

Measuring digital maturity for digital transformation projects in construction: Developing the digital transformation maturity assessment model for construction company operations.

Track: Project Experiences

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Abstract

Historically, the construction industry has been slow to change. With the chance to increase productivity and cut costs by adopting new technologies, many construction companies are starting a digital transformation journey. However most do not know where to start, what technology to adopt, and how to successfully change. The purpose of this development paper is to propose a new digital transformation maturity assessment model (DTMAM) for the construction industry to provide direction and highlight the key areas that need addressing during digital transformation. The DTMAM is developed using an established methodological framework for developing maturity models. This process included developing an integrated framework from systematic literature reviews and focus groups. The model will be validated through a mixed method approach at two case study organisations. The study highlights the holistic nature of digital transformation, requiring people, processes, and technology to change at strategic and operational levels. It also provides value by identifying key areas for growth and development at construction companies taking on a digital transformation.

1.0 Statement of research problem

Exponential growth and access to the latest technologies has led to a rapid increase in digital transformation projects (Correani et al., 2020). Each project promises to rapidly transform processes and capabilities whilst driving efficiency across organisations and industries (Correani et al., 2020). The construction industry is no stranger to this with McKinsey (2019) suggesting that digital transformations can lead to 15% productivity gains and 6% cost reductions.

In what has been described as a digital cyclone (Kane et al., 2019) a raft of new technologies threatens to disrupt the construction industry (Papadonikolaki et al., 2022). These include Building Information Modelling (BIM), additive manufacturing, artificial intelligence (AI), robotics and automation, internet of things (IOT), immersive technologies, digital twins, and nanotechnology (Ghaffar et al., 2022). However, whilst digitally centric industries have been quick to respond to technological developments, a historical lack of innovation, investment, and research in the construction industry has created an institutionalised culture where innovation is not the norm and digital transformation is difficult (Lepinoy, et al., 2022). Construction companies need to overcome this historical lack of innovation to ensure they can adopt new technologies and enjoy the benefits they offer (Ghaffar et al., 2022).

Despite the potential opportunities arising from digital transformation, it can affect the whole business, often causing projects to fail (Volker Tresp et al., 2016). Correani et al., (2020) argued that most projects fail because of the lack of a clearly defined plan and understanding of how introducing digital technologies affect the whole business. It is therefore imperative that companies identify what they need to successfully transform and then develop a plan to manage these changes (Correani et al., 2020).

It has been suggested that digital maturity models can provide clear guidelines to support digital transformation within construction companies (Perera et al., 2022). A raft of digital maturity models have been developed across a range of industries and even on specific construction topics such as BIM or site operations (Wernicke et al., 2021). However, they are often too complex, too localised, and do not consider the holistic nature of digital transformation (Aghimien et al., 2021). Therefore, the construction industry needs to develop a standardised maturity model to provide industry specific roadmaps for digital transformation (Aghimien et al., 2021). Thus, the aim of this research project is to propose a digital transformation maturity assessment model (DTMAM) for the construction industry.

This research project will be conducted in three phases. Phase one is complete (see section 4). It focused on developing the DTMAM for the construction industry. Phase two focuses on testing the model and has begun with the initial collection of quantitative data using the DTMAM at two construction companies currently undertaking two-year digital transformation projects. Phase three focusses on deploying and maintaining the model i.e., making the model available for use across the construction industry. This phase has not yet started and will follow on from completion of phase two.

2.0 Literature Review

2.1 Digital Maturity

Digital maturity assessments have been used by businesses to identify their current status and aid the development of roadmaps to reach higher maturity levels by highlighting low scoring areas (De Bruin et al., 2005). According to Teichert (2019), digital maturity assessment models consider digital transformation as a holistic organisational approach through pre-determined domain components and subcomponents. These measurable components and

subcomponents can be defined as the layers and distinct attributes that make up the phenomenon (De Bruin et al., 2005). Measurements of these pre-defined criteria can be used to target investment, development, and growth which drive performance (Berghaus and Back, 2016). Systematic literature reviews from Teichert (2019) and Kraus et al., (2022) were used to identify the most common maturity criteria (table 1).

Table 1: Common digital maturity areas

Maturity Criteria	Characteristics
Culture and Innovation	Design thinking, iterative cycles, collaborative project teams, tolerance of risk and failure, openness to change, reward and recognition, ambidexterity, structure, and resource allocation.
Technology	IT architecture, agility and supporting systems, internal service provider, and horizon scanning
Data	Information capture, data analytics, common data environments, project filing structures, and email etiquette.
Process	Continuous improvement, cross functional teams, information flow, internal process communication, and workforce experimentation.
Strategy and Vision	Communication and defined visions, planning and prioritisation, and horizon scanning
Organisational structure	Management structure supporting digital business and cross functional collaborative teams.
Skills and talent	Knowledge and skills in digital transformation, diverse learning opportunities, and knowledge transfer.
Customer experience	Single view of the customer, customer journey and experience.
Governance	Change management, resource allocation, and awareness.
Digital Ecosystem	Supply chain performance, digital platforms, training, and integrated systems.
Leadership	Promoting the vision for digital transformation, reinforcement of behaviours, flexibility to change, future thinking, risk, and experimentation.
Compliance and security	Compliance with regulatory bodies, IT security, risk management, and access to systems.
Products and services	Digitalisation of products and services and the use of smart products.
Business Model	Competitive advantage, process differentiation, value creation, and digital process.

Adapted from Teichert (2019) and Kraus et al., (2022)

Digital maturity analysis is an ongoing process that needs continually re-evaluating according to changes in the environment (Nasiri, et al., 2021). As environments change so do businesses, and by measuring digital maturity, organisations can successfully target investment in digital initiatives (Gurumurthy et al., 2020). Digital maturity assessment can also provide organisations with additional benefits, including measuring effectiveness, outlining capabilities, and enhancing the effect of industry 4.0 technologies (Gurumurthy et al., (2020), Kane et al., (2019) Khin and Ho, (2019)).

Pre-defined levels can be used to effectively measure maturity (De Bruin et al. (2005) and characterise its performance (Teichert, 2019). Maturity is often measured across six levels or stages (Williams et al., 2019). The levels suggested by Gokalp and Martinez (2021) outline

the step-by-step process that digital transformations take. These levels provide a roadmap for development as seen in table 2.

Table 2: Digital transformation maturity levels

Level	Description
Incomplete	No initiative yet
Performed	Roadmap developed but no unit responsible for delivery yet
Managed	Pilots conducted, standards, guidelines and procedures defined.
Established	Vertical integration, standardised qualification of digital transformation processes
Predictable	Data driven decisions and horizontal integration
Innovating	End to end digital integration, innovative processes, and continual improvement

Gokalp and Martinez, (2021)

3.0 Methodology

To develop the DTMAM, this research project will follow three phases. Phase one has been completed and the findings are presented in section 4. Phase one involved building on the two systematic literature reviews on digital transformation (i.e., Teichert (2019) and Kraus et al., (2022)) through a series of focus groups with academic and industry experts in construction. Through a thematic analysis, the data from the focus groups were used to determine the domains, domain components, and domain subcomponents to support the development of a self-assessment questionnaire (Table 6). Phase two is currently in being undertaken. It involves a mixed methods study of two case construction firms. The purpose of phase two is to validate the DTMAM developed during phase one. It involves using the self-assessment questionnaire (Table 6) and then conducting semi structured interviews with construction managers within these firms to measure the effectiveness of the model. Phase three will start once phase two is completed. It will focus on deploying the model to make it available for use across the construction industry.

4.0 Phase one

4.1 Development of the DTMAM

The development of the DTMAM was underpinned by design science research. This methodology uses artefacts to achieve goals from specific domain problems (Becker, Knackstedt, and Poppelbuss, 2009). Successful digital transformation requires construction companies to develop new capabilities. Therefore, the proposed model was designed to determine the desired route for developing digital transformation maturity. This study thus drew on De Bruin et al., (2005) who suggest a standardised six step methodological framework to support the development of maturity models (Table 3).

Table 3: Development and rationale DTMAM.

Development Stage	Rationale for development
Scope	The scope of the assessment model is focussed on the construction industry. The model focusses holistically across a business looking at people, processes, technology, and strategy. The DTMAM has been developed in combination with academia and practitioners.
Design	The DTMAM is aimed at internal executives involved within digital transformation. It been designed to be a self-assessment model, driven internally to realise current maturity levels. Respondents will come from senior management and above.
Populate	The DTMAM assessment levels have been adapted for Gokalp and Martinez's (2021) digital transformation capability assessment, ranging from 1-6 (Table 5). Thirteen dimensions have been identified across four groups as outlined (Table 4). These have been selected based on Teichert's (2019) systematic review of the literature and Kraus et al. (2022) keyword search in the first iteration and following discussion with academics and practitioners to finalise the model domains, components, and subcomponents.
Test	A mixed method approach case study will be used to check the application of the model.
Deploy and maintain	The model has been developed and is ready to be deployed, tracked, and maintained.

(Adapted from De Bruin et al. (2005))

4.2 Maturity stages

To populate the stage of the model's development, levels of maturity needed identifying and defining so they could be reported back to the audience. De Bruin et al., (2005) discuss the importance of meeting an audience's needs and balancing complexity and simplicity to avoid confusion and resemble the complex nature of the specific domain. Hence, the DTMAM draws on Gokalp and Martinez (2021) to measure the extent to which an organisation transforms operations in response to new digital initiatives (Table 4).

Table 4: DTMAM Levels of maturity

Level	Description
1-Immature	There is little or no areas of the statement currently addressed within the organisation.
2-Basic	Some areas of the statement have been addressed but this has not been put into operation.
3-Managed	Some areas of the statement have been addressed and implemented.
4-Established	Most areas addressed. They are aligned and coherent.
5-Predictable	All areas addressed. They are aligned and coherent.
6-Optimising	All areas addressed. It is aligned and coherent. Plans have been established to further innovate and improve the business.

(Adapted from Gokalp and Martinez, 2021)

4.3 Defining Domain Components and Subcomponents

The digital transformation maturity model was designed to measure maturity in a staged approach against the domain, domain components and domain subcomponents. Digital transformation needs to be seen as a step-by-step transformation process across the whole construction company. Such an approach to measuring maturity will enable the construction firms to identify specific improvements needed to increase maturity at all levels across the business.

Drawing on Teichert (2019) and Kraus et al. (2022), specific subcomponents were identified and discussed in focus groups with academics and industry experts to formalise thirteen different dimensions across four groups. These were then tested to finalise the domain components and domain subcomponents (Table 5).

Table 5: DTMAM Components, Subcomponents and Characteristics

Domain Component	Domain Subcomponent	Characteristics
Technology	Systems and Technology	IT architecture, agility and supporting systems, internal service provider, and horizon scanning.
Technology	Compliance and Security	Compliance with regulatory bodies, IT security, risk management, and access to systems.
Technology	Products and Services	Digitalisation of products and services, and use of smart products.
Technology	Governance	Change management, resource allocation, and awareness.
Technology	Data Management	Information capture, data analytics, common data environments, project filing

		structures, and email etiquette.
People	Culture and Innovation	Design thinking, iterative cycles, collaborative project teams, tolerance of risk and failure, openness to change, reward and recognition, ambidexterity, structure, and resource allocation.
People	Skills and Talent	Knowledge and skills in digital transformation, diverse learning opportunities, and knowledge transfer.
People	Leadership	Promoting the vision for digital transformation, reinforcement of behaviours, flexibility to change, future thinking, risk, and experimentation.
Process	Operations and processes	Continuous improvement, cross functional teams, information flow, internal process communication, and workforce experimentation.
Process	Customer insight and experience	Single view of the customer, customer journey and experience.
Process	Digital eco-systems	Supply chain performance, digital platforms, training, and integrated systems.
Strategy	Business models	Competitive advantage, process differentiation, value creation, digital process.
Strategy	Vision and strategy	Communication and defined visions, planning and prioritisation, and horizon scanning.

Adapted from Teichert (2019) and Kraus et al. (2022)

4.4 Digital Transformation Maturity Assessment

The final part of the populate stage was identifying the correct assessment tool (Table 6) (De Bruin et al., 2005). The assessment tool designed for the DTAMAM is an online self-assessment questionnaire, enabling a consistent statistical analysis.

Statements for each subcomponent were designed in line with the identified domain components, subcomponents, and characteristics from the two systematic literature reviews. During phase two, statements for each subcomponent will be measured against the levels of maturity on a scale of 1-6 as shown in table 4.

The domain score will then be taken as the mean average of scores across all statements. Domain component scores will then be taken from the mean of the subcomponent statement

scores in that specific component. Finally, a score for each subcomponent will be taken from the mean of each statement linked to that subcomponent. The maturity level will show the extent to which transformation occurs across all areas of the construction company and the willingness to continually improve and optimise across each dimension (Gokalp and Martinez, 2021).

As a result, areas of improvement can be identified across the domain component and subcomponents and reported to the construction company. These areas can then be planned and prioritised by the company to create a digital transformation roadmap for the whole business.

Table 6: DTMAM Self-assessment statements

Section	Category	Statement
Section 1 (Technology)	Systems and Technology	The company has a clear understanding of the application landscape and continuously seeks to simplify the overall operational systems to enhance efficiencies across the group.
		The company's IT team provides an internal service with service level agreements, it has a clear focus on risk mitigation and is measured on the internal customer service.
		The company identifies, monitors, and communicates future technologies and innovations that can be used to improve products and services for customers and colleagues.
	Digital Ecosystems	The company's systems allow clear visibility of supply chain performance enabling better business decisions.
		The company encourages partners from other organisations to collaborate across our industry standard digital platforms.
		The company delivers suitable training to its supply chain and staff to help engage with changes and new systems.
	Products and Services	The company employs the latest technology to enhance the customer journey and employee experience.
		The company collects and analyses data to help enhance products and services
		The company measures the impact of investment on new digital initiatives.
	Governance	The company employs a standardised change management process and system that is continuously reviewed.
		The company's board and Senior Leadership Team continually reviews resource allocation for governance and provides adequate resource where appropriate.
		The company communicates and develops staff awareness of all required standards and regulations.
	Data management	The company's systems are fully integrated and allow information capture, data analytics, and communication across all systems to help data flow.
		The company operates a single common data environment (CDE) across the group.
		The company has a clearly defined project filing structures and naming conventions in place across the group.
		The company has a clearly defined etiquette around general communication channels and email management process including attachments and link management.
	Compliance and Security	The company is compliant with general data protection regulations (GDPR) and regularly reviews new policies and procedures and communicates to all colleagues effectively.
		The company provides regular security training for all colleagues.
		The company uses the latest technology and has a clearly defined process for handling document/data security and privacy and data loss protection.

		The company regularly communicates all system and security changes to all colleagues through suitable channels.
Section 2 (Strategy)	Business Model	The company views its systems and processes as a key differentiator which allows for a competitive advantage.
		The purpose of digital initiatives within the company are to create value for the customers and colleagues.
		The company offers customers and colleagues a simplified digital process to help enable the delivery of the business model.
	Vision and Digital Strategy	The company has a defined and communicated a clear vision for digital transformation across the group.
		The company's leaders and managers have a clear and shared understanding of how digital technology is impacting our business.
		The company has a clear development and execution plan for digital transformation which are clearly aligned to the group strategy and vision
Section 3 (Process)	Operations and Processes	Through continuous improvement the company has identified, mapped, digitised, and automated key internal processes to support new digital initiatives.
		The company uses cross functional teams to map processes and identify cross departmental roles, impacts, and information flow across the group.
		The company's internal processes are well communicated and trained into teams to develop operational excellence.
		The company uses workplace experimentation to test and refine new processes and ways of working to help mitigate risk.
	Customer Insight and Experience	The company's systems are integrated to allow a single view of the customer and supply chain activity allowing a greater understanding of interactions with the company.
		The company constantly interacts with colleagues and customers to identify improvements to the customer experience.
Section 4 (People)	Digital Culture Innovation Organisation	The company work at a fast pace delivering digital initiatives in short iterative cycles and focusses on the end user when making decisions
		Cross functional collaborative project teams are given autonomy to make decisions and take risks on new digital initiatives, as failure is not stigmatised rather seen as a way to develop knowledge.
		The company is open to regular change and promotes ambidexterity allowing individuals and teams to explore new innovations.
		The company employees are rewarded for developing new initiatives.
		The company's board provide adequate resources to support digital transformation.
		The company has the optimal structure for supporting a digital transformation (we have the right role, in the right place in the business).

	Skills and Talent	The company have a highly skilled and knowledgeable IT team that support learning and development within the organisation.
		The company have clearly articulated the skills required to enable digital transformation and have a recruitment process that allows the recruitment to support this.
		The company employs a diverse set of learning opportunities to develop digital fluency within the organisation and encourages knowledge transfer and learning between teams.
	Leadership	The company's leaders take an active role in learning, promoting, and communicating the vision for digital transformation across the organisation.
		The company's leaders reinforce key behaviours for digital transformation including collaboration, risk taking, experimentation, flexibility to change and autonomy.
		The company's leaders help to identify new opportunities for digital transformation and centrally coordinate digital goals and cascade these across the group.

5.0 Next steps and questions

This research project aims to develop a new assessment model to provide a roadmap for construction companies to digitally transform through a holistic approach.

This developmental paper has outlined how the digital maturity model was developed through the methods outlined by De Bruin et al. (2005). The maturity assessment model was been developed with supporting questions (Table 6) and quantitative data collected within two construction companies. The next stage of the research project is to complete phase two i.e., the test phase. Following this, phase three will start with opportunities to extend the use of the model across the construction industry to determine generalisability.

Whilst beyond the scope of this paper, the project will identify the relationships with existing project management maturity models to measure the effectiveness of the DTMAM at driving successful digital transformation projects within two construction companies.

Moving forward, the key areas to develop are (1) whether the domains identified are comprehensive enough for the industry and (2) whether the statements within the assessment tool reflect the maturity levels well enough to enable a suitable roadmap to be developed.

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