Future-Proofing Organizations in the Digital Construction Era

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Abstract
An advancement of its precursor like its precedents, the fourth industrial revolution has been described as a blend of physical and digital worlds, with various technologies being leveraged to create value and transform business sectors. In the construction industry, key innovation technologies include BIM, Artificial Intelligence, Robotics, 3D printing, IoT, Digital Twins, among others. However, despite numerous technological advancements, several studies reveal that 70-80 percent of digital initiatives fail to meet their objectives. This study sets out to identify digital technologies within the construction industry, establish reasons why several past digital initiatives have failed, as well as identify means through which organizations can ensure that they succeed in the digital era. The study identifies the volume, variety as well as the sheer speed at which data is generated through digitization as the main challenge in this era. This calls for an agile approach to digital implementation where businesses leverage data and technology to drive decision-making for value optimization to clients. Additionally, the evolution of workforce skillsets is eminent for the effective synthesis of data to enable extended intelligence. Leaders must also engage their teams actively in the implementation process to ensure individual ownership as well as commitment to organizational objectives.

Keywords: BIM, Digital Data, IoT, Virtual Reality, 3D Printing, Data Analysis, Business Intelligence, Extended Intelligence, Digital Strategy, Digital Transformation

1 Introduction

The first industrial revolution was marked by mechanization which was driven by water and steam power production. This was later following by mass power production, enabled by electric power production, ushering in the second industrial revolution. The third industrial revolution went further to enable automation through a fusion of electronics and information technology. Like previous industrial revolutions, the fourth industrial revolution has been an advancement of its precursor, thriving on a blend of technologies to give rise to the digital era. However, the speed of current innovations has no historical precedent (Rose, 2016) and carries along with it a need for rapid decision-making within organizations.

The conversation on digital transformation is on the rise in literally every industry and has slowly trickled into the construction industry which had, for a long remained mostly reliant on analog methods of documentation and delivery. The digital revolution presents a gold mine of data captured through various technologies which can be leveraged for actionable insights. However, this poses an unanticipated challenge. That of a deluge of data, in uncoordinated formats, and voluminous quantities which if not strategically managed can remain useless, if not expose an organization to numerous risks (Rose, 2016).

Accenture, a multinational cooperation that offers digital transformation and technology solutions, committed to the Digital Transformation Initiative alongside the World Economic Forum in 2015 to provide insights on the impact of digital technologies on businesses. Their digital transformation study in 2019 revealed that 78 percent of the 1350 senior industrial executives interviewed reported failed return on investment goals. Forbes Technical Council (2018) further states that 70 percent of initiatives to apply digital capabilities to transform businesses fail to meet their intended goals. This implies the need for a retrospective strategy in digital transformation, applying lessons learned by early entrants into the journey to enable leapfrogging.

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2 Research Methodology and Findings

This study adopts a secondary research methodology, aimed at reviewing existing data on digital transformation within the construction industry. This methodology was selected in consideration of the limited time available for research and enabled the researchers to access a wide range of data as well as contributions from subject matter experts internationally. Initially, the study reviews data on the various digital capabilities currently being exploited in the industry with a focus on the role of reliable data for the success of these technologies. The study then reviews the shortfalls of digital integration into business processes with a view of establishing strategies that can be adopted by organizations to ensure lasting outcomes.

The last few years have seen the advent of numerous construction technologies. UK Connect identifies the crucial construction technology trends in 2021 to include Building Information Modelling (BIM), Virtual Reality (VR), Augmented Reality (AR), Artificial Intelligence (AI), Machine Learning (ML), Internet of Things (IoT), Robotics and drones, 3D Printing, Big Data, and Blockchain. This is in line with Gartner's (2018) findings, which further extend the list to include Digital Twins, Cloud and Edge computing, among other top strategic technology trends for 2019. These are only a few of the technologies currently in play, but perhaps currently the most impactful.

BIM is the intentional management of information through the whole life cycle of an infrastructure project. It entails considering the intended use for an asset at the beginning of the project and how it will be integrated, ran, and sustained. The BIM platform offers an avenue for the simulated construction of building components as well as coordination of all elements and processes before production (Maina, 2018). VR enables immersion into a computer-generated 3D simulated environment with a seemingly real interaction with this environment. AR on the other hand enhances elements in the real world by superimposing computer-generated graphics, thereby enhancing the real-world element. VR and AR coupled with BIM have limitless capabilities in enabling project collaboration, speedy decision making through improved visualization and understanding of project elements as well as potential safety improvements through construction simulation for process improvement.

AI is exhibited where computers or programs mimic human behavior. These machines are fed with a vast range of information related to the world to program them to respond with common sense as well as problem-solving and analytical capabilities. ML, a subset of AI, further introduces algorithms that assess past patterns to derive predictive insights (Marr, 2020). These concepts have been harnessed in the construction industry to embed environmental and geographical data on BIM Models creating digital twins which enable predictive design. These two concepts have further improved productivity in the industry by eliminating redundant processes and enabling automation. AI is especially useful in fast-tracking review of project management historical data to derive insights on cost and time management aspects (UK Connect).

Drone technology is currently being applied for site monitoring without the physical presence of construction professionals, as well as to deliver materials on site. In tandem with data captured by ground-based or Autonomous Mobile Robots (AMRs), drone data is relayed to VR technology, presenting a real-time view of site progress from any geographical location off the site. Additionally, robotics use in construction technology has enabled automation of some manual tasks such as bricklaying, delivery of materials using automated vehicles, as well as for demolition works. This reduces the time in which these tasks are performed significantly (Matthews, 2019). 3D printing, on the other hand, entails the use of printers fed with cement, molten metal, plastics, or other materials which solidify upon cooling or curing, which are linked to BIM software which feeds project element data to the printer enabling layering of the material to create a physical representation of the model. This accelerates product development by reducing the design to manufacturing cycle and is especially helpful in the manufacture of complex forms (Schwab, 2016).

IoT in the construction context entails technology-enabled systems which enable multiple elements, processes, smart devices, and sensors to create interactive and automated environments. This smart technology is used to boost efficiency and sustainability by the use of sensors to switch off systems and machines during idle time, as well as automate redundant processes and enhance safety on sites through alerts. The concept of Digital Twins, a virtual asset coined from a physical asset, has been progressed to blend IoT, AI, ML, and BIM. This results in a digital model which can be manipulated and optimized for efficiency, predict outcomes based on scenario analysis, and ultimately derive maximum value for clients (Monteith, 2019).

Big data refers to extremely large data sets from internet searches, social media, and other digital communication media, which create a digital footprint that can be analyzed to uncover hidden trends and

correlations between elements. Energy, weather, traffic, and geolocation data are linked to BIM systems to determine ecological impact as well as optimize sustainability solutions, in addition to scheduling project management and facility maintenance activities (Marr, 2016). Cloud computing technology allows for access, use, and manipulation of data stored in remote servers relaying data to construction participants in real-time. This facilitates efficient collaboration. Similarly, edge computing facilitates the processing of data on smart devices such as phones and tablets at the source.

The sheer number of parallel innovative construction technologies can be overwhelming (Oswald, 2017). Ironically, Forbes, the World Economic Forum, Accenture, among other institutions that have invested in research on the performance of digital interventions conclude that 70-80 percent of digital innovation strategies fail. McKinsey's Digital Global Survey 2016 and 2017 suggests that this is the case because a majority of incumbent business models fail to acknowledge that digital innovations disrupt the traditional nature of competition as illustrated in the figure below.

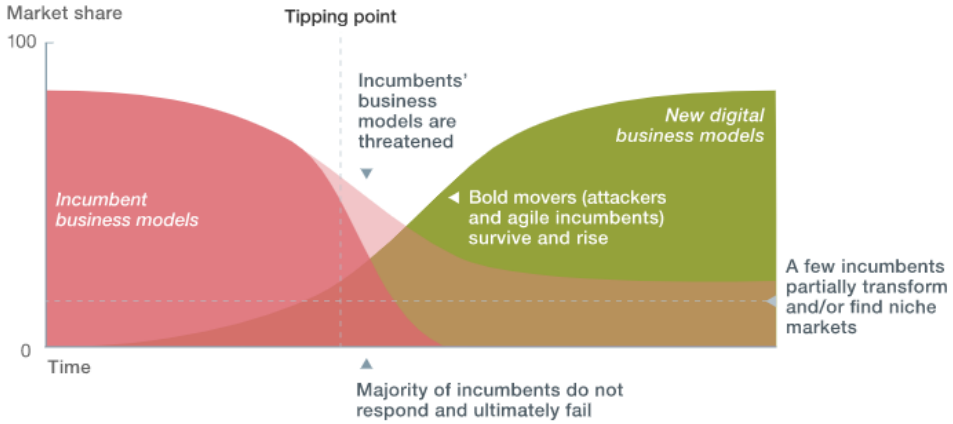

Figure 1: Influence of digital disruption on Market Share/ Competition

Oswald et al (2017) argue that these technologies present complexities due to vast connectivity. This creates the need for agility, and smart decision making to increase efficiency and respond in real-time to ever-changing customer demands in addition to posing a digital information security challenge. Failure to acknowledge that digitization disrupts the traditional operation and strategic models results in organizations approaching digital transformation in isolation, as opposed to reviewing its effects on every aspect of the business. Moreover, these efforts to reinvent the business need to be done iteratively, given the rapid rate at which technology is changing.

This failure is also linked to uncoordinated digital efforts without a systematic approach or within silos, and without the commitment of the entire organization. Additionally, Schwab (2016) submits that the requisite institutional framework governance for innovation is inadequate, if not absent altogether. The lack of a clear direction on digitization objectives, allocation of resources, and responsibilities results in a vicious cycle with no way to measure the impacts of implementation. Without this framework, digital interventions are applied in isolation with no focus on the long-term objective which makes them ultimately unsustainable.

Failure to understand that digital strategies will vary from company to company is yet another challenge. McKinsey proposes that to survive in the digital economy, two broad principle categories apply to organizations. There are digital reinventors who are first movers who make heavy technological investments and major changes to their business models. However, not all companies can afford this venture. The second category of organizations is fast movers who are highly adaptive to digital changes, learning from mistakes of the digital reinventors and refining innovations as opposed to reinventing the wheel.

Accenture categorizes these challenges into six broad deficits. Alignment deficit refers to a lack of harmony across the organization on digital value as well as the approaches to adopt to harness its capabilities. Infrastructure deficit denotes to shortage of technology to enable innovation within an organization. Skills deficit, on the other hand, implies the insufficiency of skills to create value on digital platforms. Partnership deficit is listed as yet another challenge, pointing towards limited collaboration with strategic partners who can jointly leverage technology and innovation. Further, Accenture defines measurement deficit as failure to define metrics against which any innovation can be compared to determine implementation success. Finally, the lack of a digital culture which is a prerequisite for the growth of digital initiatives is defined as Cultural deficit. These deficits when combined, are among the leading causes of digital implementation failure.

Digital innovation must be tailormade to suit an organization's context and should be evaluated carefully for sustainable implementation. There's no question as to whether taking up the digital transformation journey is worthwhile. If anything, institutions that are left out of this sprint are likely to become redundant. These initiatives however carry along significant financial implications, thus it is necessary to rethink tactics to surmount the implementation challenges identified.

3 Discussion

Investing blindly in technology can be a wild goose chase, as technology is rapidly changing with the daily advent of innovative solutions. Niessing et al (2020) recommend that businesses need to adopt a digital resilience strategy, anchored on leveraging data and technology to drive customer value. This is the only way organizations can survive in the long-term. The digital revolution orbits around data. Any software or technology is only as good as the data fed into it, which calls for the need for a structured approach to data collection, manipulation, relay, and archiving. An organization's efficiency greatly depends on its ability to manipulate and synthesize data pertinent to its processes for its benefit. The information generated through construction process keeps escalating, with multiple stakeholders feeding into the process as well as with the increasing complexity of construction projects (Maina, 2018).

Rogers (2016) alludes to the fact that digital transformation is not about technology, but is instead about strategy, listing five key domains for consideration: customers, competition, data, innovation, and value. Oswald et al (2017) further add people and skills, business models and processes as well as organizational culture to the key dimensions critical for successful digitalization. Businesses and industries are called upon to reinvent themselves, and more importantly, to adopt an agile strategy, as the shift from analog methods carries along with it a need for versatility. Customers' pain points should be at the core of business digital strategies and models. With greater access to information, clients form the best focus group to engage in developing dynamic solutions that derive optimum value.

Digitization disrupts the traditional concept of competition, with new entrants into markets typically controlled by core service providers. Mobile technology firms, for example, are slowly bringing value into the construction industry which was predominantly served by construction professionals. Organizations, therefore, need to consider strategic relationships where they focus on what matters and leave the rest to the experts in the field, a concept known as digital out-tasking, thereby leveraging on competition (Oswald et al,2017).

Data is the lifeline of every organization. With digitization, data is generated in large volumes, in structured and unstructured formats, which has proved to be valuable in developing insights on customer feedback and product performance (Chaki, 2015). Big data is, however, often not valuable in its native format unless synthesized to add value. The need for the evolution of workforce skillsets is eminent, with the emergence of tech roles and competencies for data collection and coordination for downstream analytics to ensure that the right data is acquired and amalgamated to generate value. Additionally, business intelligence experts are required to derive actionable insights from the data by asking the right questions, creating test scenarios for analysis, and enabling data visualization. Data scientist's role in creating algorithms that are used to predict outcomes which can then be used to progress recommendations has also proved to be critical in the digital scene (Niessing, 2020).

Developing technical solutions off these analytics may imply heavy technological investment. However, unlike traditionally where the focus was on producing a final product before releasing it into the market, the current trend advocates for the release of minimum viable products which allow for incorporation of customer feedback and variations to accommodate rapidly changing needs and technology. This has been found to save time and reduce costs while improving on the product and organizational learning (Rogers, 2016).

Organizations can also invest in strategic relationships for collaborative innovation where firms that lack specific skills such as customer analytics but have capital and mature operations can collaborate with counterparts with the latter, or vice versa. This combined approach to a company's digital strategy turns data into an asset for long-term value, keeping abreast with customer needs and the changing environment to uncover unexpected patterns and unlock new sources of value. Ultimately, integrating any change into an organization has its challenges, thus this journey is not expected to be without its pitfalls. Leaders must therefore ensure that a digital culture is cultivated by actively engaging their teams in the implementation process. This aids in creating a sense of individual ownership of the journey as well as a commitment to the company's overall strategy.

4 Conclusions

To harness digital prospects, organizations must go beyond simply leveraging emerging technologies. The digital economy calls for a new setup with improved technical capabilities. The need to reinvent business models around customer needs, investing in a workforce with the right skills as well as upskilling of the current workforce, in addition to the development of collaborative partnerships based on mutual trust is eminent. Moreover, businesses are required to adopt a data-driven approach where business intelligence is derived from effectively synthesized data. Ultimately, this will result in extended intelligence with agile business decision support systems.

More important than acquiring core technology is digitizing the mindset of decision-makers. Businesses should ensure that they begin with an audit on their readiness for digital transformation which aids in the identification of technology and resource gaps as well as a clear road map from the current state to the desired state. Over and above being ready to identify their strategic blind spots, it is imperative for organizations to rapidly implement the necessary changes, and to commit to an iterative journey of learning and unlearning to survive in this digital space.

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References

1. Accenture Media, Accenture-IXO-HannoverMesse-report.pdf last accessed 2021/09/30
2. Chaki S. Enterprise Information Management in Practice: Managing Data and Leveraging Profits in Today's Complex Business Environment. 1st Edition. Apress Media LLC. California (2015)
3. Gartner Newsroom, https://www.gartner.com/en/newsroom/press-releases last accessed 2021/09/28
4. Maina P., An Investigation into The Role of Building Information Modelling in Reducing Cost and Time Overruns Experienced in 2-Dimensional Based Construction- A Survey of Construction Practitioners in Nairobi County. University of Nairobi (2018)
5. Marr B. Tech Trends in Practice: The 25 Technologies that are Driving the 4th Industrial Revolution. John Wiley & Sons, 2020
6. Matthews, K. 5 ways in which construction robotics is disrupting the industry Construction robotics is changing the industry in these 5 ways (therobotreport.com) (2019)
7. MacKinsey Digital Insights Why digital strategies fail | McKinsey last accessed 2021/09/29
8. Monteith, M. What is a Digital Twin? IoT for All https://www.iotforall.com/ last accessed 2021/09/28
9. Niessing J., Dubois D., Bejjani A. Building Digital Resilience around the customer, https://knowledge.insead.edu/marketing (2020) last accessed 2021/09/27
10. Oswald, G. Kleinemeier, M. Shaping the Digital Enterprise: Trends and Use Cases in Digital Innovation and Transformation. Springer International Publishing Switzerland (2017)
11. Rogers, D. The Digital Transformation Playbook: Rethink your Business for the digital age. 1st Edition. Columbia University Press, New York (2016)
12. Rose g. The Fourth Industrial Revolution: A Davos Reader. Foreign Affaise (2016)
13. Schwab, K. The Forth Industrial Revolution. World Economic Forum®, Switzerland (2016)
14. UK Connect Insights & Events 10 Construction Technology Trends (2021) | - UK Connect last accessed 2021/09/28
15. Zobell S. Forbes Technical Council Why Digital Transformations Fail: Closing The $900 Billion Hole in Enterprise Strategy