Essentials of Digital Construction

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Essentials of Digital Construction

Lessons learned from digital transformation

Amador Caballero

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I would like to extend my heartfelt thanks to my family, especially my wife, for their unwavering support. While I may not have been able to dedicate the time you all deserved as I worked on this book during weekends and holidays, your encouragement has been invaluable to me. I also offer my sincerest gratitude to the friends who have supported me throughout this journey, particularly those who are no longer with us to witness the fruits of their support.

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About the author

Amador Caballero is a experienced professional with a deep passion for professional development in the construction industry. Holding a architectural technologist degree, a master's degree in health and safety and diplomas in 3D architectural visualisation and data analytics, he brings a multifaceted skill set to his work.

His career began on construction sites, working for main contractors, which formed the foundation of his professional experience. He has also worked in architectural practices and currently serves as enterprise architect. Over the years, he has amassed a wealth of expertise, offering him profound insights into the sector.

Amador's journey into digital construction took a significant turn in 2014 when he started leading the implementation of building information modelling (BIM), in accordance with PAS 1192-2, within a main contractor firm. Driven by a strong commitment to disruptive innovation, and with a pragmatic approach, he has focused on streamlining processes, implementing digital tools and analysing data to identify beneficial emerging trends. His extensive involvement in a multitude of BIM projects has endowed him with a comprehensive understanding of the BIM landscape in the UK.

Previously serving as the head of digital construction, Amador led the charge in implementing digital strategies and technologies, including the roll-out of BIM within the business. In his current role as an enterprise architect, his focus is on aligning technology and processes with business objectives to enhance efficiency and client satisfaction.

He has been instrumental in helping companies achieve significant milestones, such as BIM Level 2 certification from the Building Research Establishment (BRE) in 2016 and ISO 19650 1-2 certification from the British Standards Institution (BSI) in 2020. His efforts have been acknowledged through a number of UK national awards for successful BIM implementation and nominations for training strategies.

A consistent feature of his career has been his proactive involvement in seminars and discussions centred on digital construction and data analytics. He is deeply committed to supporting, educating and sharing knowledge and experiences with both supply chain partners and clients. As a fervent advocate for digital construction, Amador promotes a culture of ongoing education and learning, which he views as crucial for achieving collective goals and advancing the industry.

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Preface

The purpose of sharing these perspectives is to offer a thought-provoking exploration of various subjects, drawing from my individual observations, research and experiences.

The thoughts and opinions shared within these pages are solely my own, shaped by my unique experiences, and should be interpreted as such. They are not intended to represent the official stance or endorsement of any organisation I am currently or have previously been affiliated with.

A primary aim in writing this publication is to provide individuals and companies interested in digital construction with a practical handbook that answers a number of common questions arising around digital transformation and to facilitate the effective delivery of digital transformation projects. Drawing on extensive experience in delivering digital construction projects, I aim to offer candid reflections and insights to help in avoiding the pitfalls and challenges that I, and others, have encountered.

The book serves as a practical guide for digital construction leaders and organisations, providing a clear understanding of the process of digital transformation and how to navigate it effectively. The content is grounded in my own triumphs and setbacks, offering valuable advice for successfully leading an organisation's digital evolution.

Rather than focusing exclusively on theories and standards, this book delves into the potential obstacles and significant opportunities within digital construction. I share my experiences and lessons learned while tackling such issues as resistance to change, inconsistent documentation or unreliable suppliers.

The contents of this book are a valuable resource for anyone, irrespective of their experience level in digital construction. The book is designed to help in avoiding common mistakes and navigating the different challenges that are likely to crop up.

You will probably find familiar scenarios and obstacles while reading these pages. My goal is to equip you with the tools to manage your digital construction projects with greater efficiency and confidence.

I am committed to providing an honest, unfiltered account of my experiences in digital construction. Real-world insights are more valuable than theoretical concepts alone. The aim is to deepen your understanding of the practical challenges and successes in this field, assisting you in your own successful journey in digital construction.

Empowering leaders in the digital transformation journey

This book seeks to provide valuable support to leaders embarking on the exciting and fulfilling path of leading a business's digital transformation. The journey involves acquiring knowledge about various departments within a company to standardise and improve processes, integrate new technology and enhance operations for ultimate success. Although the role can be challenging, requiring significant mental resilience to overcome resistance and opposition, it also offers a unique opportunity for growth and accomplishment.

As a leader responsible for implementing digital construction within a company, you must ensure that the organisation is digitally equipped to meet market demands. At the same time, you should drive cultural and procedural changes for sustainable and thriving transformation in the long term. It is true that your efforts might not always be acknowledged or appreciated; however, by educating businesses about the benefits of digital construction and advocating for recognition and support, you can create an environment conducive to successful implementation.

In this role, challenges and insecurities are common, and high levels of initiative, independence and adaptability are required to navigate the ever-evolving industry landscape. Overcoming both internal and external resistance can be difficult but, by sharing experiences and insights, leaders can be more prepared to handle these obstacles more effectively. Witnessing individuals embrace digital construction, challenge their preconceived notions about it and advocate for its integration is rewarding and paves the way for success in today's business environment.

By the end of this book, you will feel more confident and better equipped for managing digital construction. The book will help you to gain a deeper understanding of the necessary cultural shifts and learn how to manage requirements at various stages of a project's lifecycle. Ultimately, this publication aims to serve as a practical companion, empowering you to face challenges head-on and succeed in your particular digital transformation journey.

Progress yet to be made in building information modelling implementation

Focusing on the implementation of building information modelling (BIM) in the construction industry, this book explores BIM's significance as a cornerstone of digital construction. The BIM Mandate, published in 2011 as part of the UK Government Construction Strategy, required 'fully collaborative 3D BIM (with all project and asset information, documentation and data being electronic) as a minimum

by 2016.' However, my experience suggests that the industry is still not meeting this target, owing to a lack of adequate knowledge and skills. While some early adopters, such as design consultants and large main contractors, have embraced BIM, a significant portion of the industry still needs to adopt this process for it to become standard practice.

At the time of writing, the most recent National Building Specification (NBS) *Digital Construction Report* is from 2021. Although 2 years have passed since its publication, the findings can nonetheless help us understand the current state of BIM adoption. The report, (Bain and Hamil, 2021), which surveyed 906 construction professionals, primarily from the UK but with international representation.

The survey results are concerning, revealing a limited understanding of the BIM process. For instance, 29% of respondents thought that BIM is solely about using 3D parametric models. Only 60% used a common data environment for collaboration, and merely 37% had utilised a task information delivery plan in the previous year. These percentages contradict the 71% of respondents who claimed to have adopted BIM.

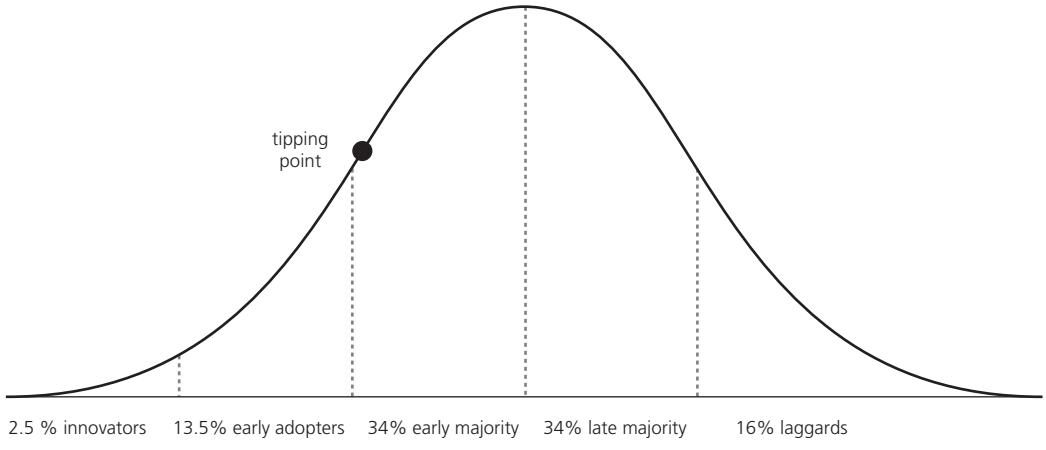
Clearly, a significant portion of the industry is yet to grasp the basics of digital construction. The level of implementation varies widely; some companies are ahead of the curve, while others are lagging behind.

Rapid advances in technology are underway in the construction industry, posing a challenge for businesses to keep pace. Companies that fail to adapt to these changes risk falling behind. Therefore, rather than awaiting guidance from competitors, it is vital that companies proactively embrace these shifts. Although early adoption may present challenges, it holds the potential to provide a significant competitive edge in the long run.

The law of diffusion of innovations, conceptualised by Professor Everett Rogers (1962) and further expanded by Geoffrey Moore (1991) in his work *Crossing the Chasm*, serves as a framework for understanding the adoption of new ideas and technologies over time. This theory categorises adopters into five groups: innovators, early adopters, early majority, late majority and laggards, as illustrated in Figure 0.1. Applying this framework to BIM, we can assess its level of acceptance within the industry.

In his influential TED talk *How Great Leaders Inspire Action*, Simon Sinek (2009) discusses the law of diffusion of innovations and refers to the 15–18% penetration level as a crucial tipping point for mass market success and acceptance of an idea. This percentage serves as a useful benchmark in understanding when an innovation like BIM might start achieving broader acceptance.

Figure 0.1 Law of diffusion of innovations (adapted from Rogers, 1962)



Although the NBS *Digital Construction Report* suggests that BIM may have reached beyond the initial market penetration phase, this is just the starting point. The real challenge lies in ensuring that BIM is adopted correctly and extensively, not only by major firms but also by clients and smaller companies. A high rate of BIM adoption does not necessarily translate into its effective use. It's essential for the construction industry to not only embrace BIM in terms of quantity but also to focus on the quality and resilience of its implementation. This involves continuous efforts to integrate BIM practices effectively, ensuring that they are not just widely used, but also used in a way that maximises their potential benefits in the sector.

In conclusion, the construction industry must invest in education and training to enhance the understanding and adoption of BIM and other digital technologies. By focusing on correct implementation and fostering a culture of early adoption, the industry can succeed in its digital transformation, benefiting all stakeholders. Large contractors and smaller subcontractors alike need to work collectively towards this aim, propelling the industry towards a more efficient and sustainable future.

Who this book is for

This book is designed to benefit a broad spectrum of stakeholders involved in shaping their companies' futures. While it is particularly useful for those in specialist digital roles, it is equally relevant for senior managers and directors looking to transform their businesses. Additionally, those involved in the actual delivery of projects

– including design consultants, subcontractors and clients – will find value in its insights.

The broad range of subjects that are covered should present a comprehensive resource for anyone in the built environment sector seeking to understand and apply digital construction. The content has also been designed to be accessible for those with varying levels of familiarity with digital transformation concepts.

A key strength of this resource is the grounding in real project experiences. This practical focus will enable readers to learn from actual case studies, helping them to navigate the range of issues and challenges that they may encounter.

The emphasis throughout is on actionable insights for improving work efficiency and effectiveness, thereby ensuring the content's relevance and applicability for the reader.

Practitioners

Practitioners, such as architects, engineers, surveyors or specialist contractors, typically use BIM tools for tasks such as design, analysis, coordination and actual construction.

For practitioners, BIM isn't just theoretical; it's an essential part of their daily work. The book provides insights into real-world case studies and addresses common challenges, serving as both an introduction for newcomers and a reference guide for experienced professionals. This aims to enhance individual productivity and project success. Chapters 3, 7, 8 and 9, along with Sections 4.3, 6.2, 6.6 and 6.7, are specifically designed to address the needs of practitioners.

Senior managers and directors

Senior managers and directors are influential decision makers, responsible for steering their organisations' digital transformation. While they may not directly engage with digital construction tools and processes, they oversee strategic planning, make pivotal business decisions and safeguard the company's interests.

This book offers a top-down view of how digital transformation can improve the construction process, enhance productivity and streamline operations. It emphasises the importance and benefits of initiating a cultural shift within an organisation, equipping senior managers with foundational knowledge for informed discussions and decision making. Senior managers and directors will find Chapters 1, 2 and 5, as well as Sections 4.2, 7.3 and 7.12, particularly beneficial.

Digital construction leaders

Digital construction leaders drive digital construction strategy and transformation within an organisation. They bridge the gap between new processes and solutions, integrate technology across departments, provide training and support and ensure adherence to industry standards and best practices. They are especially focused on leveraging and understanding innovations in the construction sector.

For digital construction leaders, this book serves as a comprehensive guide to digital construction, the catalyst for digital transformation in the construction industry. The book offers recommendations, practical tips and highlights emerging trends. This equips digital construction leaders to align digital construction strategies with broader organisational objectives and prepare for future technological advances. While a digital construction leader may find something valuable within all the chapters, I believe that Chapters 1, 2, 3, 6 and 8 will provide them with some useful resources to support implementation within their businesses.

Clients

In the context of this book, 'client' refers to the parties who either commission and finance the construction project or manage the information function on behalf of the appointing party.

For clients, gaining a deep understanding of the capabilities and benefits of BIM is essential for eliminating misunderstandings and garnering support for its implementation in their projects. The book provides actionable guidance on the steps to take, starting from the tender stage, to establish correct documentation and select appropriate teams. With this knowledge, clients can make well-informed decisions at different stages that align with their project goals and maximise the value of their investments. Chapters 1 and 5, as well as Sections 3.3, 6.3, 6.4, 7.10, 7.11, 7.12 and 7.13, are designed to serve as a helpful resource for clients.

Glossary

This glossary contains terms that are specifically pertinent to the content presented in this book. While this independently compiled selection offers focused insights, another, more extensive, collection of industry terminology can be found in the BRE Group's compilation of BIM terminology, available on their website (BRE Group, 2023).

Acceptance Acceptance refers to a stakeholder's formal agreement that provided information aligns with the stipulated project requirements, a responsibility carried out by the appointing party.

Accountability The obligation of individuals and teams to take responsibility for their actions, decisions and performance and to answer for the outcomes.

Authorise The process of providing permissions for information utilisation is a responsibility carried out by the lead appointed party.

Appointed party The party responsible for supplying the specified information for the project, as outlined in the appointment agreement.

Appointing party The appointing party, also known as the client or asset owner, is the recipient of information from the lead appointed party.

Appointment The appointment pertains to the professional service agreement between parties. These are the appointing party, consultancy services and subcontractors.

Approval The validation of information to ensure adherence to specified requirements before moving to the next stage. Approval relates to ensuring managed and shared information meets defined standards.

Artificial intelligence (AI) Artificial intelligence (AI) utilises hardware and software to execute functions that would normally demand human cognitive skills (McKinsey & Company, 2023). The objective of AI is to streamline processes, enhance safety and improve efficiency at various stages of a building's lifecycle.

Asset information The data collected and managed about an asset throughout its lifecycle, encompassing technical specifications, current condition and maintenance history. Such consolidated information is crucial for making informed decisions about the asset's construction, operation and maintenance.

Authorisation The process of providing permissions for information utilisation is a responsibility carried out by the lead appointed party.

BCF The BIM Collaboration Format (BCF) enables seamless communication between BIM tools by utilising previously exchanged Industry Foundation Classes (IFC) models. By adhering to open standards, the BCF ensures that model issues can be shared easily, thereby eliminating the need for proprietary systems.

BSRIA stages The Building Services Research and Information Association (BSRIA) is a non-profit organisation that operates through

membership. Its aim is to share knowledge and offer expert services to those involved in construction and building services. Initially released in 1994, BSRIA Guide BG 6, *A Design Framework for Building Services*, was created to provide a clear understanding of roles and responsibilities during the design stages of construction projects. Over time, the guide has been updated to keep pace with evolving practices in the UK construction sector and subsequent changes in design duty assignments.

CAFM Computer-aided facility management (CAFM) software helps facility managers manage various aspects of facility management, such as maintenance, space planning, asset tracking, operational services and related financial information.

CDP package The contractor's design portion (CDP) package comprises a set of documents that outline the contractor's design responsibilities in a project. It specifies the design deliverables expected from the contractor.

COBie The Construction Operations Building Information Exchange is a dataset designed for collecting and transferring asset information during the different stages of the asset's lifecycle. It consists of a series of tables that outline the information required for each asset within the building.

Cost of error The financial impact of mistakes made during the construction process. Poor information management, ineffective communication and inappropriate team selection are directly related to these costs.

Cyber Essentials A UK Government-backed certification scheme that helps organisations defend themselves against common cyber threats (National Cyber Security Centre, 2023). It outlines basic technical controls for cyber hygiene. The scheme comes in two levels: Cyber Essentials, based on self-assessment, and Cyber Essentials Plus, which includes hands-on technical verification. Both aim to bolster defences and reduce vulnerability to attacks.

Delivery team The delivery team includes the lead appointed party and their respective task teams or appointed parties.

IFC Industry Foundation Classes (IFC) is a standardised digital representation of the built environment, including buildings and infrastructure. Recognised as an international standard under ISO 16739-1:2018, IFC is vendor-neutral and can be used across various devices and software for different purposes. Developed by buildingSMART International (2023) to support openBIM, the IFC schema provides a systematic data model for describing the use, construction and operation

of a facility. This encompasses everything from building components to work schedules and cost analysis.

Information container A uniquely identified set of information, such as a model, drawing, document, table or schedule, that can be retrieved from within a file, system or application storage hierarchy.

Information model A mix of structured and unstructured data, which can include geometric details, alphanumeric content and documentation.

ISO 19650 An international standard for managing information across the whole lifecycle of a built asset through the use of building information modelling (BIM). Currently consists of five parts:

- Part 1: Concepts and principles (BSI, 2019)
- Part 2: Delivery phase of the assets (BSI, 2021)
- Part 3: Operational phase of the assets (BSI, 2020a)
- Part 4: Information exchange (BSI, 2022)
- Part 5: Security-minded approach to information management (BSI, 2020b).

ISO 27001:2022 An international standard for information security (ISO, 2022), BSI (2023) for the UK, that provides a set of standardised requirements for an information security management system (ISMS) (NPSA, 2023).

Lead appointed party The lead appointed party is directly appointed by the appointing party and is responsible for coordinating information between various task teams as the leader of the delivery team.

Machine learning Machine learning (ML) is a form of AI that enables systems to learn from data. These systems can identify patterns, make predictions and recommendations and automatically enhance operational efficiency. Over time, they adapt in response to new data and experiences, thereby improving their effectiveness. This adaptability aids in making predictive or automated decisions that contribute to better project management.

Multifactor productivity Multifactor productivity (MFP) assesses how well labour and capital are used in production. This includes such factors as management and scale. If gross domestic product (GDP) grows but inputs stay the same, the growth is due to MFP. This is tracked as an index and in yearly growth rates.

Project team The project team includes everyone involved in the project, regardless of their appointment; this also includes the appointing party.

RIBA stages The Royal Institute of British Architects (RIBA) Plan of Work (2020) organises the planning, designing, building and management of construction projects into eight stages. Each stage specifies the outcomes, essential activities and required information exchanges:

Stage 0: Strategic Definition
Stage 1: Preparation and Briefing
Stage 2: Concept Design
Stage 3: Spatial Coordination
Stage 4: Technical Design
Stage 5: Manufacturing and Construction
Stage 6: Handover
Stage 7: Use.

Stages 0 to 4 are generally completed in order. Stages 4 and 5 overlap in the project schedule for many projects. Stage 5 starts when the contractor takes control of the site and ends on practical completion. Stage 6 begins with the building being handed over to the client immediately after practical completion and concludes at the end of the defects liability period. Stage 7 starts concurrently with Stage 6 and continues throughout the building's lifespan.

Scope of work A document that defines the tasks to be performed by the appointed party. It outlines the comprehensive series of tasks, responsibilities and deliverables required.

SFG20 The benchmark for specifications in building maintenance. The SFG20 application helps in creating and customising maintenance plans to align with a property's business needs. This ensures that businesses can easily stay compliant with evolving regulations.

Supply chain For the purpose of this book, the term 'supply chain' includes both design consultants and subcontractors.

Task team Those responsible for carrying out a particular task. In this book, the term 'task team' is used interchangeably with 'appointed party'. The service may be provided by either a design consultancy or a subcontractor (supply chain).

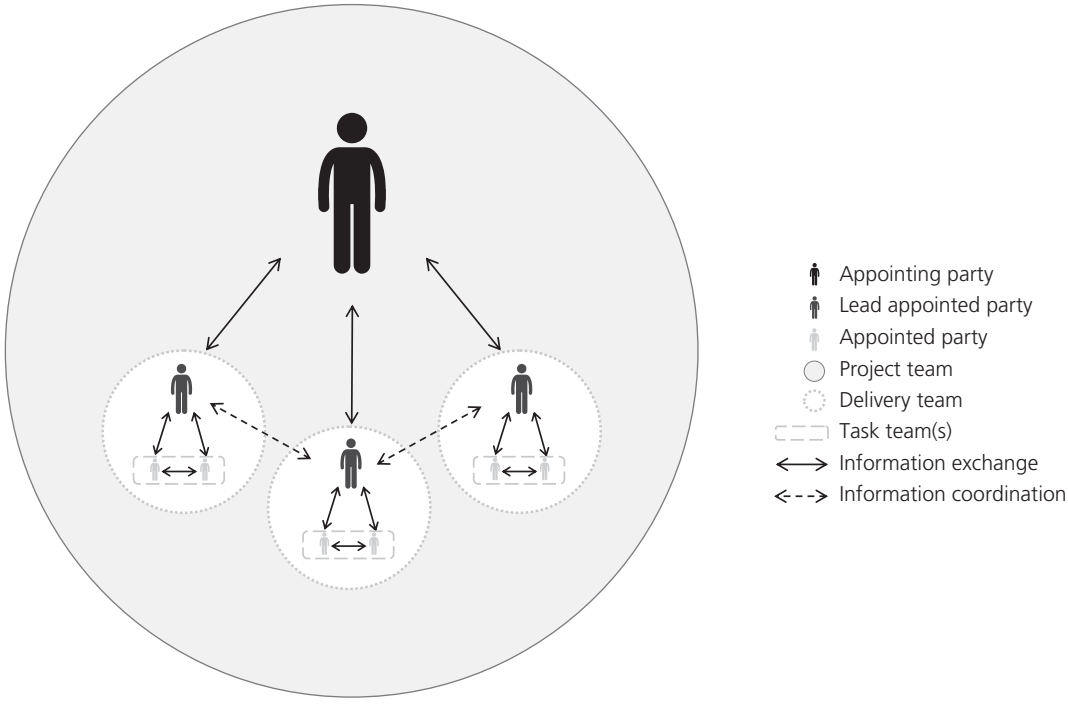
Uniclass 2015 In the UK, the construction industry has traditionally used the Common Arrangement of Work Sections (CAWS) as a classification system. However, with CAWS no longer being updated, Uniclass is increasingly being adopted for projects. The Uniclass classification is a comprehensive and unified system, consisting of various tables designed to meet different industry needs. This versatility enables facility managers and owners to classify their assets with Uniclass and helps designers and constructors organise specifications and manage projects more efficiently.

Validation Checking for compliance with permissible values, ensuring completeness and correct format; the aim is to ensure that the information and service meet the needs and expectations of users. For example, the digital team is responsible for validating the asset data.

Verification The process of confirming, through objective evidence, that specific requirements have been met and that information is accurate. This involves ensuring that information and service match the designated specifications. For example, the technical team is responsible for verifying the asset data.

Figure 0.2 is based on ISO 19650-2 (BSI, 2021) and serves as a visual aid to facilitate understanding. It shows how various parties interact, using terminology that corresponds to the ISO 19650 series.

Figure 0.2 Relationships within project team (based on BSI, 2021; Icons: Leremy/Shutterstock)



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Chapter 1
Introduction

1.1. Introduction

In this chapter, I take a journey through the world of digital transformation in the construction industry. As you read, you will understand the importance of digital construction, discover the driving forces behind its adoption and learn about strategic approaches to achieve the full potential of this significant shift.

Citing the latest official data from the Insolvency Service, *Construction News* reported that a record-breaking 471 construction firms went into administration in May 2023 (Vogel, 2023). An analysis of the monthly insolvency statistics in England and Wales reveals that 2022 was a difficult year for the construction industry (Webster, 2023). A total of 4163 companies faced administration, marking a significant jump from 2580 in 2021. This distressing trend is fuelled by a combination of rising inflation, supply chain problems and the persistent effects of the COVID-19 pandemic. As we moved into 2023, the situation showed no signs of improvement; by May, 1825 construction firms had already entered administration. The sector is grappling with an array of challenges, from escalating costs and labour shortages to uncertainties surrounding Brexit and increased funding costs caused by rising interest rates.

These obstacles are likely to continue to exert pressure on the industry in the future. To stay resilient and retain market relevance in this challenging environment, construction companies must embrace change and adopt digital technology in their operations to increase efficiencies and productivity.

Like all other industries, the construction sector must adapt its processes to the technological advances in our ever-changing world. This chapter highlights the critical role of digital construction in today's competitive market. Building information modelling (BIM) is the main enabler, leading to enhanced efficiency, streamlined processes and improved project delivery. This change requires not just the adoption of new technologies, but also a cultural shift, driven by senior leaders. Effective collaboration across all departments is essential for standardising processes and managing information and data accurately. It is often remarked that 'Insanity is doing the same thing over and over and expecting different results.'

Given the challenges facing the construction industry, coupled with exceedingly narrow profit margins, even minor mistakes can result in significant financial losses. As a result, businesses need to adopt digital construction methods to mitigate these issues. Digitalisation offers various benefits, including attracting skilled labour, improving productivity and efficiency, optimising supply chain management and advancing sustainability. Innovative technologies, such as 3D modelling, information management, data analytics and artificial intelligence, enable businesses to build resilience and adapt to ever-changing challenges.

This chapter explores the significance of assessing your business's current situation and objectives. This involves understanding your team's challenges and fostering a mindset towards digital transformation.

Having the right management support is fundamental in implementing a digital construction strategy and in effectively adopting technology and processes to overcome challenges that emerge throughout the implementation. Also, I highlight the importance of a cultural transition towards becoming a learning-focused organisation and holding teams accountable for successfully implementing the strategy.

1.2. What is digital transformation in the construction industry?

Rapid advances in technology are reshaping both our lives and the business landscape across all sectors. For companies to stay viable and preserve competitiveness, adopting digital transformation and finding new operational methods is not an option. Hence, it is necessary to embrace the opportunities that digital transformation and new operational methods can bring.

The significance of digital transformation cannot be overstated. Adopting it is essential for any organisation to remain competitive. Failing to embrace digital solutions and processes puts a business at risk of lagging behind competitors and losing market share. An example of this is how new entrants, like Uber, Airbnb and Netflix in other sectors, have radically changed traditional business models and client expectations.

In this section, I will explore why understanding the concept of digital transformation is essential in today's world. Many organisations, some perhaps unknowingly, are already on this transformative journey, but lack a robust strategy and roadmap to help them to navigate the necessary changes required.

Understanding the concept of digital transformation

Much like other buzzwords that frequently circulate, the term 'digital transformation' has evolved, leading to varied interpretations depending on the audience. One definition that resonates with me comes from Salesforce (2023):

> Digital transformation is the process of using digital technologies to create new – or modify existing – business processes, culture, and customer experiences to meet changing business and market requirements. This reimagining of business in the digital age is digital transformation.

What I appreciate about this explanation is its clarity: digital transformation is not just about adopting new technology. It's about a business continuously improving and altering its processes and internal culture to provide a better client experience. It's an ongoing evolution, not a one-time event.

It is important to appreciate that digital transformation requires collective buy-in from all departments and the leadership team within an organisation. It's not something that one person or department can achieve single-handedly; it must have full support from the board of directors. To truly make a lasting change, an organisation needs to shift its culture and mindset, fostering collaboration and openness to change across all departments. This is also called cross-functional alignment.

The main goal of digital transformation is to boost productivity by making processes more efficient and delivering greater value to clients through new technologies and methods. A second key

element is to make processes more effective – that is, add greater value to projects. This can help a business maintain its edge in a competitive market and create new opportunities for growth.

Sadly, many companies underestimate the scope of digital transformation, viewing it as merely a tech upgrade. This is a narrow viewpoint. Digital transformation has the power to impact every facet of an organisation – from its technology and processes to its strategy, culture and overall mindset.

When discussing digital transformation, a pressing question emerges: should innovation be customer-led or technology-led? Digital transformation is multifaceted, and so too is innovation in the realm of digital construction.

Most agree that customer-driven innovation is generally effective. Companies design products based on customer needs, catering to both the client overseeing the construction and the end users. A prime example is modular construction, a method tailored to the client's demands for efficiency, cost and sustainability.

However, there's also merit in technology-led innovation. As Steve Jobs famously said, 'People don't know what they want until you show it to them' (Reinhardt, 1998). Such techniques as point cloud surveys and AI emerged without direct customer input but have since become invaluable industry tools.

The optimum strategy might be a hybrid of both. By focusing on customer needs while staying open to groundbreaking technology, companies can offer both immediate and potentially transformative solutions.

Digital construction and the three pillars for implementation

In my view, digital construction refers to the incorporation of digital transformation strategies within the construction industry. This approach utilises processes and digital tools to enhance the lifecycle of each asset, from conception and design to delivery and maintenance.

A driving force behind digital construction is the building information modelling (BIM) process. This process significantly simplifies the transition towards a more efficient and digitally focused construction environment.

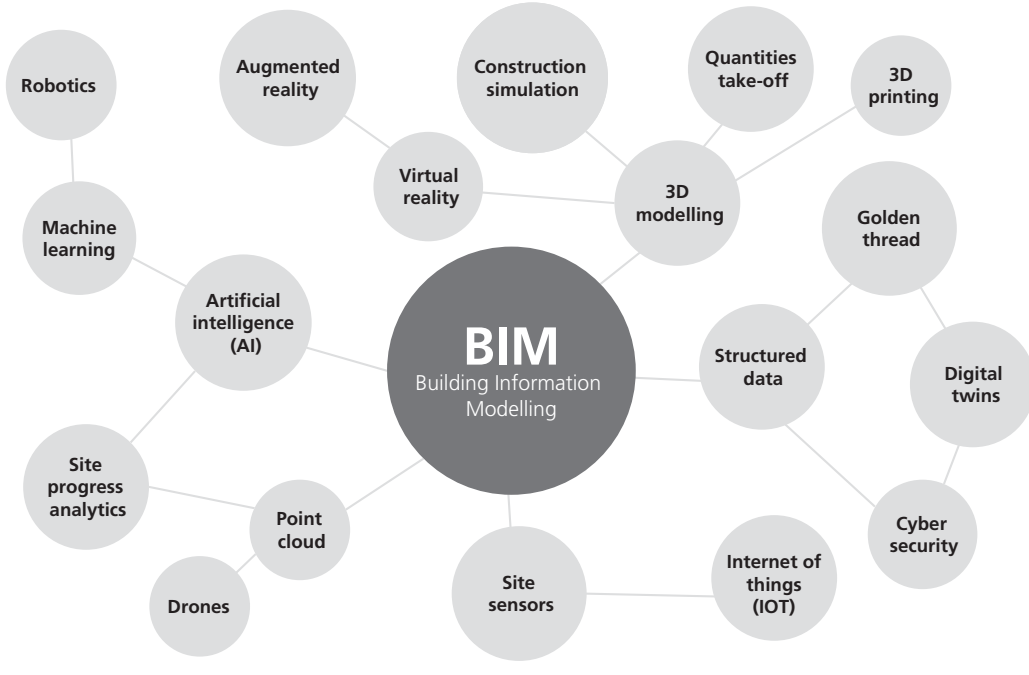
Figure 1.1 shows how BIM facilitates digital construction, serving as the central component and enabler. It's important to note that the figure represents the elements associated with BIM, and that the connections between the circles are symbolic.

Successfully implementing digital construction and driving organisational transformation requires an optimal balance of process, culture and technology, as shown in Figure 1.2. This is essential for supporting the business changes required for a successful digital transformation.

Process transformation

The adoption of BIM fundamentally alters the manner in which information is produced, shared and managed across all phases of the project lifecycle. Teams from various departments must adapt to these new methodologies, which exert a far-reaching impact on everyone engaged in the project. Moreover, the incorporation of digital construction technology opens up a wide array of opportunities. For example, techniques in digital construction can substantially enhance client

Figure 1.1 BIM as enabler of digital construction



engagement through such features as virtual walk-throughs, real-time updates and other interactive experiences. Additionally, the utilisation of artificial intelligence (AI) and data analytics paves the way for more strategic decision making, streamlining not just project management tasks – such as scheduling, resource allocation and verification of the work – but also boosting the overall efficiency and productivity of a project.

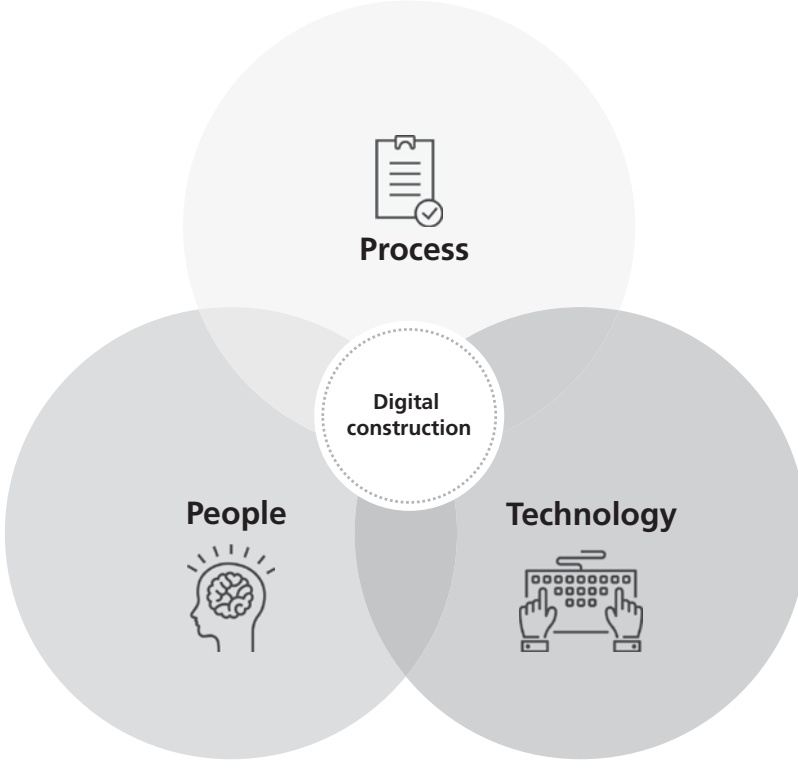
Cultural transformation

In my experience, the most important and challenging aspect of digital transformation is effecting a cultural shift within the organisation. Changing tools and processes is one thing, but transforming an organisational culture and mindset is far more complex. Success relies on organisational backing and the accountability of teams for adopting new processes and utilising new tools. It is crucial that this integration takes place within the daily responsibilities of teams, with a cycle of continuous improvement fuelled by ongoing feedback. To achieve such seamless integration, a willingness to evolve is essential. This must be accompanied with appropriate training of existing staff. Moreover, replacing sceptics and recruiting new, digitally savvy talent may be necessary to achieve more of the benefits that digital transformation has to offer.

Technology adoption

In the construction sector, the introduction of new technologies can often replace existing systems, providing teams with new functionalities and simplifying tasks by phasing out obsolete tools. Advanced technologies, such as 3D design models, data analytics, AI-powered tools, machine learning and robotics, are now available to facilitate informed decision making, streamline processes and enhance efficiency and productivity. These technologies not only reduce operational

Figure 1.2 People, process and technology (based on the PPT framework; Icons: M.Style/Shutterstock)



costs but also contribute to higher project quality and effectiveness. Through the implementation of digital construction techniques, businesses position themselves to outpace the competition and drive innovation.

At a time when automation is more popular than ever, the People, Process, Technology (PPT) Framework – originally introduced by Harold Leavitt in the early 1960s and later popularised by Bruce Schneier in 1999 – remains a relevant guide for organisational success (Simon, 2019). Schneier (2013) highlighted how the slow pace of human decision making could be a bottleneck, compared with swift computer operations. He advocated for automation as a solution to enhance security and efficiency. With the advent of advanced automation technologies, the PPT framework is undergoing a transformative shift. Now people need to acquire new skill sets to stay relevant, processes are becoming more streamlined than ever and technology is evolving to offer interconnected, data-driven solutions. All these elements work in tandem, making the PPT framework even more adaptable and indispensable in the current emerging innovations in the industry.

1.3. Why we need digital construction

Historically, the construction industry has been slow to adopt new technologies and processes, relying heavily on manual methods in both design and construction. However, the adage 'modernise or die' is particularly pertinent today. In recent years, awareness has grown regarding the necessity for modernisation to remain competitive and to fulfil client and regulatory requirements.

The UK BIM Mandate (Cabinet Office, 2011), although falling short of initial expectations, acted as a significant catalyst for transformation, promoting collaboration and information sharing among stakeholders. It provided awareness of the issues that the industry is facing and the need for change. Despite these advances, the industry has yet to fully embrace technology and lean processes that drive innovation and improve performance. A considerable gap remains between the potential capabilities of new processes and technologies and the current practices of many construction organisations. To bridge this gap, the industry must proactively seize these new opportunities to boost efficiency, cut costs and elevate project quality.

Although the uptake of BIM and digital construction has been slower than is required, I remain optimistic. With a committed approach to change, the future of the construction industry seems promising, provided there is effective adoption of digital construction. This transformation could result in a healthier, more sustainable sector, reduce the number of struggling companies, preserve jobs and economic stability, and attract younger people to a career in the industry.

Digital construction has the potential to substantially enhance various critical areas currently facing challenges in the construction industry. I would like to direct attention to the following.

Skilled resources

The construction industry is currently facing a shortage of skilled workers, owing to the retirement of older generations and a lack of uptake among younger generations. To address this issue, we must modernise and change the perception of the industry by embracing digital construction methods, such as 3D models, drones, robotics, augmented reality, artificial intelligence and data analytics. Additionally, by supporting remote work, we can also make the industry more agile and appealing to attract potential new talent.

Technology is already playing a role in reducing overheads by automating tasks in the construction industry, allowing companies to deliver more work with the same number of people. However, some individuals may view technology as a threat to the profession rather than an opportunity for improvement and increased productivity. It is important, therefore, to shift the culture and mentality of the industry to embrace and support technology in order to evolve and succeed.

In the short term, the current labour shortage in the construction industry will have negative impacts. However, by attracting high-quality talent and equipping the workforce with the right skills and technology, the industry will be much better off over the longer term.

Productivity

Productivity issues are prevalent in the construction sector, frequently stemming from complex processes and inadequate focus on workforce education, development and innovation. Such shortcomings can lead to oversized teams, reducing a company's competitive edge. By automating and simplifying tasks, firms can address these productivity challenges.

In my opinion, another hindrance to productivity is the industry's persistent issue with accountability and repeated errors. A more open approach to identifying and correcting mistakes is needed, yet there is often a reluctance to confront these problems, leading to recurring issues that could have been avoided, increased disputes, compromised performance and additional rework.

Although some factors affecting productivity in construction are beyond control – such as weather conditions, client changes or unexpected site discoveries like asbestos – many can be mitigated

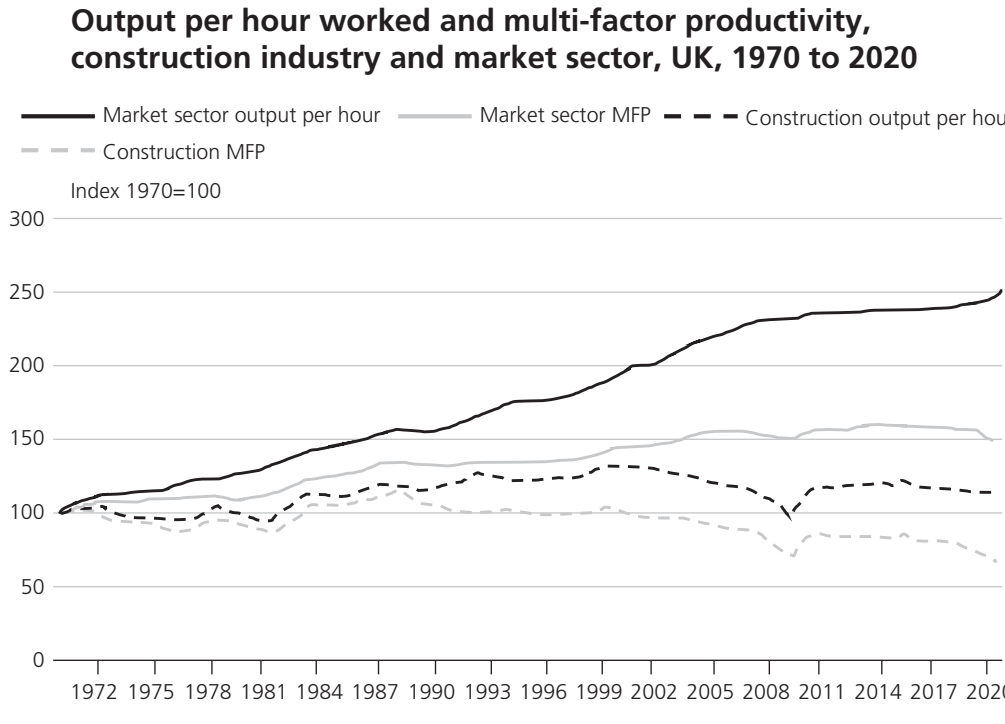
through proper processes and the correct use of tools. Labour is often squandered on tasks that could be automated, or by resolving disputes, waiting for materials, addressing on-site issues or redoing work resulting from poor coordination and ineffective communication between different parties involved in the project.

Implementing digital construction methods can significantly improve productivity and reduce the cost of errors in projects. This is achieved primarily through improved information management. Adopting new technologies and data analytics will help address the challenges facing the construction industry, enabling better decision making, risk management and quality control.

Looking at the historical context, before the 2008 financial crisis, the construction industry was a weak spot for UK productivity, pulling down the overall productivity numbers. Since 2008, things have improved slightly in construction, with the construction industry growing faster than the rest of the economy. However, the industry has still not reached the UK average for productivity. As shown in Figure 1.3, data from the Office for National Statistics indicate that productivity in the construction industry has seen minimal improvements over the past half-century.

The construction industry is inherently unstable, influenced by global economic shifts and such events as Brexit, the COVID-19 pandemic, the Ukrainian war and inflation. These events

Figure 1.3 Output per hour worked and multi-factor productivity (MFP), UK, 1970 to 2020 (Martin, 2021; Source: Office for National Statistics – Labour productivity and multi-factor productivity)



considerably weaken the construction supply chain, leading to project delays, elongated lead times and rising costs. Such factors can result in suppliers falling short of meeting demands, placing financial strain on construction firms. The industry operates on tight profit margins and schedules, making it difficult to absorb these disruptions, potentially leading to failure.

Given the industry's high susceptibility to external adverse events, businesses should adopt digital construction methods. These include material forecasting, real-time material tracking, planning for material shortages and off-site construction. Such measures will help organisations to be better prepared and more resilient to external pressures. Collaboration with innovative companies that employ technology to tackle these issues is necessary. By doing this, businesses can achieve improved outcomes and reduce risks.

Quality of information

Traditional construction projects have often overlooked quality information management, focusing primarily on the execution of on-site works. This neglect has resulted in rework, difficulties in retrieving information, supporting asset operation and securing accurate insurance coverage.

Digital construction, however, addresses these issues by offering better control of project information and allowing verification of the completed work against the accepted design. These capabilities ensure higher quality and build trust in the information provided to end users, as well as aiding in asset management.

This not only improves collaboration and assists construction companies in obtaining accurate insurance coverage by providing verifiable data on the quality of executed work, but it also contributes to the creation of a valuable knowledge base. This enables better decision-making for future projects. Overall, digital construction aims to bridge information gaps, helping in both project execution and compliance, thus alleviating long-standing challenges in the industry.

Sustainability

As governments intensify efforts to reduce greenhouse gas emissions, including emissions of carbon dioxide, the construction industry faces growing pressure to diminish its environmental impact and embrace sustainable practices. A key strategy is the use of technology to minimise energy consumption during construction, thereby reducing the embodied energy and overall greenhouse gas emissions of projects. The adoption of digital construction methods supports both sustainability and broader decarbonisation initiatives, contributing to a significant reduction in emissions beyond just CO_2.

Incorporating sustainable design principles and using materials with a smaller carbon footprint, such as recycled steel, is necessary. A McKinsey article (2021) underscores the substantial emissions, including those of various greenhouse gases, from processing raw materials and operational activities in construction. Efficient resource utilisation, recycling and the implementation of energy-efficient systems are key to mitigate these emissions. These strategies, coupled with digital construction techniques, play a crucial role in steering the construction industry towards a sustainable and low-carbon future, in accordance with governmental objectives to curtail greenhouse gas emissions.

Minimising waste during the construction process is essential for sustainability and cost management. Embracing modern methods of construction (MMC), which include innovative building