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EXAMINING THE GAP BETWEEN CONSTRUCTION SOFTWARE MODULES AND LEAN CONTRACTOR PRACTICES

Matt Stevens[1] and Kola Olayiwola[2]

ABSTRACT

Construction contracting software has existed for over three decades while this industry has suffered many of the same problems, such as disproportionately high bankruptcy rates and stagnant multifactor productivity. This paper reviewed industry software operating manuals and conducted executive interviews to examine a significant blind spot in the Australian construction industry. This gap is the lack of support their products give to the accepted practices of contractors' operations. Software developers appear to have not pursued the clear Lean ideal of "perfection". All their client's needs and wants have not been met. Many small and medium-sized contractors rely on customising computer spreadsheets to calculate supporting information needed to execute some practices. In contrast, others are unaware of the methods or have not taken this additional step. The researcher has identified eight specific processes to research software firms' product literature to discover the extent of the gap. The sources of these issues are many; however, tailoring construction software to enable effective practices while "hardwiring" them into a company's process could lessen industry problems. Lean Construction researchers have asserted that this is the potential of Information and Communication Technology through a "push" approach.

KEYWORDS

Construction software, contractor ICT, built environment technology

INTRODUCTION

The construction industry globally has been slow to adopt Information and Communication Technology (ICT) even though projects generate much information that must be processed timely and securely stored. Additionally, construction contracting is more complicated than any other sector due to one-of-a-kind production (Andújar-Montoya et al. 2020). The industry has many ad-hoc production control methods, most of which are informal, fostering uncertainty that prevents smooth production flow (Dave et al. 2016).

Rapid standardisation and automation are highly improbable without software tools and digitalised business processes (Matt and Rauch 2014). Nevertheless, the transformational potential is apparent to many researchers in the standardisation and automation of processes and workflows in both the planning and execution stages. Moreover, practitioners and scientists have made efforts to improve the current situation (Faghihi et al. 2015).

[1] Lecturer, School of Engineering, Design and Construction Management. Western Sydney University, Kingswood NSW Australia, matt.stevens@westernsydney.edu.au, orcid.org/0000-0003-2301-1311

[2] PhD Student, School of Engineering, Design and Construction Management. Western Sydney University, Kingswood NSW Australia, k.olayiwola@westernsydney.edu.au, orcid.org/0000-0002-1025-66461

Researchers and software vendors have provided many reasons for the low implementation of ICT solutions in the industry, such as high acquisition cost, ongoing investment, and mastery time it requires. However, this paper asserts that there may be another reason, it does not possess significant value (total cost versus profit) for contractors over generic software such as spreadsheets. Standardisation and automation can be provided by using accessible spreadsheets.

Approximately 3/4 of contractors physically construct the work (subcontractors or specialty contractors), and more than 95% employ 20 employees or less, qualifying as Small-Medium Enterprises (SME) (ABS 2022). These SMEs deliver significant value to project owners by installing materials in compliance with the specifications. This is where ICT can make the most industry impact. Increasing value-for-money for all more will adopt more information technology; thus, performance in critical areas such as safety, quality and productivity should improve. Technology appears to be the logical solution enabler. Improvement seems highly probable if it can be tailored through construction software recoding, application programming interface or a mobile computing application. Not creating these well-established and accepted practices in the industry standard software will contribute to the continuing malaise.

LITERATURE REVIEW

This literature review examined the nexus between construction contracting accepted practices and construction software modules.

INDUSTRY CONTEXT

Construction is characterised by factors that affect the schedule, forecasting of resources and quality. It is considered complicated and information critical based primarily on the accuracy of interpreting varied issues based on a professional's body of work (Wu et al. 2012). Prior studies have identified the construction industry's unique working methods as the main barrier to implementing an industry improvement (Dubois and Gadde 2002).

Lean Construction researchers have recognised that expected productivity can decline due to conflicting goals between individual trades and the project (Sack et al. 2010). Hartmann et al. (2012) suggest that project teams must align their work processes to the new "collaborative and integrated ways of working" including using ICT to reach these goals. Contractors – main and sub - typically work with constrained resources to complete different projects simultaneously, making portfolio management a critical skill. The organisation enables well-executed projects. They try to optimise these resources, which requires thoughtful planning to execute interdependent tasks well (Lasni and Boton 2022). Best construction practices help manage multiple processes that must work simultaneously to make a construction firm consistently profitable and raise its position on the Risk-Reward Curve (Stevens 2012). Constant planning, as well as careful schedule monitoring, detailed decision-making, proactive problem recognition and, thus, earlier than needed solutions (Ahuja et al. 1994). However, according to the Australian government, multifactor industry productivity in that country has been stagnant for over two decades (Stevens and Smolders 2023)

A recent technological shift, such as Building Information Modelling (BIM), appears to be re-energising the focus on effective practices, including those considered Lean (Sacks et al. 2018); it enables project stakeholders to plan, design, review, program, cost or manage construction projects. This interactive process enhances the design end product (Kuiper & Holzer 2013). In addition, ICT can improve construction industry operational procedures, particularly planning and control (Martins et al. 2020). The most used goals for contractors revolve around time, cost, quality, profitability, customer satisfaction, safety, and sustainability (Fahri et al. 2015).

Construction managers must interpret and process voluminous data for proper up-to-date decision-making in effectively running a project. Therefore, the project's success depends on the increased reliance on technology. However, individuals' readiness to adopt technology has four dimensions: optimism, innovativeness, discomfort and insecurity. The four are independent; optimism and innovativeness encourage people to use and hold a positive attitude to technological products and services, while a lack of comfort and security prevent their adoption (McNamara, Shirowzhan & M.E. Sepasgozar 2022).

The research literature does not contain a rigorous review of ICT Technologies applied in the construction industry, although several have been proposed. There has been a fluctuating decline in articles since 2002, resulting in fewer publications in 2015. (Adwan and Al-Soufi 2016). Additionally, minimal research has been conducted to capture the issues barring technological adoption among small firms (Clermont et al. 2020) to help them identify their real needs and wants, including their challenges. This identification can help companies make changes and better address pressure from competitors (Lasni and Boton 2022).

Software Development and Upgrading Hurdles

Today, software development is conducted in a chaotic environment. For example, Holmstrom et al. (2012) found disordered and dynamic markets, complicated and uncertain customer demands, shorter development cycle time pressures, and Moore's Law effects in most software development projects. Notably, nine barriers in the industry dampen construction innovation, Also, this results in suboptimal investment in new ideas, including software development (Stevens and Smolders 2023).

There is no standard software development process due to the differing characteristics of the organisations, products, and projects. The process is contingent on the knowledge and experience of the software Research and Design staff and the organisational guidelines, including the economic ones they must work within (Choi et al. 2017). In many software development firms, product managers struggle to get well-defined customer perceptions, needs and wants. Often, software value and utility validation occur after deployment. Furthermore, learning from customers is neither typically formalised nor continuous. As a result, the selection and prioritisation of utilities become suboptimal, and products are misaligned from what the customers need or want (Fabijan 2015). Literature has established that the lack of programming management commitment has been one of the top reasons for the failure of Software Process Improvement (SPI) (Abrahamson 2000ba). Their framework defines the levels of success achieved in SPI initiatives.

Agile software development is well-known for its focus on the customer. However, while it has succeeded in developing strong programming, there is an urgent need to understand customer use, perceived value, and shortcomings. Continuous deployment is delivering functional software consistently to customers while learning extemporaneously about customer usage. However, the transition towards short-cycle deployment involves several barriers (Holmstrom et al. 2012). Abrahamson (2000b) suggested five dimensions to gauge the success achieved in SPI: (1) project efficiency, (2) impact on the process user, (3) business success, (4) direct operational success and (5) process improvement fit. These were adapted from the project management literature and support Lean Construction principles.

Some existing implementation theories in construction management advocate "technology push" implementations during which current construction practices need to be radically changed to align with software functionality. Others advocate using well-accepted construction management planning, execution and measuring processes (Hartmann et al. 2012). Mobile Computing Apps appear to be part of the march toward better solutions for practitioners of all industries. Singularly focused individuals can author them and do not have to be integrated with other software modules (Weichbroth, P. 2020)

However, despite this literature, most software programs have been deemed insufficient to meet user requirements. Several comprehensive studies have been conducted to determine usability. The Software Usability Measurement, Inventory (SUMI) survey is specific to answering value-oriented questions. It uses 50-questions making use of five defined subscales for a) Efficiency, b) Affect, c) Helpfulness, d) Control and e) Learnability for querying users' attitudes toward the software. The work on SUMI began in 1986 by Kirakowski, who was entrusted with a project with two objectives: To examine the competence scale of the Computer User Satisfaction Inventory and to achieve an international standardisation database for a new questionnaire.

LEAN CONSTRUCTION SOFTWARE

Toyota's success was no accident. It has been cultivated through high-quality design, unyielding innovation, and bold moves. Their products have met their customer's needs and wants (Womack et al. 2007). Construction Software Developers should adhere to Lean Principles. Seeking perfection is understood as permanent incremental (kaizen) or radical (kaikaku) improvements, eliminating waste and improving value for the client. To achieve perfection, the product and its production process shall be highly specified as content, sequence, timing, and outcome (Spear and Bowen, 1999).

Lean Construction Management (LCM) targets value improvement by eliminating waste. This manifests in less wasted time, better cost performance, and more profit (Fernandez-Solis et al. 2012). Numerous ICT applications have been developed to achieve Lean Production goals in the Construction Industry. Sacks et al. (2010) proposed computer-enabled visualisation to support lean construction by making the whole construction process transparent ("exposing rocks in the lake") called VisiLean, which provides the construction team with a Lean production management system integrated with Building Information Modelling. Another application is KanBIM which supports Lean workflow control on construction sites facilitating short-cycle work planning and monitoring, visualising the age of tasks planned and the status of work in process. Additionally, SetPlan captures information from a BIM model and displays it in a dashboard that supports project participants in developing "one source of truth" for objects as the design unfolds. Ponz-Tienda and colleagues created in 2015, an integrated spreadsheet that computes and visually represents critical information from the Last Planner System for production control. Lastly, SimpLean facilitates the coordination of activities, staff and resources. The software operation mechanism enables the application of Lean Construction concepts, including the Last Planner® System (Dave et al. 2016). Notably, Lean researchers' software development is mostly project focused and does not assist organisational-wide processes such as work acquisition or project portfolio management (Lean Enterprise). A quick search on SCOPUS of the phrase "construction AND project AND software" querying titles, keywords, and abstracts produces 10,995 papers. Contrast that with the words "construction AND software AND organisation or firm or company" results in 5,001 articles. The selected practice featured in this article mainly serves the organisation in the acquisition, planning and execution of the multiple projects they construct each year.

LEAN CONSTRUCTION CONTRACTOR PRACTICES

Stevens and Smolders (2023) listed the following practices as efficacious for construction contracting operations. In this listing, the researcher has added the Lean effect each practice has on productivity.

1. *Dual Overhead Rate Application* – a methodology that precisely assigns overhead (Office G&A) cost to site labour, equipment, material, and subcontractors. This is used in both project estimating and job cost reporting. Accurate costing improves Tender success and flows through to job cost and project return on investment. This reduces wasted work acquisition efforts and gives a project's construction cost.

2. *Job Sizing Adjustment* – adjusting overhead due to the project size variation - the difference from the average job size of the company on average jobs - based on banking and industry data.

Accurate costing improves Tender success and flows through to job cost and project return on investment. This reduces wasted work acquisition efforts.

3. *Predictive Tender Modelling* – a competitive practice that determines a competitor's price from history. It utilises all the factors a constructor uses to adjust their price and systematises the process so the company does not grossly underbid. In other words, using it helps contractors leave less margin between their price and the competitors. Less time predicting and surmising where competitors will price a project and "leaving less money on the table" in a winning bid improves profitability. This reduces wasted work acquisition efforts.

4. *Forecasting Project Resource Demand* – limited and shared inputs such as cash, craftsperson, managers, and equipment must be placed where they produce the most benefit across the projects a constructor will build simultaneously. Forecasting from 6 weeks to 6 months ahead allows executives to ensure share resources are available when needed. In addition, contractors manage multiple projects at a time with limited resources. Therefore, getting more done with the same inputs positively impacts the company and its clients. This reduces wasted resources from quick decisions since planning starts six weeks in advance.

5. *Unit-Based Project Reporting* – utilises a count-based number for all products installed in a building. Units include each for doors or toilets, square meters of concrete forming, cubic meters of concrete or excavation, and linear meters of handrail or coping. This allows precise progress determinations and billing calculations while encouraging quality completion of each unit. A method to estimate, cost and administrate projects more precisely. Less conflict, especially in monthly pay requests. This reduces arguments (wasted time) about physical progress, thus, provides monthly payment justification.

6. *Task Completion Monitoring and Measuring* - all tasks to be completed are listed electronically and assigned to the responsible employee, such as planning or budgeting tasks. Construction firms may allocate many functions to the project manager for the job. Monitoring and measuring completion timeliness increases adherence. Teams build projects. Individual members complete critical tasks such as planning or procuring are best done in a pre-determined order. Accomplishing these tasks ultimately and timely increases multifactor productivity. This reduces wasted time and effort by keeping employees focused on critical tasks.

7. *Staff Load Balancing* – using a dozen or more factors, such as the number of duties, new clients, meetings, and project distance, to determine the relative utilisation of each staff member to ensure a relatively equal workload. People are the enabler of safety, quality, and productivity. Overloaded staff make mistakes; thus, rework negatively affects critical outputs. Employees feigning "overwhelm" is a character problem that should be addressed immediately. This keeps wasted time – underutilisation of some employees and overburdening of others – to a minimum.

8. *Project Site Material Laydown Planning and Logistics* – since approximately 70% of lost time is due to material logistics factors such as delivery timing, counts, product quality and handling, this is a critical practice to improve productivity. Since approximately 70% of lost time is due to material logistics, i.e., timely delivery, counts, quality, and handling, it is critical to pre-plan onsite material storage, handling, and flow. This reduces wasted worker time and effort handling material on the job site.

METHODOLOGY

The paper examines software information to understand the gap between the eight selected practices and the functionality of construction software modules. The user guides were reviewed for vocabulary and functions described in the chosen practices. In addition, the researcher selected a contemporary evaluation framework for software. The researcher decided not to list the specific brands of construction software (user guides) reviewed. This was done for fairness until a more complete and thorough review of the programs can be executed.

The selection of the leading software was executed using two factors: a) the popularity of construction software via an internet search (multiple rankings were considered) and b) industry communication with three experienced executives. This was not meant to be exhaustive or conclusive but a starting point for further research. This paper did not disclose the companies or products due to the nature of the methodology used and the limited data collected.

The selection of practices was determined by consultation with the same executives and the researcher's experience. These eight processes aligned with project operations as well as organisational throughput. More specifically, three were work acquisition, four were project portfolio management, one was project operation, and one was financial management. Generally, these could be considered practices that apply to all sizes and types of construction contractors. Importantly, each practice helps construction firms manage better and stay in business. Stated another way, these practices positively affect a company's risk/reward ratio.
The more mature software developer and contracting firms (existing for 20 years or more) appear to have developed the programming jointly for the flexibility needed. This supports a general perception of the construction executives interviewed and the researcher's experience.

In our research approach, we interview three people with executive-level experience.

- Executive 1 – Construction Contracting Firm Majority Shareholder and Managing Director. They have 20 years of experience in Main Building Work. Clients include national brands, universities and local entrepreneurs.
- Executive 2 – Retired Construction Contractor Firm Owner and Managing Director. Active in academia for an Australian Construction Management Program.
- Executive 3 – A person with over ten years of construction technology selection and implementation for construction contracting firms; still active in the industry but pursuing a PhD in BIM and related strategies.

We asked each executive the following:

- Six demographic questions, such as position and years of experience, and software use, such as weekly hours and discipline focus
- Presented the practice statements and queried for each item its strength - none, low, medium and high
  - The value of the practice
  - The performance of this practice by their firm
  - How strongly is it embedded in the firm's software

RESULTS OF USER GUIDE REVIEW AND EXECUTIVE INTERVIEWS

The results show that none of the eight practices was supported to a significant degree in the surveyed programming modules, as evidenced by the user guides and three knowledgeable industry professionals. However, we did not disclose the names of the software packages for confidentiality and legal considerations.

- Dual Overhead Rate Application - Three Leading Work Acquisition Packages - A supporting function was not found, nor were the executives aware of a software module(s) that offered this.
- Job Sizing Adjustment - Three Leading Work Acquisition Packages - A supporting function was not found, nor were the executives aware of a software module(s) that offered this.
- Predictive Tender Modelling - Three Leading Work Acquisition Packages - A supporting function was not found, nor were the executives aware of a software module(s) that offered this.

- Forecasting of Project Resource Demand - Three Leading Project Operations Management Packages - A supporting function was not found, nor were the executives aware of a software module(s) that offered this. Some packages can capture many variables, compute them and place them in a customer report.
- Unit-Based Progress Reporting - Three Leading Project Operations Management Package - A supporting function was not found, nor were the executives aware of a software module(s) that offered this. Some packages can capture many variables, compute them and place them in a customer report
- Task Completion Monitoring and Measuring - Three Leading Project Operations Management Packages - A supporting function was not found, nor were the executives aware of a software module(s) that offered this. One package can capture many variables, compute them and place them in a customer report.
- Staff Load Balancing - Three Leading Project Operations Management Packages - A supporting function was not found, nor were the executives aware of a software module(s) that offered this.
- Project Site Laydown Planning and Logistics for Material Installation -Three Leading BIM Packages - BIM software can represent this virtually or in print, depending on its the operator must capture the information and master the skills to produce it. However, there is no construction site-operations focus, i.e. 4D is scheduling, 5D is costing, 6D is sustainability, and 7D is facility management.

FUTURE INDUSTRY SURVEY

The researchers have created a survey and will recruit industry professionals. The researchers are applying to our university's Human Ethics committee for approval. The survey

- Asks nine demographic, such as position and years of experience, and software use, such as hours per week and discipline focus.
- Presents the practice statements and queries for each item below in none, low, medium and high
    - The value of the practice
    - The performance of this practice by their firm
    - How strongly is it embedded in the firm's software
- (Asks) What needed practices are not in the software you are familiar with? (text response)
- What mobile computing applications (Apps) are needed? (text response)
- Are any other thoughts you would like to share? (text response)

From this data, the researchers will have evidence of current construction contractor software's general value and utility in work acquisition, project operations, financial management, and building information modelling.

DISCUSSION

Lean Construction asserts that perfection serves the client's wants and needs. Toyota continues to delight its customers with vehicles (and houses) that provide "value for money". In economic recession or growth, the company is focused on perfection. Unfortunately, software developers appear not to have accomplished this goal for construction contractor users.

Software businesses, in general, are economically oriented, like most for-profit organisations. They appear to be falling short of providing high levels of usability and, thus, value. However, mature construction software developers have standardised many unique client requests. Their construction clients seem to have found "workarounds" to perceived gaps. Comments from executives suggested that developers may use construction software programming in other industries under different names. In the short term, this paper asserts that little reprogramming is needed for the construction industry's ICT to support proven practices. They appear to exist primarily in construction companies' authored Excel templates. Hartmann et al. noted (2012) that existing project management best practices guide understanding and supporting BIM implementations at the operational level of an organisation. Also, a group of researchers have advocated for tailoring software to support best practices for over a decade.

Focusing software programming on construction contracting firms' overall operational practices is a slight departure from the project orientation that has been a consistent trend in academia and ICT. This paper asserts that the construction organisation is an enabler of the project outcomes while building other projects simultaneously. Critically, the contracting firm supports the project team, i.e., with office personnel assistance, their experience, coordination of company assets, and enforcing contract terms and conditions. Project teams can be likened to residing on an island where the limits of resources are constrained to the area they occupy. Those in the corporation can connect the project team to capable resources facilitating task completion safer and faster with higher quality. So, systematising company-wide practices with the support of ICT can minimise or eliminate stubborn problems such as efficient resource allocation. Software developers should be incentivised to fill the hypothesised gaps with increased sales.

This paper's selection of effective practices represents critical contractor operational functions – Work Acquisition, Project Operations and Financial Management; not available in one package. Thus, software brands investigated were more than one type. Since the gaps appear consistent across developers and specialised software, there is credible evidence of the gap hypothesised. Importantly, these practices were selected because they generally satisfied the SUMI, SPI and Lean principles.

Some SME contractors rely on customising computer spreadsheets to calculate the supporting information needed to execute some practices. In contrast, others are unaware of the methods or have not taken this additional step. This apparent inconsistent application and execution can be improved by software developers creating interfaces that raise sufficient practice use levels.

Lastly, this previously documented gap in most software (all industries) raises the question, "What else has been overlooked in the programming of construction software now and in the future?" The researcher senses that there is a need for an association-sponsored panel for each construction segment. It might formally report on best practices to enlighten the industry and software developers.

SUMMARY AND CONCLUSIONS

Construction contracting software has the potential to solve the industry's stubborn problems, such as disproportionately high bankruptcy rates and stagnant multifactor productivity. The sources of these issues are many; however, this paper asserts that tailoring construction software to enable effective practices could lessen these problems. This paper documents a review of user guides and informal industry interviews to examine a significant blind spot in the construction industry. Developers have chaotic industry challenges regardless of industry.

The paper hypothesised that a significant gap exists between leading construction software modules and well-accepted practices. This assertion appears credible from interviews and a cursory examination of construction software information catalogues (however, we did not review the working software). Furthermore, the construction software industry seems chaotic and has commercial priorities, such as revenue generation and income diversity. Added to that, mobile computing applications are rapidly filling market voids. Finally, the beginning practices suggested have existed for decades and are considered valuable by many industry professionals showing a blind spot for programming.

ICT researchers have a substantial interest in future possibilities. However, some backfilling seems necessary to make the industry safer, more predictable, reduce costs and produce more value. Of course, realising software's full potential now helps many stakeholders, including workers and contractors, become safer and more efficient while delivering higher quality to society. Also, software firms grow their business. This paper attempts to point toward an alignment of software that can provide value to the industry.

The researcher's future investigation will include interviews and online surveys querying professionals' perceptions of the utility and value of their software and its functionality for supporting the eight selected practices. Specificity, the questionnaire will include brand names and articulated construction processes. A complete exam of product information, including user guides that demonstrate support for the chosen methods, and thus, a more substantial conclusion should be confidently made.

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REFERENCES

Abrahamsson, P. (2000a) 'Is management commitment a necessity after all in software process improvement?' Proceedings of the 26th Euromicro Conference. EUROMICRO 2000. Informatics: Inventing the Future, pp. 246-253 vol.2, doi: 10.1109/EURMIC.2000.874425.\

Abrahamsson, P, (2000b). Measuring The Success of Software Process Improvement: The Dimensions. Eurospi'00, Copenhagen, Denmark. https://doi.org/10.48550/arXiv.1309.4645

Andújar-Montoya, M., Galiano-Garrigos, A., Echarri-Iribarren, V., & Rizo-Maestre, C. BIM-LEAN as a methodology to save execution costs in building construction-An experience under the Spanish framework, Appl. Sci. (Switz.) 10 (6) (2020) 1–21, https://doi.org/10.3390/app10061913.

Australian Bureau of Statistics (ABS) (2022), '8165.0 Counts of Australian Businesses, including Entries and Exits, June 2017 to June 2022'

Adwan, E. & Al-Soufi, A. (2016) A Review of ICT Technology in Construction (November 22, 2016). International Journal of Managing Information Technology (IJMIT) Vol.8, No.3/4, Available at SSRN: https://ssrn.com/abstract=3237181

Ahuja, H. N., Dozzi, S.P.and AbouRizk. S.M. (1994). Project management: Techniques in planning and controlling construction projects. New York: Wiley

Choi, S., Kim, S., & Kim, J. (2017). A Technique Identifying Reusable Software R&D Process Assets for Software Process Tailoring. International Information Institute (Tokyo). Information, 20(10B), 7857-7864.

Clermont, S., Lefebvre, G. and Boton. C. (2020). "Understanding the diffusion of building information modeling among contractor SMEs in the Quebec construction industry." In Proc. of the 38th Int. Con. of CIB W78, 762–772. Luxembourg: Luxembourg Institute of Science and Technology.

Dave, B., Kubler, S., Främling, K., & Koskela, L., (2016) Opportunities for enhanced lean construction management using Internet of Things standards. Automation in Construction, Volume 61, Pages 86-97, ISSN 0926 5805,https://doi.org/10.1016/j.autcon.2015.10.009.

Dubois, A., & Gadde, L. (2002). The construction industry as a loosely coupled system: Implications for productivity and innovation. Construction Management and Economics, 20(7), 621-631. doi:10.1080/01446190210163543

Fabijan, A., Olsson, H.H., Bosch, J. (2015). Customer Feedback and Data Collection Techniques in Software R&D: A Literature Review. In: Fernandes, J., Machado, R., Wnuk, K. (eds) Software Business. ICSOB 2015. Lecture Notes in Business Information Processing, vol 210. Springer, Cham. https://doi.org/10.1007/978-3-319-19593-3_12

Faghihi, V., Nejat, A., Reinschmidt, K. & Kang, J. (2015) Automation in construction scheduling: a review of the literature, Int. J. Adv. Manuf. Technol. 81 (9–12)1845–1856, https://doi.org/10.1007/s00170-015-7339-0.

Fahri, J., C. Biesenthal, J. Pollack, and S. Sankaran. (2015). "Understanding megaproject success beyond the project close-out stage." Constr. Econ. Build. 15 (3): 48–58. https://doi-org.ezproxy.uws.edu.au/10.5130/AJCEB.v15i3.4611.

Fernandez-Solis, J., Rybkowski, z., Lavy, S., Porwal, V., Lagoo, N., Son, K., &Shafaat, A. (2012) Survey of motivations, benefits and implementation challenges of Last Planner® system users, J. Constr. Eng. Manag. 139 (4) (2012) 451, https://doi.org/ 10.1061/(ASCE)CO.1943-7862.0000606.

Hartmann, T., Van Meerveld, H., Vossebeld, N., & Adriaanse, A. (2012). Aligning building information model tools and construction management methods. Automation in construction, 22, 605-613.

Hayat, H., Lock, R., & Murray, I. (2015). Measuring software usability. Department of Computer Science, Loughborough University

Holmström Olsson, H., Alahyari, H., Bosch, J. (2012). Chapter 1 Climbing the Stairway to Heaven. In: Bosch, J., Carlson, J., Holmström Olsson, H., Sandahl, K., Staron, M. (eds) Accelerating Digital Transformation. Springer, Cham. https://doi.org/10.1007/978-3-031-10873-0_2

Kuiper, I & Holzer, D 2013, 'Rethinking the contractual context for Building Information Modelling (BIM) in the Australian built environment industry.', Australasian Journal of Construction Economics and Building, vol. 13 no. 4, pp. 1-17, DOI 10.3316/informit.777556446153900.

Lasni, A., & Boton, C. (2022). Implementing construction planning and control software: A specialised contractor perspective. Journal of Construction Engineering and Management, 148(9) doi:10.1061/(ASCE)CO.1943-7862.0002330

Martins, S. S., Evangelista, A. C., Hammad, W.A. Tam, V. W. Y, and Haddad, A. (2020). "Evaluation of 4D BIM tools applicability in construction planning efficiency." Int. J. Constr. Manage. 1–14. https://doi-org.ezproxy.uws.edu.au/10.1080/15623599.2020.1837718.

Matt, D.T., and Rauch, E. (2014) Implementing lean in engineer-to-order manufacturing, in: V. Modrak, P. Semanˇco (Eds.), Handbook of Research on Design and Management of Lean Production Systems, IGI Global, 2014, pp. 148–172, https://doi.org/ 10.4018/978-1-4666-5039-8.ch008.

McNamara, AJ, Shirowzhan, S & M.E. Sepasgozar, S (2022) Investigating the determents of intelligent construction contract adoption: a refinement of the technology readiness index to inform an integrated technology acceptance model, Construction Innovation, DOI 10.1108/ci-10-2021-0191.

Sacks, R., Eastman, C., Lee, G., & Teicholz, P. (2018). BIM handbook: A guide to building information modeling for owners, designers, engineers, contractors, and facility managers. John Wiley & Sons.

Sacks, R., Radosavljevic, M., & Barak, R. (2010) Requirements for building information modeling based lean production management systems for construction. Automation in

Construction. Volume 19, Issue 5, Pps 641-655. ISSN 0926-5805,https://doi.org/10.1016/j.autcon.2010.02.010.

Spear, S. and Bowen, H. (1999). Decoding the DNA of the Toyota production system. Harvard Business Review, sept-oct, 96-106.7862.0000102

Stevens, M. (2012). The Construction MBA: Practical Approaches to Construction Contracting. McGraw-Hill. NewYork.

Stevens, M. & Smolders J. (2023) Understanding Australian Construction Contractors: a guide for emerging professionals. Routledge. London.

Weichbroth, P. (2020) "Usability of Mobile Applications: A Systematic Literature Study," IEEE Access, vol. 8, pp. 55563-55577, 2020, doi: 10.1109/ACCESS.2020.2981892.

Womack, J., Jones, D. & Roos, D. (2007) The Machine that Changed the World. Simon and Shuster. New York.

Wu, J. W., Tseng, J.C. Yu, W.D., Yang, J.B., Lee, S.M., and Tsai, W.N. (2012). "An integrated, proactive knowledge management model for enhancing engineering services." Autom. Constr. 24 (Jul): 81–88. https://doiorg.ezproxy.uws.edu.au/10.1016/j.autcon.2012.02.006.