



Implications of Digitization on a Construction Organization: A Case Study

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Abstract

As the construction industry transitions to a post-pandemic world, the use of technology brought forward by Construction 4.0 has accelerated. This increase in technological advancements has placed greater emphasis on the need for digitization and is consequently driving construction organizations to change. Thus, it becomes crucial to understand how digitization is affecting the organizational aspects of construction companies including strategy, structure, people and culture, and processes and technology. This study addresses the gap and presents a case study on a large EPC company (Company X) that has been going through a digitization organizational change of both engineering and construction services since 2017. The company is a legacy company that has been operating for over 100 years and is placed in the Top 400 Contractors List published by the Engineering News Record (ENR). Network analysis was performed on transcriptions from four semi-structured interviews conducted with company representatives to understand: (1) the drivers of digitization (weight of the past, push of the present, and pull of the future); (2) the response of Company X to successfully implement this organizational change (implications on strategy, structure, people and culture, and processes and technology); and (3) the challenges that digitization imposed on the organization. Findings of this paper offer a preview of the dynamics of the digitization organizational change and enable informed dialogue around the drivers of, response to, and challenges of digitization in the construction industry. Organizations undergoing or planning a digitization information can reflect on the practices identified through this research to successfully navigate through this organizational change.

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1. Introduction

The construction industry stands at a crossroads as it transitions to a post-pandemic world. On one hand, there is a serious need to increase productivity, improve project performance, address the labour shortage, reduce fragmentation, address resistance to change, and increase collaboration. On the other hand, the fourth industrial revolution or Industry 4.0, which is mapped as Construction 4.0 in the construction industry, has been slowly altering the industry by introducing a wave of technological advancement that is altering the way projects are designed, planned, constructed, delivered, and operated [2].

One of the main transformations offered by Construction 4.0 is to exploit the potential of digitization in the construction industry [3]. The industry is no stranger to digitization, starting in the 1970s with structural

analysis programs, the 1980s with computer graphics, and the 2000s with the rise of BIM [3,4]. Under the umbrella of Construction 4.0, digitization can be achieved through four main key aspects: (1) digital data through collecting and analysing digital data; (2) connectivity through connecting and synchronizing processes, (3) automation through creating autonomous and self-organizing systems; and (4) digital access [5].

As digitization causes disruption to the way organizations work and conduct their business, the traditional organizational structures and culture would need to change [6]. Key enablers for successful digitization efforts include forming holacracy structures, altering decision-making practices, adopting digital skills and tools, leveraging information communication technology specialists, and ensuring proper investments [5–7]. Colloquially, democratization of data to spawn a renaissance of information within the construction industry through the understanding of *people and culture*, *processes and technologies*, and *data*.

To understand the implications of digitization as an organizational change, this study aims to investigate the drivers, response, and challenges of a large Engineering, Procurement, and Construction (EPC) company that is going through a digitization change effort. Drivers of digitization were investigated using the elements of the “Futures Triangle”, an approach developed by Inayatullah [8] which maps the digitization change onto three dimensional contexts: the *weight of the past* which represents the barriers that inhibit the change; the *push of the present* which are the drivers and trends that are currently pushing the organization to change and achieve the future image; and the *pull of the future* which represents the image of the digitization vision that is pulling the organization towards the new stasis [1]. The response and challenges collected were investigated across four organizational aspects: *strategy* which determines the long-term path which organizations will follow and dictates which activities are necessary for the organization; *structure* which determines the placement of power and authority in the organization; *people and culture* which relate to human resource policies and include recruiting, selection, rotation, training, and development; and *processes and technology* which are related to the flow of information across the structure of the organization [9,10].

2. Research Method

The research method employed to address the research objective encompasses three phases as described below.

2.1. Research Setting

The setting for this research was a large EPC company (Company X) that is in the Top 400 Contractors List published by the Engineering News Record (ENR). Company X was going through a digitization organizational change of both engineering and construction services since 2017. The company is a legacy organization that has been operating for over 100 years.

2.2. Data Collection

A qualitative approach was first used to tackle the research objective. Among the different data collection methods employed in qualitative research, semi-structured interviews were selected to gather data on the response to and implications of digitization on Company X. Semi-structured interviews create a balance between structured questions and unstructured dialogue and allow researchers to develop rapport with interviewees and learn about critical aspects that are not readily assessed through a standardized questionnaire [11]. This data collection technique provides flexibility to the researcher especially when similar work has not been done previously [12]. A semi-structured interview protocol was designed to collect data on: (1) the drivers of digitization (weight of the past, push of the present, and pull of the future); (2) the response of Company X to successfully implement this organizational change (implications on strategy, structure, people and culture, and processes and technology); and (3) the challenges that digitization imposed on the organizations (discussion of strategy-, structure-, people and culture-, and processes and technology-related issues). Fig. 1 outlines the framework of the interview protocol. Four one-hour interviews were conducted with four individuals within Company X who have great visibility into the

digitization organizational change. All interviews were conducted virtually by the first author and were recorded to facilitate documentation.

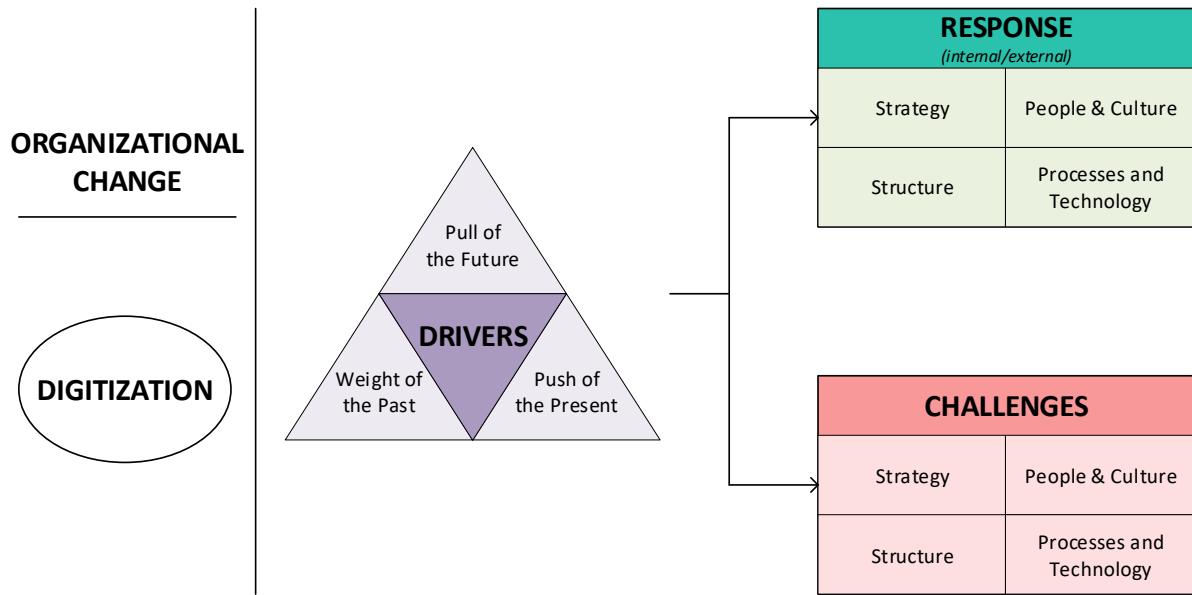


Fig. 1. Framework of the semi-structured interviews.

2.3. Data Analysis

Notes from the semi-structured interviews were transcribed verbatim from the recordings. Next, the content analysis of the interview data proceeded in three phases: initial reading, coding, and creation of themes [13]. The open coding procedure discussed by Strauss and Corbin [14] was followed to inductively identify themes in the data. The coding and generation of themes were carried out using the NVivo software. Once the themes were developed and mapped onto 16 change categories (i.e., drivers, response, and challenges), concept mapping was used to analyze the themes generated from the interview data and draw insights into the dynamics of digitization and understand its drivers, response, and challenges. Concept mapping is a method to graphically represent relationships between concepts, i.e., semantic networks [15]. In this study, concept mapping was applied to identify and visualize the semantic network with the associated implications of digitization on Company X. The semantic network consists of three elements: (1) change nodes which represent the three interview questions, i.e., the categories of analysis; (2) theme(s) nodes which represent the themes identified from the interview data; and (3) edges or ties which represent the relationship between the categories and themes. The semantic network was then quantitatively analyzed using network analysis [16]. Two measures were used to analyze the network: (1) weighted degree centrality (WDC) which identify the nodes (i.e., categories and themes) that are highly impacting the network and (2) closeness centrality (CC) which identifies how close the nodes are to one another [17,18]. The analysis was performed using UCINET 6.0.

3. Case Study Analysis

A total of 33 themes were identified from the four interviews and mapped onto the 16 change categories, namely: *weight of the past*, *push of the present*, *pull of the future* (3 categories representing the drivers of digitization), internal strategy, external strategy, internal structure, external structure, internal people, external people, culture, internal processes and technology, external processes and technology (9 categories representing the organizational response to digitization), strategy, structure, people and culture, and process and technology (4 categories representing the challenges associated with the implications of digitization on the organization).

3.1. High-Level Analysis

Before interrogating the specific themes, Fig. 2. represents a high-level aggregation of the content analysis. When considering the drivers of change, the interviews conducted with Company X show that the organization was mainly driven by the *push of the present* (with 55% of the discussion on the drivers focused on this category) and the *weight of the past* (with 40% of the discussion on the drivers focused on this category). According to the interviewees, the implementation of digitization was not driven by the *pull of the future* as only 15% of the discussion on the drivers focused on this category. However, the disparity of the respondents' macro-observations on digital transformations transpiring universally throughout all organizations and internal awareness may be a direct indication of the ancillary factors associated with competitors/suppliers being driven by the pull of future vs. Company X internal drivers focused on risk obversion (i.e., 'why fix what isn't broken').

Further, when investigating the response of Company X to digitization, the discussion provided by all interviewees was mostly dominated by the focus on the *internal* response rather than external. Particularly, more focus was placed on *strategy* (26%), *people* (23%), and *processes and technology* (21%). Moreover, interviews indicated that most of the challenges associated with the implementation of digitization were faced at the strategy and people and culture aspects of the organization (50% and 39%, respectively). This is an expected resultant when considering the interviewees' response (~85%) predominantly focused on the factors associated with the *Weight of the Past* and *Push of the Present*. Additionally, a majority (79%) of the Response category focused on Strategy, People, Process and Culture. Thus, from the data, one could infer that Company X focused the entirety of the organizations energy on the activity of implementing the organizational change versus the appropriateness of the change.

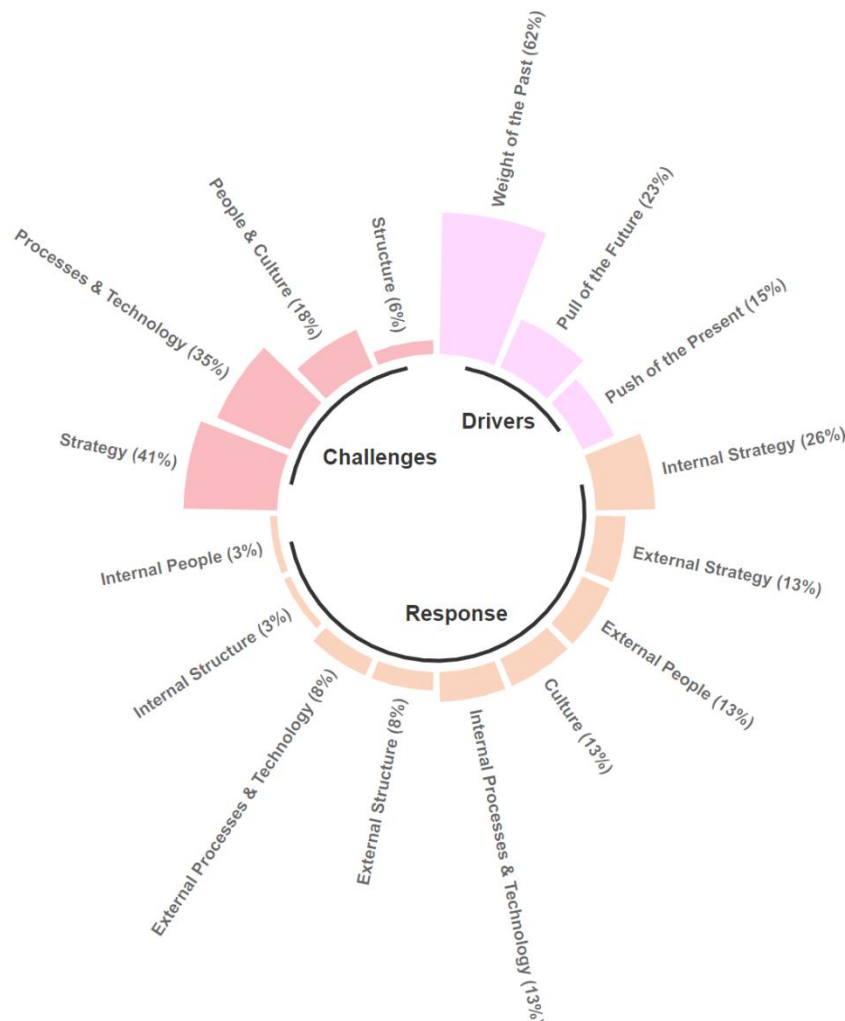


Fig. 2. Summary of the implications of digitization on Company X.

3.2. Network Analysis

The concept map (i.e., semantic network) of digitization as discussed by the interviewees from Company X is illustrated in Fig. 3. Network analysis was then employed to provide a qualitative assessment of the implications of digitization on the organization.

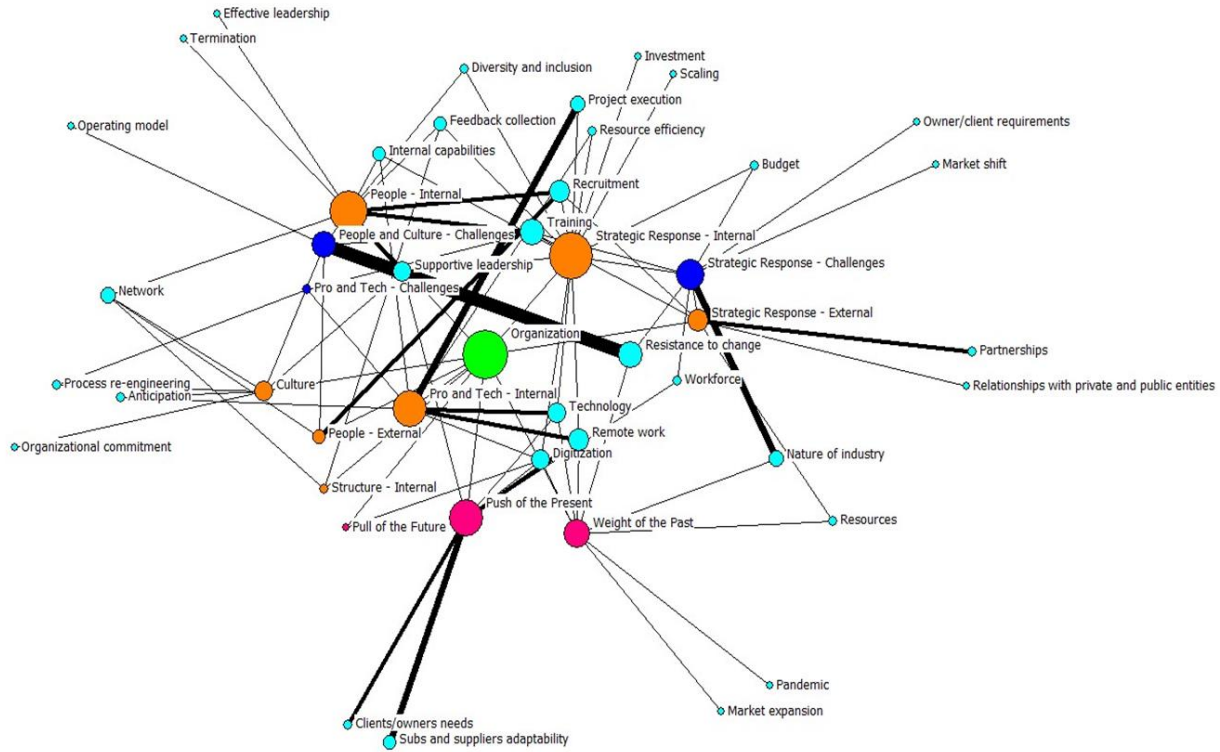


Fig. 3. Digitization Concept Map. The pink nodes represent the three categories of drivers; the orange nodes represent the nine categories of response; the navy-blue nodes present the challenges; and the cyan nodes represent the 33 themes. The thicker the edges, the stronger the connection is between the nodes.

3.2.1. Weighted Degree Centrality

The analysis of the weighted degree centrality (WDC) measure shows that *Internal strategy* (with WDC equals to 0.35), *internal people* (with WDC equals to 0.30), and *internal processes and technology* (with WDC equals to 0.28) are the nodes that dominate the network, meaning that the interviewer of company X were mostly focused on these three internal aspects of the organization while discussing the response of their company to digitization, reflecting how Company X planned this organizational change. The themes outlined in Table 1 were found to be influential and critical for the successful response of Company X to digitization.

Table 1. List of important themes

Theme	Response Category
Training	Internal Strategy Internal People
Remote work	Internal Processes and technology
Recruitment	Internal People
Supportive leadership	Internal People Internal Strategy
Digitization	Internal Processes and technology
Technology	Internal Processes and technology

To support the implementation of digitization, Company X provided internal training (virtual and physical) on tools and new processes, introduced digital environment to union by providing training to unionized

workforce. The company also leveraged remote work to facilitate digitization where virtual machines to access the design tools located in one of the international offices were used to ensure project operations were not interrupted. The company also leveraged the use of remote work tools that are easy to use and allows better integration with different corporate software. To build internal capacity, Company x hired specialized employees with expertise in robotics, data science, advanced materials, and recruited younger project professionals that have a higher propensity towards digital capacity as a digital native. The organization leadership was also supportive of the change initiative and had the mentality of “growing motivational field leaders rather than hunters and gatherers”. Further, Company X focused on intentionally making a gradual shift to “working within data” versus “working on paper” with a focus on testing physical innovations such as; robotic welding machines, benchmarking Key Performance Indicators (KPIs) for offsite and onsite work, using mobile apps connected to work packaging management system to facilitate two-way data transfer for construction crews, and enhance decision making data transfer for construction crews. As noted by the interviewers, these practices were instrumental for the success of the organizational change.

Following the focus on the above three aspects, the *push of the present* (with WDC equals to 0.26) is the next dominant node. Particularly, and as shown in the concept map, Company X began its implementation of digitization as a response to the following main trends (having bigger nodes and thicker edges with the push of the present): the shift in customer demand towards digitization where established owners have started developing their digital landscape and are pushing the need to consistently produce and use data (*clients/owners' needs* node), the need for remote work to collaborate across the organization locally and internationally while keeping operations going during the COVID-19 pandemic (*remote work* node), the need to keep up with subcontractors and suppliers that have already embraced the digital environment (*subs/suppliers' adaptability* node).

The main challenges faced by Company X, while implementing digitization, were *strategy-* and *people and culture-*related (with WDC equals to 0.24 and 0.22, respectively). The strategy-related challenges are mainly attributed to the *nature of the industry* where construction is fragmented, more heavily reliant on skilled labour, and fast paced delivery which poses various challenges in the face of new technologies being implemented or embracing dynamic change initiatives, whereas engineering and procurement are faster to embrace the digital transformation than construction. The people-related challenges mostly stemmed from the *resistance to change* where digitization was internally resisted by senior project managers, unionized leadership, and middle management. These challenges created another concern for Company X on whether the money is best spent to further socialize the change and obtain buy-in or to move past them. It should also be noted that *resistance to change* was the most discussed theme throughout the case study and in-line with expectations for a more traditional organizational change implementation.

Following the *push of the present*, the discussion with the interviews indicated that the organization was driven by the *weight of the past* (with WDC equals to 0.20). This category adequately represents the legacy system and practices that has been anchoring Company X and challenging its shift towards the future. Additionally, weight of the past drivers discussed by the interviewees include internal resistance to change, the fragmented and competitive nature of the construction industry, the limited availability of resources and skilled workforce, cyberthreats and security concerns, budget pressure caused by the pandemic, and software packages available in the market do not always fulfil the organization's specific requirements. All of which could be significant barriers to the implementation of digitization.

Further, the focus on internal *strategy, people and culture, processes and technology,* and *external strategic response* was a focus for Company X while going through digitization (with WDC equals to 0.17). Particularly, the organization was strategic about its *partnerships* with its network; working closely with subcontractors and suppliers to adopt digital workflows.

3.2.2. Closeness Centrality

The analysis of the closeness centrality (CC) measure showed that *training* had a higher score of closeness (with CC equal to 0.46) compared to other themes. This higher score was obtained because *training* was mentioned under different categories (internal strategy, external strategy, internal people, strategy

challenges, people and culture challenges, and processes and technology challenges). This finding indicates that *training* was an important action that the organization focused on while going through its digitization change effort, which could be justified by the fact digitization requires a lot of training to be achieved successfully.

Moreover, the concept map shows that *remote work*, *digitization*, and *technology* are plotted next to each other showcasing how these themes are related to each other: digitization requires technology, and remote work supports digitization. Moreover, *recruitment* and *training* are located next to each other, which indicates how these two actions are related to one another and were implemented simultaneously by the organization during the change initiative.

4. Reflection/Discussion

The Futures Triangle combined with the four organizational aspects allows for an in-depth understanding of how the journey for Company X digitization organizational change management implementation occurred. This transformative change highlights many of the anticipated hurdles that an organization may encounter (Fig. 4). However, the key difference between a typical organizational change implementation and the digitization is the significance and breadth of impact the digitization change is having on the construction industry.

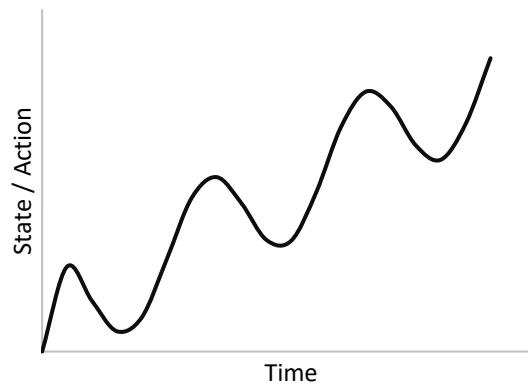


Fig. 4. Representation of the Digitization Organizational Change Management Journey

One key outcome that this case study has shown is the propensity for the weight of the past to heavily influence how quickly an organization within the construction industry is able to progress towards Construction 4.0. Specifically, the need for an increased focus on *strategy*, *people and culture*, and *processes and technology*, see Fig. 2. Further, the gap is not just limited to whether the individuals being impacted are digital natives.

The resultants highlight that a concerted effort must be made to focus on socializing ‘why’ the change is needed, the benefits of the change, and training to support the transition. Moreover, even with these actions, the organization will still follow the Digitization Journey as represented in Fig 4 to truly accomplish Construction 4.0. Without intentional care and nurturing of the change with a clear vision the organization will never experience the series of successes, followed by learnings will occur along the way.

Further, the uniqueness of this specific case study is one can easily compare previous studies [19] to the impact and speed at which the industry has had to change due to the COVID-19 pandemic and has acted as a catalyst to force the need and conversation on how to make Construction 4.0 a reality.

Digital Natives and Non-Digital Natives are struggling, and will continue to struggle, with the implementation of Construction 4.0 until all of the major EPC contractors and Owners define a clear roadmap/standard in a similar manner to the Internet Service Provider (ISP)/global phone number network.

5. Conclusions

This study presented a case study on a large EPC company (Company X) that has been going through a digitization organizational change of both engineering and construction services since 2017. The company is a legacy company that has been operating for over 100 years and is placed in the Top 400 Contractors List published by the Engineering News Record (ENR). Four semi-structured interviews were conducted with company representatives to understand the drivers of digitalization, the response of the company to successfully implement this organizational change, and the challenges that digitization imposed on the organization. Network analysis was employed to analyze the interview data. Results of the analysis showed that drivers of the push of the present, i.e, current trends, are the major drivers in Company X's decision to undergo the digitization organization change including, the shift in customer demand towards digitization and developing a data-driven digital landscape, the need for uninterrupted remote work to collaborate across the organization locally and internationally, and the need to keep up with subcontractors and suppliers that have already embraced the digital environment. The analysis also showed that while Company X was undergoing this organizational change, most of its focus was on the internal strategy, people, and processes and technology. Additionally, the major challenges faced by Company X are mainly attributed to the complex and fragmented nature of the industry from a strategy perspective, and resistance to change from a people perspective. Moreover, findings of the case study show that in the case of digitization, collocation is not required for successful delivery of a construction project, while the strategic training and over communication to socialize the intended outcome is paramount to have any hope of success for Construction 4.0. Furthermore, concerted effort must be made in developing the framework for all organizations to work from in the Construction 4.0 paradigm instead of smaller microcosm of success after significant investments. The results outline in this paper are based on the analysis of one EPC company and will be expanded on in a survey to the broader construction industry to investigate how different companies are responding to digitization and provide guidance to help construction organizations effectively plan this type of organizational change.

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