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Process digital twin: lessons learned from a construction case study

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Abstract

This briefing paper reflects on an effort to create a digital twin of the work processes of a construction company. The digital twin was to be used by the business to take advantage of digital techniques like machine learning, artificial intelligence and data analytics in optimising their activities. However, the effort to create the required process maps took longer than expected. In capturing the lessons learned, a system dynamics approach was used to reveal the structural and behavioural issues that prevented the timely completion of the task. The issues identified include problems with planning, process documentation, process standardisation, leadership and stakeholder engagement. From analysing the results, good practices are recommended to ensure timely delivery of similar tasks in the future.

Keywords

Business; Information technology; Planning & scheduling

1. Introduction

A factor in the successful delivery of construction projects is the timeliness and quality of information (Dzokoto, 2015). Where the quality of shared information is poor or not retrieved in a timely way, inadequate decisions may be made, which can damage project performance and potentially lead to conflicts or even litigations (Sheng *et al.*, 2020). Presented here is the case of a leading specialist construction business with a desire to radically turn around its information management processes to achieve higher productivity. To achieve this goal, the organisation took part in a UK-wide programme known as Knowledge Transfer Partnership (Howlett, 2010). The programme helps businesses to improve their competitiveness and productivity through the better use of knowledge, technology and skills that reside within the UK knowledge base, namely universities, further education colleges and research institutions. In this case, the business partnered with a university on a project.

The aim of the partnership project was to develop a bespoke, real-time data information portal and dashboard for effective and efficient construction decisions. However, audit of the organisation's work processes at the outset of the project revealed that the way information and data was being applied across the business was inconsistent and causing inefficiencies and errors. To revert this situation, an important objective of the project was to develop a digital representation – in essence a 'digital twin' (Qiuchen *et al.*, 2019) – of the business processes and IT systems across the organisation. This required generating process maps covering the work processes and data flows in the company.

The effort to deliver the 'digital twin' took a lot longer than initially anticipated. Indeed, in the initial project plan, the duration was estimated at 3 months; but it took 12 months to complete. So, what happened and why the delay? This article evaluates the work that went into delivering that 'digital twin', describes the challenges that were faced and makes recommendations for future similar projects. We hope this experience and the lessons learned from it will be of benefit to all organisations aiming to transform themselves to remain competitive in a digitalised construction sector.

2. Analysis of case study

To support our discussion on the challenges faced, Figure 1 captures the dynamics of the effort using a causal loop diagram - a systems dynamics representation (Abdelbari and Shafi, 2017). Firstly, there was limited documentation of the organisation's processes that would help in creating the digital twin. As a result, there was a need for further elicitation activities. The more process documents were found, the more process maps were generated and the more the process review activities had to take place. The more review activities that took place, the more the process documents were found. This fact pattern is represented by the links in the reinforcing loop R1 in Figure 1, which indicates that change in one direction is compounded by more change.

Figure 1. Causal loop diagram showing the system that emerged from the digital twinning effort

Secondly, getting the process owners and relevant stakeholders to participate in elicitation activities while contributing to their day-to-day live projects was a challenge. The fact that meetings had to take place at times most workable for the stakeholders extended the period for elicitation and reviews. The more the process review activities that took place, the more time of process owners was required. The longer process owners spent on process review, the more hidden processes were revealed, generating additional process review activities. This fact pattern is represented by the links in reinforcing loops R2 and R3 in Figure 1.

Thirdly, the business has multiple operational zones with functional teams that were found to sometimes have dissimilar processes. While this, on one hand, is valuable to ensure project teams are able to address the unique situations at their locations, on the other hand it created a point of conflict. The differences that existed required additional time for resolution because of the iterative process to get stakeholders to agree to a common standard. The more the process review activities carried out, the more the differences between teams became apparent and the fiercer the competition between them became, increasing the perceived threat amongst the less influential stakeholders. The higher the perceived threat, the less receptive affected stakeholders became to the effort and as a result spent lesser time engaging. Nonetheless, the little they contributed still provided leads that resulted in more process review activities. The fact that the disenchanted stakeholders gave little at each engagement significantly slowed the review process. This fact pattern is represented by the links in balancing loop B – in Figure 1 - which indicates that change in one direction is countered with change in the opposite direction. Fourthly, the more resistant to the effort process owners became, the longer it took to complete the task and vice versa. This fact pattern is represented by the links in reinforcing loop R4 in Figure 1.

Finally, on hindsight “pre-project planning” appeared to have been overly optimistic. It is possible to point to the fact that every project is unique. However, the risks were not adequately assessed in this case. In particular, the lack of existing resources (process documents and process owner time) was misjudged, and so was the challenge of delivering the task within a live work environment.

Overall, the patterns in the system contributed to a significant increase in the overall task duration as evidenced by the nine month increase to the planned duration. In taking stock of what happened with the task, it is always easy to focus on the singular events - conflicts, workshops, meetings etc. that took place during its execution. However, these events have limited usefulness in fully understanding the delays to the task completion. Behind the delaying events are patterns of behaviour that are sources of pressure and imbalance, causing things to change. Behaviour is shaped by structure, both physical and informational, and the events are

snapshots of that behaviour (Ventana Systems, 2015). By representing our experience from a causal perspective, the structural forces that produced the undesired behaviour have become apparent. To mitigate against these forces in similar projects in the future, interventions need to be made to counterbalance them.

3. Recommendations

Given the experience from this case study, the following are recommendations for similar efforts in the future.

- Planning: rolling wave planning (Laufer *et al.*, 2018) should be used for similar efforts as details will only become clearer as the project proceeds. In the discussed case, the pre-project planning was overly optimistic because it made too many assumptions – in particular with regard to information availability – that turned out to be flawed.
- Process documentation: The most up-to-date process documents covering all the associated processes should be collated in a separate initial effort. In the discussed case, relevant process documents that were incomplete or not mainstream resulted in additional reviews which delayed the effort.
- Process standardisation: A separate effort should be dedicated to reconciling the different views of relevant processes if standardisation is desired. This is important considering that the duration is unpredictable given the complexities that may arise. The effort should also precede the creation of any digital twin.
- Top level management: There must be clear top-down mandate that communicates the goal and importance of the effort. The mandate should empower stakeholders to prioritise the activities of the effort. This is important because any ambiguity is a leeway for unnecessary competition between stakeholders.
- Stakeholder engagement: Irrespective of the engagement method, stakeholders must be able to create suitable and proportional time for task. From the experience of this case study, the methods of engagement didn't have much impact on the efficiency of producing the process maps. In some cases, stakeholders preferred to have online meetings and mark-up electronic documents. Although this method seemed efficient because they could do it remotely and still benefit from interactive chats, they still needed to create time for the

task while engaging on their projects. In some other cases, stakeholders preferred in-person meetings and marking up printed documents in review meetings. With this option, it took longer than remote engagements because of the challenge of getting stakeholders to attend meetings while they were engaged on live projects. Lastly, although reconciling the different views of stakeholders benefited from meetings, in-person and remote, getting the required stakeholders to attend all at the same time was a challenge – and the option of going back and forth between stakeholders never got the work done.

4. Conclusion

Despite good planning effort, several projects still overrun. This, in part, is because of the difficulty with properly assessing the unanticipated side effects on planning decisions. Most planning efforts are based on an open loop mental model in which a sequential path exists from the beginning to the end of a task or project. Contrarily, there are interactions and feedback that loop back - and almost all are unintended. The case discussed in this briefing paper demonstrates this by reviewing an effort to develop process maps to be used for digital twinning. The effort took a significantly longer time than planned. To move on from the task without understanding the feedback may let some assume the experience is normal. So, analysing the experience helps in representing the mental model of what ought to be done. It is important to note that all models are wrong, and reality is what it is. However, a model close to reality will provide insight that improves our mental models. This will ensure actors engaging in similar tasks in the future are able to make better planning decisions.

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