent to the participants for validation. Data saturation was observed after the seventeenth interview, with additional interviews unlikely to provide new insights (Faulkner and Trotter, 2017). However, the interviews continued until the twenty-second respondent to ensure saturation.

Table 1. Respondent profile of the interview participants

Participant	Country	Academic Qualification	Designation	Organization Type	Experience (Year)
M1	Malaysia	MSc/Health and Safety	Managing Director	Contractor	22
M2	Malaysia	PhD/Project Management	State Director	Client	23
M3	Malaysia	MSc/Project Management	Senior Engineer	Consultant	25
M4	Malaysia	PhD/Construction Management	Consultant Engineer	Consultant	14
M5	Malaysia	PhD/Construction IT	CEO	Client	40
M6	Malaysia	MSc/Geotechnical Engineering	Managing Director	Contractor	25
M7	Malaysia	MSc/Structural Engineering	Executive Engineer	Consultant	09
M8	Malaysia	MSc/Construction Management	Constr. Manager	Contractor	09
M9	Malaysia	MSc/Geotechnical Engineering	Structural Engineer	Consultant	08
M10	Malaysia	MSc/Construction Management	Geotechnical Engineer	Constructor	09
S1	Sri Lanka	MSc/Con Project Manag., PMP	Project Manager	Consultant	22
S2	Sri Lanka	MSc/Project Management	Project Manager	Client	16
S3	Sri Lanka	MSc/Geotechnical Eng., MBA	Project Manager	Contractor	13
S4	Sri Lanka	MSc/Structural Eng., MBA	Senior Engineer	Contractor	13
S5	Sri Lanka	MSc/Project Manag., PMP	Commercial Manager	Consultant	18
S6	Sri Lanka	MSc/Construction Law, PMP	Project Engineer	Consultant	13
S7	Sri Lanka	MSc/Transportation Eng.	Chief Engineer	Client	14
S8	Sri Lanka	MSc/Water Eng. and IT	Senior Engineer	Consultant	12
S9	Sri Lanka	MSc/Structural Eng.	Chief Engineer	Client	26
S10	Sri Lanka	MSc/Constr. Management	Project Manager	Contractor	20
S11	Sri Lanka	MSc/Water Engineering	Chief Engineer	Consultant	32
S12	Sri Lanka	MSc/Const. Pro. Manag.	Consultant Engineer	Consultant	16

3.3. Data Analysis

The qualitative data from the interviews were analysed using thematic analysis, a method widely used to identify, analyse, and report patterns in data (Braun and Clarke, 2006). The analysis followed the six steps proposed by Braun and Clarke (2006). In the first step, the researchers familiarised themselves with the interview data by reading and rereading to identify initial ideas. In the second step, initial codes were generated, and keywords were systematically coded to align with the research questions. The codes were reviewed and modified as needed. Next, the researchers identified themes based on the

initial codes, frequently referring to the data. The themes were reviewed in step four to ensure they worked across the entire dataset, producing a thematic map. In step five, the themes were defined to capture the essence of each concept. The final step was to report the findings.

4. Results

Table 2 presents the themes and sub-themes identified through thematic analysis for DL competencies in entry-level positions in the construction industry. Separate themes and sub-themes were identified for knowledge, skills, and attributes. For knowledge, three main themes were identified: digital (with the sub-themes of digital literacy, software and tools, data and systems, and emerging technologies), technical (with the sub-themes of design and construction, and industry and ecosystems), and sustainable project management (with the sub-themes of green practices and project operation). For skills, three themes were identified: managerial (with the sub-themes of organisation and leadership), technical (with the sub-themes of analytical and interpretive), and interpersonal (with two sub-themes: first, teamwork and synergy and, second, communication). For attributes, two themes were identified: professional (with the sub-themes of technology embrace, ethical conduct, and work conduct) and personal (with three sub-themes: resilience and digital mindset, mindfulness, and adaptability and learning). Table 3 presents supporting statements from the interview participants for each sub-theme. Notably, the themes and sub-themes identified were shared across both countries, with no unique sub-theme found for either country. This indicates that a common understanding of DL competencies was expected from entry-level positions in the construction industry, regardless of which country the participant was from. This consensus between these two countries illustrates the global nature of the digital transformation process in the construction industry.

Table 2. Themes and subthemes identified from the interview data

KSA	Theme	Sub-theme	Participant No. Malaysia (M)	Participant No. Sri Lanka (S)	Hits
Knowledge	Digital	Digital literacy	5, 6, 7, 9, 10	2, 6, 8, 9, 12	10
		Software & tools	1, 2, 3, 4, 5, 7, 8, 9, 10	1-12 (all)	21
		Data & system	3, 4, 8, 9	1-12 (all)	16
		Emerging technologies	2, 7, 9, 10	1, 3, 5, 6, 7, 8, 10, 11	12
	Technical	Industry & ecosystems	1, 2, 3, 6, 10	1, 2	07
		Design & construction	1, 2, 3, 5, 6, 7, 8, 9, 10	1, 3, 4, 5, 6, 7, 8, 11, 12	18
	*SPM	Green practices	2, 10	1, 2, 5, 6, 7, 9	08
		Project operation	1, 2, 6, 10	1, 5, 6, 7, 8, 9, 11, 12	12
Skills	Managerial	Organizational	3, 6, 7, 9	1, 3, 4, 5, 7, 8, 9, 10, 11	13
		Leadership	3, 1	3, 6	04
	Technical	Analytical	2, 4, 9, 10	1, 4, 6, 7, 8, 9, 11, 12	12
		Interpretive	1, 8, 9	1, 3, 9	06
	Interpersonal	Teamwork & synergy	4, 5, 7, 8, 9, 10	3, 4, 5, 6, 7, 8, 9, 10, 11, 12	16
		Communication	1-10 (all)	1, 2, 4, 5, 6, 7, 8, 9,10,11, 12	21
Attributes	Professional	Technology embrace	1, 2, 8	1, 8	05
		Ethical conduct	1, 2, 3, 5, 6, 7, 9	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	18
		Work conduct	1, 4, 7, 9, 10	7, 9, 12	08
	Personal	Resilience & digital mindset	1, 2, 3, 5, 6, 7, 8, 10	2, 4, 5, 7, 8, 10	14
		Mindfulness	2, 3, 4, 6, 8	2, 5, 6, 7, 9, 10, 11, 12	13
		Adaptability & learning	**1, 9**	**1, 3, 9, 10**	06

**SPM – sustainable project management*

5. Discussion

5.1. Digital Knowledge

In this study, digital knowledge is defined as proficiency in digital literacy, software, tools, data systems, and technologies to enhance construction processes. Four knowledge domains were identified for entry-level positions in the construction industry: IT literacy, software and tools, data and systems, and emerging technologies. An understanding of IT literacy is needed, given the rapid change in the digital landscape for the construction industry. This would ensure the staff are knowledgeable about current technologies and prepared to face new developments and advancements in the digital landscape. Digital knowledge drew more emphasis from the interview participants. As such, young professionals are strongly expected to possess proficiency in software and tools that are widely used (such as BIM, project management digital applications, structural design software, digital collaborative tools, excel, and CAD) so they can execute construction projects efficiently. Their expertise can improve productivity and reduce construction project mistakes and rework. Moreover, understanding data and systems (such as data governance and security, MIS, and GIS) is required because the construction industry increasingly uses digital data for efficient information management. Awareness of emerging digital technologies among entry-level professionals can equip them to drive innovation in the built environment. Siddiqui et al. (2023) noted that, besides CAD and BIM, Construction 4.0 involves digital technologies like the IoT, AI, augmented reality, virtual reality, drones, laser scanning, 3D printing, big data analytics, GIS, and robotics. AI and machine learning (ML) have become promising technologies in the construction industry (Datta et al., 2024). Jacobsson and Linderoth (2021)

stated that new graduates need digital knowledge to enable them to integrate quickly into an organisation. Entry-level expertise in digital knowledge helps strengthen industry positions and contributes to more sustainable, innovative practices.

Table 3. Supporting statements of the interview participants

Sub-Theme	Supporting Statements
Digital literacy	"Understanding of IT basics is crucial" *(M6).* "They should possess IT literacy to handle commonly used IT tools and technologies in the industry and those that are specific to organizations" *(S6).*
Software & tools	"BIM is widely prevalent, so it is a basic requirement now"*(M4).* "They should hold working knowledge of BIM, project management tools, and design software" *(S1).*
Data & system	"Data management and security knowledge is vital" *(M8).* They should possess exposure in areas such as data analytics and data security"*(S3).*
Emerging technologies	"Understanding Artificial Intelligence (AI) is a timely need for them. If not, they risk being left behind. They must know how to use AI in their work effectively" *(M2).* "Knowledge of emerging technologies such as AI, drones/aerial technology, clouding, and automation is important" *(S1).*
Industry & ecosystems	"They should not lose sight of the ecosystem in which the industry/project operates. The technological availability varies from place to place, so they should be smart at using existing facilities to deliver project deliverables. Their knowledge should adapt to digital and non-digital scenarios with a hybrid approach" *(M2).* "They should have a general understanding of what is happening in and around the industry" *(S2).*
Design & construction	"Construction technology and material knowledge are important" *(M8).* "They should possess a good understanding of construction technology because it is what they mostly deal with early in their career, including digital technologies" *(S12).*
Green practices	"A full understanding of Environmental, Social, and Governance (ESG) principles in the context of the construction industry is important. The digitalization process is aligned with ESG. Translating ESG frameworks into the digital domain is required in Malaysia and globally" *(M2).* "Green construction understanding is crucial as the use of digital tools is to promote green practices" *(S9).*
Project operation	"Project management knowledge is vital" *(M10).* "They should clearly understand finance and economic basics, including a good understanding of Quantity Surveying" *(S12).*
Organizational	"They have to be detail-oriented and organized, which is lacking among the younger generation now" *(M3).* "A sound skill for working with schedules is crucial for them" *(S6).*
Leadership	"Transformational leadership skills must come early into their career" *(M3).* "They should develop transformational leadership to deal with all levels of people in their organizations effectively" *(S1).*
Analytical	"Good analytical ability is always important to effectively use technologies." (M9). " The skill to critically assess technical and non-technical problems for effective solutions is crucial." *(S9)*
Interpretive	"Technological transfer from digital tools to simple outcomes and thereof better interpretation is important." *(M1);* "They should develop the capacity to effectively interpret the outcomes of digital tools to those with limited exposure to such technologies." *(S1)*
Teamwork & synergy	"Teamwork and collaborative skills are highly required" *(M7).* "Presently, like physical teams, virtual teams are very common. So, team management/collaborative skills are highly important" *(S7).*
Communication	'They must have effective communication skills and convincing ability because they can interact with professionals of different levels" *(M9).* "They must be capable of effective oral and written communication skills. In my experience, around 50% of the candidates lack it" *(S6).*
Technology embrace	"They must show a positive mindset toward technology adoption" (M8). "They must proactively embrace new digital technologies critical to project and organization success and keep updating on advancements" *(S1).*
Ethical conduct	"They should protect sensitive data" *(M7).* " The attributes for data security and confidentiality of sensitive information is highly required"*(S1).*
Work conduct	"They should avoid distracting their focus off their work or changing their job within a short period" *(M7).* "They should be aware of their limitations regarding authority and responsibility in work" *(S5).*
Resilience & digital mindset	"Innovative mindset and accepting challenges is also important" *(M8).* "Other attributes, I would say, are resilience to uncertainties and adapting to new/difficult scenarios" *(S3).*
Mindfulness	"Mindfulness is highly required for them to work in complex project environments" *(M6).* "Emotional Intelligence attributes are important for them, given their emotion-based challenges" *(S9).*
Adaptability & learning	"They must be fast learners" *(M1).* "Entry-level positions require resilience to tackle challenges, bounce back from setbacks, learn, and stay positive on all occasions" *(S1).*

5.2. Technical Knowledge

In this study, technical knowledge is defined as a thorough understanding of design and construction, along with an awareness of the industry and its ecosystems. Most participants emphasised the design and construction domain, which includes construction technology, materials, structural design principles, engineering mathematics, modular/volumetric construction, MEP, and proficiency in 2D/3D drawings. Industry and ecosystems knowledge involves interdisciplinary awareness and understanding of project operations. As one participant (M2) noted, "entry-level positions in the construction industry should not lose sight of the ecosystem in which the industry/project operates. As the technological availability varies, they should be smart at using existing facilities to deliver project deliverables. Their knowledge should adapt to digital and non-digital scenarios with a hybrid approach". Previous research on engineering leadership competencies revealed that senior construction managers seek exceptional technical knowledge from entry-level engineers (Bakht, 2018). Therefore, entry-level professionals must master technical and digital knowledge to stay competitive in the industry.

5.3. Sustainable Project Management Knowledge

Sustainable project management (SPM) involves planning, monitoring, and controlling project delivery, as well as considering environmental, economic, and social aspects throughout the project's life cycle. The aim is to benefit stakeholders in a transparent, fair, and ethical manner with proactive stakeholder participation (Silvius, 2015). In this study, SPM encompassed project operation and green practices. Regarding project operation, participants highlighted that entry-level professionals should understand project management theory, Agile concepts, quantity surveying, budgeting, safety management, logistics, finance, and economics. Green practices involve knowledge of environmental, social, and governance (ESG) principles and green construction technology. As one interview participant stated, "As they begin their career, a thorough understanding of ESG principles in the context of the construction industry is important. Digitalisation process itself is aligned with ESG principles. Translating ESG frameworks into the digital domain is required in Malaysia and globally" (M2). As S2 stated, "green construction understanding is crucial as the usage of digital tools itself is to promote green practices". This is supported by Guerrero (2013), who stated that engineers are expected to lead sustainable development initiatives. Therefore, SPM knowledge is decisive for entry-level professionals navigating digital transformation. It would enable them to contribute to eco-friendly project outcomes, support corporate social responsibility, and position themselves as forward-thinking leaders in the industry, aligned with the core principles of digitalisation.

5.4. Managerial Skills

Managerial skills in construction refer to the abilities needed to accomplish project tasks successfully (Ijaola and Ogunsanmi, 2018). This study includes organisational skills and leadership ability. The organisational skills discussed in the interviews included time management, task delegation, coordination, documentation, and attention to detail. Neumeyer and Liu (2021) stated that adopting new technology contributes to success, but managerial competencies are critical. Bakht (2018) highlighted the managerial skills needed by entry-level civil engineers, such as goal execution, leadership experience, overcoming obstacles, and working under pressure. Leadership in this study included transformational leadership, logical judgement, conflict management, and mentoring. Transformational leaders bring significant changes, impacting strategy, vision, attitude, and culture (Müller and Turner, 2010). As Philip (2021) notes, transformational leaders inspire innovation and creativity, which are essential for digital transformation. In summary, entry-level professionals with these skills can effectively coordinate project teams and integrate digital technologies.

5.5. Technical Skills

Technical skills in this study included two sub-themes: analytical and interpretive skills. The former involve problem-solving, monitoring, critical thinking, context-driven decision-making, and logical reasoning. These are essential for handling digital technologies and other technical matters. Data analytics tools are widely used in the construction industry, where analytical ability is crucial. Zuhairi et al. (2018) found that analysing problems and logical thinking are highly sought after in the industry. Interpretive skills are needed to understand, apply, and communicate outcomes from technological deliverables. Participants emphasised that entry-level professionals should assess buildability, communicate digital deliverables to non-experts, and transform technical outcomes. Misinterpreting technical outcomes can negatively affect time and cost (Rzempala et al., 2023). Therefore, entry-level professionals must analyse data, make decisions, and apply analytical and interpretive skills to support projects and achieve success in the construction industry.

5.6. Interpersonal Skills

Interpersonal skills are essential in dealing with and relating to others, mainly on a one-to-one basis (McConnell, 2004). In this study, interpersonal skills included two sub-themes: first, teamwork and synergy and, second, communication. For teamwork and synergy, participants emphasised teamwork, active listening, working independently with less supervision, and coordinating across interdisciplinary teams. The communication sub-theme included hierarchical communication, effective written and oral communication, simplification and clarity, and effective presentation delivery. Bolpagni et al. (2022) reported that the main obstacle to developing Construction 4.0 is the lack of interpersonal skills like communication, relationship skills, leadership, problem-solving, and learning capacity. In Construction 4.0, interpersonal skills are critical (Adepoju and Aigbavboa, 2021).

5.7. Professional Attributes

According to the NSPE Code of Ethics for Engineers, engineers must perform according to a standard of professional behaviour that requires adherence to the highest principles of ethical conduct. Their services require honesty, impartiality, fairness, and equity, and they must safeguard public health, safety, and welfare (NSPE, 2015). The professional attributes in this study comprised technology embrace, workplace conduct, and ethical conduct. As emphasised by the interview participants, technology embrace included proactive technology adoption, hybrid thinking between digital and non-digital, and the integration of innovative solutions. This is supported by Rajkumar et al. (2024), who stated that engineers must embrace new technologies as part of the expanding digital transformation. These technologies can improve their ability to design and simulate complex systems to optimise solutions. The second sub-theme is workplace conduct. The interview participants discussed the importance of being transparent, showing clarity in their role, maintaining work-life balance, being responsible and accountable, being a change agent, having a steady work commitment, working without distractions, and sharing collaborative knowledge. The third sub-theme is upholding ethical conduct, which includes safeguarding sensitive information, abiding by the law, and respecting intellectual property rights. With the recent advancements of Industry 4.0 technologies in the construction industry, the vital aspects are developing ethical standards and regulations, focusing on human-centric technology concepts, and assessing the productivity of projects based on their social impacts

beyond financial means (Khodabakhshian, 2024). The professional attributes of staff in entry-level positions in the construction industry can positively impact the digitalisation process.

5.8 Personal Attributes

Personal attributes/values are sets of principles or ideals that guide behaviour (Robbins, 2003). In this study, personal attributes included three sub-themes: adaptability and learning, mindfulness, and resilience and digital mindset. In terms of adaptability and learning, the interview participants emphasised that young people in the construction industry must be open to learning, learn fast, maintain a work-life balance, learn from setbacks, and adjust to changes. For a successful digital transformation, the required capabilities include digital innovation, learning, and adaptability/agility (Busulwa, 2022). The second sub-theme is mindfulness, which includes understanding emotions, being present, being mindful of using AI technologies, showing empathy, and showing self-awareness. Gledson et al. (2024) stated that in addition to technical skills, traditional interpersonal skills and emotional intelligence are important in navigating Construction 4.0. Von Ohain (2019) concluded that the key attributes of a digital leader are empathy, innovation, openness, and agility. The third sub-theme is resilience and mindset, which includes maintaining a positive mindset, being tolerant of hardships, fostering innovation, being open to criticism and instructions, being humble, and having a competitive mindset. In the digital transformation, leaders with a digital mindset are better positioned to foster growth and resilience. They can support organisations and seize new business opportunities. Employees with digital mindsets are more successful, more satisfied with their jobs, and more likely to get promoted. A digital mindset refers to attitudes and behaviours that enable people to recognise how digital technologies create new possibilities and to plan for success in a data-driven business landscape (Neeley and Leonardi, 2022). Young professionals with adaptability, mindfulness, resilience, and a digital mindset can bring the required change within themselves and their organisations, supporting digital adoption and innovative practices.

5.9. Study Implications

5.9.1. Theoretical implications

The DL competency framework for entry-level positions in the construction industry addresses a gap in the literature by identifying the competencies required in this sector. Researchers can explore how digital knowledge impacts job performance, innovation, and the effectiveness of digital training programs. Investigating the role of technical knowledge in project success, operational efficiency, and career advancement could offer valuable insights. Examining the integration of SPM knowledge into education and industry practices could yield long-term benefits for project outcomes and the environment. Future researchers could also explore the relationship between managerial skills and leadership effectiveness in a digital environment and how proficiency in digital tools impacts job performance and career advancement. Interpersonal skills can enhance teamwork and collaboration during digital transformation, which is vital for team dynamics and project success. Investigating how professional attributes influence leadership effectiveness and organisational reputation could improve leadership in the digital era. Finally, examining how personal attributes such as adaptability and self-motivation contribute to resilience and the successful navigation of industry changes can inform effective digital transformation management.

5.9.2. Managerial implications

The DL competency framework offers industry leaders a strategic approach to developing DL competencies in emerging construction professionals. By focusing on digital, technical, and SPM knowledge, managers can design targeted training programs that enhance digital proficiency, technical expertise, and sustainability practices. Emphasising managerial and interpersonal skills would ensure young leaders are prepared to lead effectively in digital environments, improving leadership effectiveness and project outcomes. Focusing on professional attributes like ethical conduct and personal attributes such as adaptability would enable organisations to recruit and develop resilient leaders aligned with the evolving demands of digital transformation in the construction industry. This approach would ensure leadership development is aligned with DL competency needs, helping organisations maintain a competitive edge and drive innovation.

5.9.3 Practical implications

The practical implications of this study are significant for both industry practitioners and academic institutions. The framework provides a guide for enhancing curriculum design, thus ensuring engineering programs align with the demands of the evolving construction industry. By integrating digital literacy, technical knowledge, and ethical conduct competencies into their courses, educational providers can better prepare graduates with the essential knowledge, skills, and attributes needed to succeed in the digitalised construction landscape. For industry practitioners, the framework is a foundation for implementing competency-based assessments and development programs, helping construction organisations develop DL capabilities and equip emerging leaders with the necessary skills and attributes to lead effectively in a rapidly evolving digital environment.

5.10. Limitations and Future Recommendations

This study has limitations regarding the geographical locations of the data collection and research methods. The participants came from Malaysia and Sri Lanka. Although a common consensus was observed between the nationals of these two countries regarding the themes and sub-themes, caution should be exercised when generalising the findings to other locations. A qualitative research strategy was employed because DL in the construction industry has been underexplored. However, this approach limits the ability to generalise findings, whereas quantitative methods would not. Additionally, the framework shown in Fig. 2 is conceptual and yet to be tested and validated, highlighting the need for further testing. Further research could use qualitative and quantitative methods to triangulate the findings, enhancing their generalisability.

Additionally, future research could assess the cross-regional levels of awareness about DL competencies among entry-level positions in the construction industry. Exploring the perceptions of seasoned industry professionals could provide valuable insights into assessing competency levels. A promising area for future research includes developing a standardised rating scale for the identified DL competencies. Such a scale could benefit entry-level personnel and the industry by, respectively, clarifying industry expectations and providing a structured framework for competency assessment. Despite these limitations, this study offers a solid foundation for further exploration. The methodology and conceptual framework employed answer the research questions and contribute to the growing body of knowledge about DL in the construction industry. While its limitations must be acknowledged, this study provides a basis for future research to expand upon and validate these findings.

6. Concluding Remarks

In conclusion, this study involved developing a DL competency framework for entry-level positions in the construction industry. The framework, shown in Fig. 2, was categorised into knowledge, skills, and attributes. The knowledge component includes digital, technical, and sustainable project management themes, with eight sub-themes. The skills component covers managerial, technical, and interpersonal themes, with six sub-themes. The attributes component includes professional and personal themes, with six sub-themes. This framework advances the theoretical understanding by identifying key industry-specific DL competencies. It invites research on the effects of digital knowledge on job performance and innovation; the impact of technical knowledge on project success; and the benefits of integrating sustainable project management knowledge. It also suggests examining the influence of managerial and technical skills on leadership effectiveness; the role of interpersonal skills in digital transformation; and how professional and personal attributes shape leadership and resilience. In managerial terms, it provides a strategic approach to developing essential competencies, emphasising digital knowledge, technical skills, and sustainable practices. It highlights the importance of managerial and interpersonal skills for effective leadership, project success, and the professional and personal attributes needed to build resilient leaders. In practical terms, the framework guides academic curriculum enhancement and the implementation of competency-based development programs, which would ensure emerging leaders are equipped with the required knowledge, skills, and attributes to thrive in the evolving digital construction landscape.

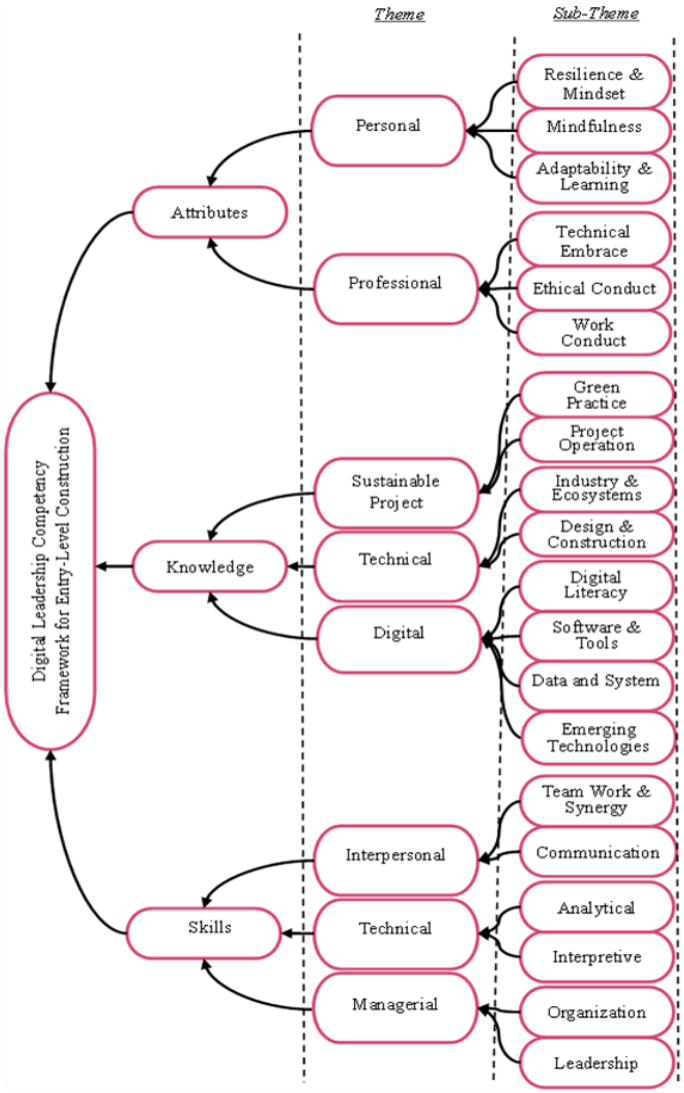

Fig. 2. DL competency framework for entry-level positions in the construction industry (developed by authors)

Acknowledgement

The authors are grateful to the professionals in the construction industry who took part in the interviews and the editors and anonymous reviewers for their insightful comments, helping to improve the quality of this manuscript.

Author Contributions

Risath Athamlebbe contributed to the conceptualization, methodology, data collection, data analysis, and writing of the original draft. Rahimi A. Rahman contributed to manuscript editing, supervision, project administration, and funding acquisition. All authors have read and agreed with the manuscript before its submission and publication.

Funding

The Ministry of Higher Education, Malaysia, supported this work through the Fundamental Research Grant Scheme (FRGS2019/TK08/UMP/02/6) /1/ (University reference RDU1901200).

Institutional Review Board Statement

Not applicable.

References

Adepoju, O. O., and Aigbavboa, C. O. (2021). Assessing knowledge and skills gap for construction 4.0 in a developing economy. *Journal of Public Affairs*, 21(2). doi:10.1002/pa.2264

Aghimien, D., Aigbavboa, C., Oke, A., Thwala, W., and Moripe, P. (2022). Digitalization of construction organisations–a case for digital partnering. *International Journal of Construction Management*, 22(10), 1950–1959. doi: 10.1080/15623599.2020.1745134

Ames, H., Glenton, C., and Lewin, S. (2019). Purposive sampling in a qualitative evidence synthesis: A worked example from a synthesis on parental perceptions of vaccination communication. *BMC Medical Research Methodology*, 19(1). doi: 10.1186/s12874-019-0665-4

Bademosi, F. M., and Issa, R. R. A. (2022). Essential Knowledge, Skills, and Abilities Required for Talent Cultivation in Construction Automation and Robotics. *Automation and Robotics in the Architecture, Engineering, and Construction Industry*, 31-57. doi: 10.1007/978-3-030-77163-8_2

Bakht, A. B. (2018). Engineering Leadership Competencies for Entry-Level Civil Engineers. *PhD Thesis*.

Bolpagni, M., Gavina, R., Ribeiro, D., and Arnal, I. P. (2022). Shaping the Future of Construction Professionals. *Structural Integrity*, 1-26. doi: 10.1007/978-3-030-82430-3_1

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101. doi: 10.1191/1478088706qp063oa

Busulwa, R. (2022). Digital Innovation, Digital Learning, and Adaptability/Agility Capabilities. *Navigating Digital Transformation in Management*, 183-199. doi: 10.4324/9781003254614-15

Chan, D. W. M., Olawumi, T. O., and Ho, A. M. L. (2019). Critical success factors for building information modelling (BIM) implementation in Hong Kong. *Engineering, Construction and Architectural Management*, 26(9), 1838-1854. doi: 10.1108/ECAM-05-2018-0204

Dahlström, P., Desmet, D., and Singer, M. (2017). *The seven decisions that matter in a digital transformation: A CEO's guide to reinvention*. Digital McKinsey, 1-7.

Datta, S. D., Islam, M., Rahman Sobuz, M. H., Ahmed, S., and Kar, M. (2024). Artificial intelligence and machine learning applications in the project lifecycle of the construction industry: A comprehensive review. *Heliyon*, 10(5), e26888. doi: 10.1016/j.heliyon.2024.e26888

De Carolis, A., Macchi, M., Negri, E., and Terzi, S. (2017). A maturity model for assessing the digital readiness of manufacturing companies. *IFIP Advances in Information and Communication Technology,* 13-20. doi: 10.1007/978-3-319-66923-6_2

Economic & Social Research Council (ESRC). (2007). *Framework for Research Ethics*, 50.

Ernstsen, S. N., Whyte, J., Thuesen, C., and Maier, A. (2021). How Innovation Champions Frame the Future: Three Visions for Digital Transformation of Construction. *Journal of Construction Engineering and Management*, 147(1). doi: 10.1061/(asce)co.1943-7862.0001928

Faulkner, S. L., and Trotter, S. P. (2017). Theoretical Saturation. *The International Encyclopedia of Communication Research Methods*, 1-2. doi: 10.1002/9781118901731.iecrm0250

Ghorbani, A. (2023). A Review of Successful Construction Project Managers' Competencies and Leadership Profile. *Journal of Rehabilitation in Civil Engineering*, 11(1), 76-95. doi: 10.22075/JRCE.2022.24638.1560

Gledson, B. J., and Greenwood, D. (2017). The adoption of 4D BIM in the UK construction industry: An innovation diffusion approach. *Engineering, Construction and Architectural Management*, 24(6), 950-967. doi: 10.1108/ECAM-03-2016-0066

Gledson, B., Zulu, S. L., Saad, A. M., and Ponton, H. (2024). Digital leadership framework to support firm-level digital transformations for Construction 4.0. *Construction Innovation*, 24(1), 341-364. doi: 10.1108/CI-12-2022-0328

Guerrero, L. A. (2013). The role of engineers in Mexico's development. *Electrical Engineering*, 67(10), 940–940. doi: 10.1109/ee.1948.6444361

Han, Y., Du, H., and Zhao, C. (2024). Development of a digital transformation maturity model for the construction industry. *Engineering, Construction and Architectural Management*. doi: 10.1108/ECAM-10-2023-1009

Hannan Qureshi, A., Salah Alaloul, W., Kai Wing, W., Saad, S., Ali Musarat, M., Ammad, S., and Farouk Kineber, A. (2023). Automated progress monitoring technological model for construction projects. *Ain Shams Engineering Journal*, 14(10). doi: 10.1016/j.asej.2023.102165

Hennink, M. M., Kaiser, B. N., and Marconi, V. C. (2017). Code Saturation Versus Meaning Saturation: How Many

Interviews Are Enough? *Qualitative Health Research*, 27(4), 591-608. doi: 10.1177/1049732316665344
Ijaola, I., and Ogunsanmi, O. (2018). Construction Managers' (CMs) Skills and Project Performance. *Built Environment Journal*, 15(1), 1-12.
IPMA. (2015). Individual competence baseline for project, program, and portfolio management. *IPMA: Vol. ICB 4.0*.
J. W. Creswell. (2014). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. SAGE Publications.
Jacobsson, M., and Linderoth, H. C. J. (2021). Newly graduated students' role as ambassadors for digitalisation in construction firms. *Construction Management and Economics*, 39(9), 759-772. doi: 10.1080/01446193.2021.1955398
Johari, S., and Hendra, S. (2023). An Overview of Digital Leadership Dimensions in Construction Industry. *International Journal of Business and Technology Management*, 5(2), 49–66. doi: 10.55057/ijbtm.2023.5.2.5
Kasim, N., Razali, S. A., and Kasim, R. (2021). Reinforce Technology IR 4.0 Implementation for Improving Safety Management in Construction Site. *International Journal of Sustainable Construction Engineering and Technology*, 12(3). doi: 10.30880/ijscet.2021.12.03.028
Khodabakhshian, A. (2024). Ethics-Aware Application of Digital Technologies in the Construction Industry. *Springer Briefs in Applied Sciences and Technology*, 49-64. doi: 10.1007/978-3-031-52962-7_5
Kissi, E., Eluerkeh, K., Aigbavboa, C., Addy, M., and Babon-Ayeng, P. (2024). Project managers' competencies in the era of digitalization: the case of the construction industry. *Built Environment Project and Asset Management*. doi: 10.1108/BEPAM-03-2024-0051
Larjovuori, R.-L., Bordi, L., Makiniemi, J.-P., and Heikkila-Tammi, K. (2016). The Role of Leadership and Employee Well-Being in Organizational Digitalization. What's Ahead in Service Research? *New Perspectives for Business and Society*, 1159-1172.
Li, Q., and Wang, Y. (2021). Blockchain's role in supporting circular supply chains in the built environment. *Proceedings - 2021 IEEE International Conference on Blockchain, Blockchain 2021*, 578-583. doi: 10.1109/Blockchain53845.2021.00087
Liao, L., and Teo, E. A. L. (2019). Managing critical drivers for building information modelling implementation in the Singapore construction industry: an organizational change perspective. *International Journal of Construction Management*, 19(5), 1-17. doi: 10.1080/15623599.2017.1423165
Marshall, B., Cardon, P., Poddar, A., and Fontenot, R. (2013). Does sample size matter in qualitative research?: A review of qualitative interviews in is research. *Journal of Computer Information Systems*, 54(1), 11-22. doi: 10.1080/08874417.2013.11645667
Maruthuvellu, S. G., Salamzadeh, Y., and Richardson, C. (2022). Digital leadership competencies in the Malaysian context: A study in manager levels. *Handbook of Research on Developing Circular, Digital, and Green Economies in Asia*, 13-41. doi: 10.4018/978-1-7998-8678-5.ch002
McConnell, C. R. (2004). Interpersonal skills: What they are, how to improve them, and how to apply them. *Health Care Manager*, 23(2), 177-187. doi: 10.1097/00126450-200404000-00012
Michaelis, B., Stegmaier, R., and Sonntag, K. (2009). Affective Commitment to Change and Innovation Implementation Behavior: The Role of Charismatic Leadership and Employees' Trust in Top Management. *Journal of Change Management*, 9(4), 399-417. doi: 10.1080/14697010903360608
Mistarihi, A. (2021). Strategic Leadership Competencies: Evidence from the State of Qatar. *Journal of Human Resource and Sustainability Studies*, 9(1). doi: 10.4236/jhrss.2021.91005
Mohajan, H. K. (2016). Knowledge is an Essential Element at Present World. *International Journal of Publication and Social Studies*, 1(1), 31-53. doi: 10.18488/journal.135/2016.1.1/135.1.31.53
Mohd Affandi, H., Mustaffa Kamal, M. F., and Hassan, F. (2016). Malaysian Entry Level Construction Managers Generic Competency: Mismatch Between Industries Requirement and Construction Management Students' Expectation. *ICERI2016 Proceedings*, 3202-3208. doi: 10.21125/iceri.2016.1733
Moloi, T. (2021). Key features of the fourth industrial revolution in south africa's basic education system. *Journal of Management Information and Decision Sciences*, 24(5), 1-20.
Müller, R., and Turner, R. (2010). Leadership competency profiles of successful project managers. *International Journal of Project Management*, 28(5), 437-448. doi: 10.1016/j.ijproman.2009.09.003
Munsamy, M. (2022). A Digital Leadership Competency Framework in the Era of 4IR. *PhD Thesis*.
Musarat, M. A., Alaloul, W. S., Zainuddin, S. M. B., Qureshi, A. H., and Maqsoom, A. (2024). Digitalization in the Malaysian construction industry: Awareness, challenges and opportunities. *Results in Engineering*, 21(7). doi: 10.1016/j.rineng.2024.102013
Naji, K. K., Gunduz, M., Alhenzab, F. H., Al-Hababi, H., and Al-Qahtani, A. H. (2024). A Systematic Review of the Digital Transformation of the Building Construction Industry. *IEEE Access*, 12, 31461-31487. doi: 10.1109/ACCESS.2024.3365934
Neeley, T., and Leonardi, P. (2022). Developing a Digital Mindset. *Harvard Business Review*, 50-56.
Neuman, L. W. (2006). *Workbook for Neumann Social research methods: qualitative and quantitative approaches*. Allyn & Bacon.
Neumeyer, X., and Liu, M. (2021). Managerial Competencies and Development in the Digital Age. *IEEE Engineering Management Review*, 49(3), 49-55. doi: 10.1109/EMR.2021.3101950
Niu, Y., Wen, W., Wang, S., and Li, S. (2023). Breaking barriers to innovation: The power of digital transformation. *Finance Research Letters*, 51(C). doi: 10.1016/j.frl.2022.103457
NSPE. (2015). *National Society of Professional Engineers: Code of Ethics for Engineers*
Opoku, D. G. J., Perera, S., Osei-Kyei, R., and Rashidi, M. (2021). Digital twin application in the construction industry: A literature review. *Journal of Building Engineering*, 40. doi: 10.1016/j.jobe.2021.102726
Papadonikolaki, E., Krystallis, I., and Morgan, B. (2022). Digital Technologies in Built Environment Projects: Review and Future Directions. *Project Management Journal*, 53(5). doi: 10.1177/87569728211070225
Parry, S. B. (1996). The Quest for Competencies. *Training*, 33(7), 48-56.

Pathuri, R. T., Killingsworth, J., and Mehany, M. S. H. M. (2022). Knowledge, Skills, and Abilities for Senior-Level Construction Managers: A U.S. Industry-Based Delphi Study. *International Journal of Construction Education and Research*, 18(3), 234-250. doi: 10.1080/15578771.2020.1861136

Perera, W. S. D., Ranadewa, K. A. T. O., Parameswaran, A., and Weerasooriya, D. (2023). Status Quo of Digitalisation in the Sri Lankan Construction Industry. *World Construction Symposium*, 944-959. doi: 10.31705/WCS.2023.76

Philip, J. (2021). Viewing Digital Transformation through the Lens of Transformational Leadership. *Journal of Organizational Computing and Electronic Commerce*, 31(1), 1-16. doi: 10.1080/10919392.2021.1911573

Portnova, I., and Peiseniece, L. (2020). Leaders' Competences for Successful Leadership of Invention and Implementation of Innovation: A Conceptual Model. *Journal of Business Management*, 6(1), 40-55.

Punch, K. (2005). *Introduction to Social Research: Quantitative and Qualitative Approaches (2nd Ed.)*. Sage, London.

Robbins, S. P. (2003). *Organizational Behavior (11th Ed.).* New Jersey: Prentice-Hall.

Rzempala, J., Janecka, K., and Juzwik, M. (2023). The Importance of Developing Soft Skills in Project Management - Students' Perspective, Based on the Example of IPMA-Student Certification. *European Research Studies Journal*. XXVI(2), 628-640. doi: 10.35808/ersj/3193

S. Rajkumar, B. Vijayalaxmi, D. Srinivas, B. Praveen, and M. Neel Kamal. (2024). An Overview of Mechanical Engineering and its Latest Technologies. *International Research Journal on Advanced Engineering and Management (IRJAEM),* 2(3), 54-64. doi: 10.47392/irjaem.2024.0010

Sawy, O. A. E., Amsinck, H., Kræmmergaard, P., and Vinther, A. L. (2016). How LEGO built the foundations and enterprise capabilities for digital leadership. *MIS Quarterly Executive*. 15(2). doi: 10.4324/9780429286797-8

Sheikhshoaei, F., Naghshineh, N., Alidousti, S., and Nakhoda, M. (2018). Design of a digital library maturity model (DLMM). *Electronic Library*, 36(3). doi: 10.1108/EL-05-2017-0114

Siddiqui, F. H., Thaheem, M. J., and Abdekhodaee, A. (2023). A Review of the Digital Skills Needed in the Construction Industry: Towards a Taxonomy of Skills. *Buildings*, 13(11), 2711. doi: 10.3390/buildings13112711

Silvius, G. (2015). Considering sustainability in project management processes. *Handbook of Research on Sustainable Development and Economics*. doi: 10.4018/978-1-4666-8433-1.ch014

Sima, V., Gheorghe, I. G., Subić, J., and Nancu, D. (2020). Influences of the industry 4.0 revolution on the human capital development and consumer behavior: A systematic review. *Sustainability (Switzerland)*. 12(10), 4035. doi: 10.3390/SU12104035

Sunindijo, R. Y. (2015). Project manager skills for improving project performance. *International Journal of Business Performance Management*, 16(1), 67-83. doi: 10.1504/IJBPM.2015.066041

Tayeh, R., Bademosi, F., and Issa, R. R. A. (2020). Information systems curriculum for construction management education. *Construction Research Congress 2020*, 800-809. doi: 10.1061/9780784482872.087

The Harvard University Area IRB. (2015). *Introduction To Human Subjects Research.*

Toyin, J. O., and Mewomo, M. C. (2023). Assessing the innovative skills and competencies required of construction management graduates. *Organization, Technology and Management in Construction*. 15(1), 90-106. doi: 10.2478/otmcj-2023-0002

Turner, J. R., and Müller, R. (2005). The Project Manager's Leadership Style as a Success Factor on Projects: A Literature Review. *Project Management Journal*, 36(2), 49-61. doi: 10.1177/875697280503600206

Von Ohain, B. P. (2019). Leader attributes for successful digital transformation. *40th International Conference on Information Systems, ICIS 2019*.

Wahyuni, D. (2012). The research design maze: understanding paradigms, cases, methods and methodologies. *Journal of Applied Management Accounting Research*, 10(1).

Yang, K., Sunindijo, R. Y., and Wang, C. C. (2022). Identifying Leadership Competencies for Construction 4.0. *Buildings*, 12(9), 1434. doi: 10.3390/buildings12091434

Yang, K., Sunindijo, R. Y., Wang, C. C., and Zhang, S. (2024). Key Leadership Competencies in Different Management Levels for Digital Transformation in Construction Organisations. *Association of Researchers in Construction Management, ARCOM 2024 - Proceedings of the 40th Annual Conference, October*, 139-147.

Zhang, Z., Jin, J., Li, S., and Zhang, Y. (2023). Digital transformation of incumbent firms from the perspective of portfolios of innovation. *Technology in Society*, 72(C). doi: 10.1016/j.techsoc.2022.102149

Zhu, H., Wang, L., Li, C., Philbin, S. P., Li, H., Li, H., and Skitmore, M. (2024). Building a Digital Transformation Maturity Evaluation Model. *Buildings*, 14(1), 91. doi: 10.3390/buildings14010091

Zuhairi, F. F. M., Ibrahim, C. K. I. C., and Belayutham, S. (2018). Analysis of employability skills for future civil engineers in Malaysian construction industry. *International Journal of Continuing Engineering Education and Life-Long Learning*, 28(3/4), 310. doi: 10.1504/ijceell.2018.098074

Zulu, S. L., and Khosrowshahi, F. (2021). A taxonomy of digital leadership in the construction industry. *Construction Management and Economics*, 39(7), 565–578. doi: 10.1080/01446193.2021.1930080

Zulu, S. L., Saad, A. M., Ajayi, S. O., Dulaimi, M., and Unuigbe, M. (2023). Digital leadership enactment in the construction industry: barriers undermining effective transformation. *Engineering, Construction and Architectural Management*, 31(10). doi: 10.1108/ECAM-05-2022-0491

Risath Athamlebbe is an academic at the Department of Civil Engineering, Faculty of Engineering, South Eastern University of Sri Lanka. He obtained his Bachelor's degree in Civil Engineering from the University of Peradeniya, Sri Lanka, in 2009. His Master's degree in Construction Project Management was awarded by the University of Moratuwa, Sri Lanka, in 2018. He is currently a Ph.D. candidate at the University Malaysia Pahang Al-Sultan Abdullah (UMPSA). Additionally, he has industrial experience, having worked on infrastructure projects in Qatar and Sri Lanka. His current research interests include digital construction, green construction, and risk management in construction.

Rahimi A. Rahman received both a Bachelor's degree in Civil and Environmental Engineering and a Master's degree in Environmental Science and Civil Engineering from Saitama University, Japan, in 2012 and 2014, respectively. He earned his Ph.D. in Civil, Environmental, and Sustainable Engineering from Arizona State University in 2018. He is an Associate Professor in the Faculty of Civil Engineering Technology at Universiti Malaysia Pahang Al-Sultan Abdullah (UMPSA). He has extensive experience serving clients in various industries on project governance, organization design, and talent development. His current research interests include project management and digital construction.