Digital Transformation Readiness in Infrastructure Project

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Abstract

Digital technologies have brought a new performance momentum in all industries and businesses wherever it has been fully adopted from manufacturing to healthcare and to climate change monitoring. In construction, the digital transformation has been limited to design phases while missing the operations part. It becomes crucial for the world's largest ecosystem to accelerate this digitalization at full scale. In infrastructure projects, digitalization is introduced to the operational level as a ready-made tool that lacks flexibility. This paper describes the barriers to the digital transition in construction operations, combined with the emerging impact of the COVID-19 pandemic from planning and progress monitoring aspects. Adoption of lean construction implementation in infrastructure projects in the State of Qatar, requires adoption for digital tools for data collection, verification, and analysis. This process is continuously improved at the project level to deliver a digital tool that is tailored to the infrastructure projects. This paper describes the initial steps for digital transformation in infrastructure projects in-line with a digital maturity growth.

Keywords: Digital Transformation; Lean Construction; Planning and progress monitoring; Infrastructure project

1 Introduction

Digitization has been facilitated by the fourth industrial revolution Betti *et al*. (2020), which is allowing the use of Internet of Things (IOTs) and automation, and it also supports reduction in the environmental impact (Hasan *et al*., 2018). Eventually, digital change is affecting construction industry, and many new technologies are being developed by experts and implemented on pilot projects. These include Building Information Modelling (BIM), big data, cloud storage, multidimensional design [4D and 5D], automated prefabrication, robotics, 3D printing, artificial intelligence, and intelligent buildings (Sykes, 2018). Nevertheless, the construction sector is still considered as one of the least digitally advanced industries in terms of its adoption and usage of digital solutions and digital workforce engagement (Ribeirinho *et al*., 2020). One of the barriers to implementing automation in the construction industry is the different interpretations of the term construction automation (Chen *et al*., 2018). It tends to be a challenging issue due to the different levels of automation and digitalization during the various project phases. The application of the

digital solutions is a driver of change that helps increase efficiency in most aspects of the construction industry, especially design, construction, and operation phases (Aghimien *et al*., 2018).

Despite its importance, construction phase is least incorporated in digital solutions. Combined with a lean construction practice, developing a platform, which integrates the different modules in the construction phase environment, would be beneficial to manage sites through data collection, and analysis that will affect not only progress monitoring or planning, but also safety, quality, sustainability, and handover. This article will present a combination of lean thinking and digital transformation in infrastructure projects.

2 Lean Construction and Infrastructure Projects

The primary success criterion for any construction project is the completion of the project without cost and time overruns. As traditional project management approach is ineffective in resolving such issues, which may have a root in the organizational processes and historical pattern, a lean construction management is being slowly adopted as a new management technique. The adoption in several countries show enhancement in the project performance and increased likelihood of a project's success. According to Chung & Mutis (2020), lean construction concept processes or measures help minimize non-value adding activities and make sure that the value-adding activities are extensively controlled to increase productivity. Thus, the major intention of lean construction as a concept is to decrease wastage whilst increasing the value of the outputs. This can be done by using the right principles, resources, and measures to deliver things right the first time (Dehdasht *et al*., 2020). Several lean techniques are adopted in infrastructure projects such as continuous improvements, visual management, and collaboration between team members. Contrary to the traditional system, lean ensure reliable workflow and eliminate variation at an early stage of the project.

2.1 Challenges Facing Lean Implementation in Infrastructure Projects

In 2019, Public Work Authority (ASHGHAL) introduced the lean construction philosophy in infrastructure projects in Qatar. Since then, lean concepts, methods, tools, and thinking were implemented with different degrees of maturity and practice. However, some challenges related to understanding, adoption and exercise have emerged among them about the data collection, analysis, and visualization. Traditional methods of data life cycle are still being used by contractors, consultants, and clients. Those methods, such as storing the data on-premises in a local file server are an overburden to users and systems. Lean practice data analysis requires a smoother and more advanced approach on this particular side.

Besides, one of the main practices in lean is the daily huddle, where all engineers and team members gather in the visual performance centre to provide their progress updates, and reasons for non-conformance and assess the next day's plan. COVID-19 enforced a strict work regulation for health and safety. It resulted in stopping the physical gathering for daily huddles that hampered an essential part of lean not just for progress monitoring but also for production loss identification.

Moreover, complexity, ambiguity, and fragmented supply chain in infrastructure projects combined with uncertainty are typical challenges in construction, which requires a digitised lean intervention.

2.2 Digitised Lean Implementation

The imprecise performance of lean implementation within the contractors is rooted in a lack of bespoke requirements of processes and tools to be followed which limits standardization. The

existing lean implementation is not agile enough and requires optimization to have smoother process of data collection, reporting, interpretation, and visualization. Further, unpredictable plans and unreliable commitments, along with inadequate process, impact the lean practice assessment.

A study by Porter & Heppelmann (2015) stated that digitalization is expected to play an increasingly important role in the management and design of global chain supply primarily to companies vigorously involved in value-adding activities, including those involved in production of logistics systems.

The COVID-19 pandemic established an opportunity to consider digital transformation as the strategy to respond to the evolving disruptive environment and reinforce lean implementation through technology.

3 Digitization in Infrastructure

Digitization effect in progress monitoring specifically in infrastructure projects is not widely researched yet and few empirical evidence is found in the literature.

Before adopting digital solutions, contractors must understand the capabilities of each technology and the type of tasks that can be performed. It requires one to assess the strengths and limitations of each solution. The digital solution should process the data and deliver it to end users using personalized and reliable interactive dashboards.

Digital transformation can provide better collaboration, more control of the value chain, and enable more data-driven decision-making. It will make data more accessible and lower the risk of data loss and manipulation. From a lean perspective, the non-value-added communications will be eliminated.

3.1 Pilot Process Assessment Methodology

This study assesses the difficulties the project's current condition is encountering and how the proposed digital solution will effect the project's future state. DMAIC (Define, Measure, Analyse, Improve, and Control) which is the data-driven development method (Kurnia & Hardi, 2021) is used to study the digital change at an organizational level. Each stage of the process has a specific function to play in achieving the best results. This process was created as follows:

1. **Define:** by identifying the challenges facing data collection, reporting, and retrieving.
2. **Measure:** the time needed for data collection, reporting, and interpretation using the conventional method and compare it with the time spent with a simulated version of digitization.
3. **Analyse:** conduct a pilot study and evaluate the opportunities and challenges presented, and the factors that influence implementation.
4. **Improve:** suggest alternatives and recommendations within the experienced module.
5. **Control:** develop a process on how to emphasize certain process and sustain it.

3.2 Pilot Process Workflow

Figure 1 illustrates the process used in infrastructure projects to develop the weekly performance dashboard for monitoring and managing progress.

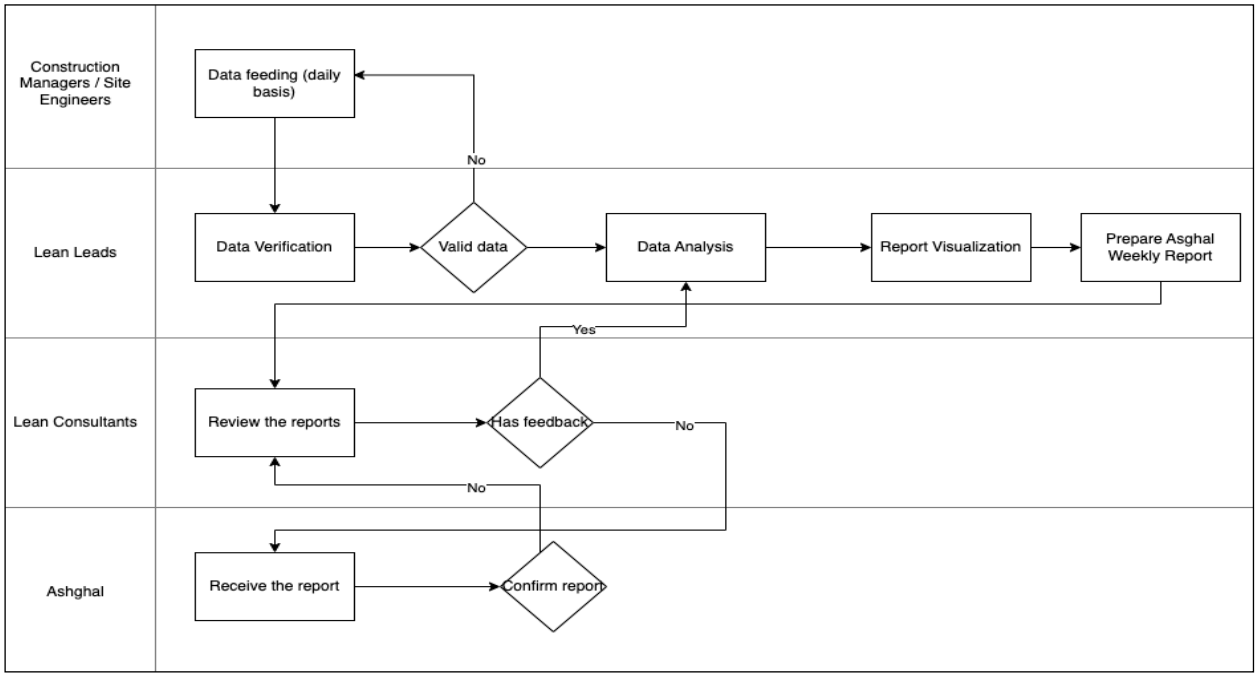

Fig. 1: Process Workflow

The workflow under research aim to enhance the data collection and analysis approach, increase its efficacy and accuracy, and optimize anion-value steps identified.

3.3 Pilot Process Simulation

A simulation pilot is conducted in one infrastructure project to evaluate the effects of digital transformation on productivity by examining the time savings for data collection, organization, documentation, interpretation, and analysis. An alpha version digital solution is developed to shift the daily huddle inputs into a comprehensive sheet with a user-friendly tab. The input process followed the same daily huddle steps for actual quantity update.

Table 1 summarizes a comparison of the findings during the simulation between conventional and pilot processes workflows.

Table 1 : Comparison between Conventional and Pilot Process Workflows

Variable	Conventional workflow	Pilot workflow
Data collection	Almost 2 days were needed for the engineers to provide their planned schedule data in addition to follow-up and reminder time.	Engineers will have the ability to modify progress data to some extent according to restricted rules and time limits emphasized by the system, which enables a more efficient and faster way.
Data reporting	It took the lean leads about 3 hours to review and revise the progress data for additional verification	The demand for repetitive entry of engineer's data will be reduced since the engineer will enter the data himself
Daily update	Updates took almost 30 min along with the daily huddle discussion	Manual update will no longer be needed since engineers update the actual on digital forms and just attend daily huddles
Data visualization	It took more than an hour to create or update the charts needed for progress dashboards	Once the data is entered, an automated visualization chart will be created
Data	Analysing various chart types and the causes	Automatic comparison and insights will be

Analysis	of shortfalls took almost two hours	generated along with the business intelligence tools
Data retrieval	Finding the required update, dashboard or PPC values took at least an hour going through the server	Any insights or data can be retrieved instantaneously with a single click using an interactive platform
Data Accuracy	Data accuracy was about 80 percent	Data accuracy reached 98 percent
Expansion analysis	Limited storage capacity and processing speed are set with no ability to improve	Storage is flexible and the processing time is dynamic and highly optimized

A fundamental change is observed in the progress reporting, monitoring and control mechanism.

Digitization of a basic and simple process showcased the tremendous savings not only in engineers' productivity, but also on the manager decision making approach as more accurate and reliable data is available.

3.4 Digitization Barriers

Resistance toward change, lack of top management commitment, lack of awareness and understanding about the significance and advantages of digitization, and limited financial tolerances are often seen as the barriers to digitization, similar to what is initially experienced in lean implementation. The inherent barrier to any transformation is typically rooted in human and organizational culture.

4 Future of Digitization in Infrastructure Project

Infrastructure projects need to initiate the shift towards a more digitised execution and management approach than being enforced to adapt to new sustainability requirement trends which are digital oriented. Digital transformation impacts productivity, data safety and decision-making approach as well.

A thorough assessment of the organization's culture and technological readiness must be emphasized to ensure the efficient adoption of digital solutions.

Virtual performance centres may be the new norm in construction projects management, that will shape the future of the industry and change the way of working as well as, it will shift the contractors and business owners toward data-driven decision-making.

Further, adopting artificial intelligence (AI) and machine learning to provide a predictive analysis and insights on future status based on current trends, will provide valuable insights for contractors and construction professionals to make better data-driven decisions.

Conclusion

Although technology has been used in the construction industry at different level of maturity, its application to the infrastructure sector is still unclear. Infrastructure projects have used lean construction to overcome the industry obstacles. However, the implementation of the lean concept had significant gaps, which were caused by the uses of traditional methods and lack of standardized process during implementation. This article tested the suggested digital solution pilot's possible effects on infrastructure projects, and the results showed definite advantages. Integrating digital solution in lean construction and other infrastructure modules for progress monitoring and control will reduce waste and increase efficiency of project delivery. However, there will be several obstacles confronting changes. Additionally, the future of digitalization points to a promising future in infrastructure and building, where AI will be essential for reliable insights from forecasted trends and predictions. If Lean implementation is backed up with digitization process, it creates an

infrastructure projects ecosystem with more consolidated, integrated, and standardized processes.

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