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EVALUATING THE USABILITY OF THE LEANBUILD SOFTWARE APPLICATION AFTER THE DESIGN STAGE

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ABSTRACT

Industries are experiencing a new paradigm shift driven by advanced digitalization, automation, smart technologies, and the internet of things. Lean construction (LC) advocates have been promoting the adoption of existing and emerging technologies through Lean construction 4.0 (LC 4.0). This paper presents an opportunity for the adoption of smart digital technologies in the construction industry in the form of "LeanBuild project management software".

This paper aims to evaluate the usability of the LeanBuild software after the design stage of development. This paper evaluated the ease of use and effectiveness, and assessed the comprehensiveness of the software design flow. Focus groups, questionnaire survey and interviews were conducted with industry practitioners, academics, and software/IT professionals.

The results suggest that the incorporation of data privacy and security, modules for designing and tracking modular and off-site construction, tools for calculating carbon footprints and sustainability, and artificial intelligence, will improve its usability and provide more value to end-users. The paper concludes that while the LeanBuild software has some limitations in terms of scope and functions, it is generally easy to use and effective for its intended users. The study provides insights for software developers to design more user-friendly project management software.

KEYWORDS

Lean construction, digitalisation/technology, project management, software usability test.

INTRODUCTION

Industries are experiencing a new paradigm shift as a result of the rapid growth of technology and its applications, tagged the "4th industrial revolution"; this shift is primarily driven by advanced digitalization, increased automation, smart future-oriented technologies, and the internet of things (Hamzeh et al., 2021). The construction industry is not left out in this socio-economic trend of the fourth industrial revolution as it aims to deploy new information and communication technologies (ICT) (Gimenez et al., 2022).

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Consequently, the construction industry is facing a restructuring crisis that is based on rethinking and focusing on reforming current production processes and workflows to improve both the production process and the product. The crisis has been facilitated by advances in information technology, which have been promoted as the primary enabler of process reengineering in the construction industry (Gimenez et al., 2022; Love et al., 1996).

There has been a strong advocate for the adoption of existing and emerging technologies as the architecture, engineering, and construction (AEC) sector is yet to fully profit from the established and emerging technologies that characterize the fourth industrial revolution. (Sawhney & Odeh, 2020; Hamzeh et al., 2021, Li et al., 2012). To this end Hamzeh et al., (2021) proposed a change to Lean Construction 4.0 with a focus on maintaining the people-processes-technology synergies between production management theory and digital/smart technology. LC 4.0 is the integration of digital technologies into the construction process (Hamzeh et al., 2021).

Studies have shown a low level of innovation, a lack of collaboration, and limited knowledge sharing in the construction industry (Musa et al., 2019, Alashwal et al., 2011, Ahmed et al., 2017, Xue et al. 2014). The studies noted that investment in Research and development (R&D) and intangible assets (such as new processes) is low (Egan, 1998) due to uncertain demand for new goods, limited collaboration (Musa et al., 2019, Namadi et al., 2017), and low transfer of technology from academia to industry. However, recently, there has been a strong interest to harness the power of innovation through the adoption of digital/smart technologies in LC community. The growth of automated construction is gaining traction as a radical new way of adopting digital tools and technologies

Although many innovative solutions are already being applied on a small scale albeit in few countries, yet the industry still needs large-scale applications or better adaptation of current technological developments. As LC 4.0 advocates for the integration of ICT in the construction industry, it is worth noting that transforming the current construction business model would be difficult without the adoption of innovations, technologies, and techniques by all construction stakeholders. The introduction of new technologies, almost always has an influence, whether favourable or unfavourable. The use of Target Value Delivery (TVD) in many projects throughout the world has had a wide-ranging influence on various parts of those projects (Musa, et al., 2016).

TVD as a Lean practise can serve as a strategic pathway for adopting LC, to eliminate waste and satisfy clients' expectations (Musa, 2019, Musa, & Pasquire, 2020). TVD is an innovation that aims to create value for the stakeholders by reducing waste and ensuring all aspects of the construction process are carried out with the stakeholder’s agreed targets in mind; cost, quality, standards, time, and stakeholders’ value (Musa, 2019).

This paper presents one of the opportunities for the adoption of smart digital technologies in the construction industry in the form of software, "the LeanBuild project management software." The software aimed to manage various types of projects and is currently being developed and digitized from a framework that emulates TVD principles and values called Framework for Implementing Target Value Delivery (FFITVD). The concept involves the development and deployment of computer software. Presently, the discovery phase of the software development has been concluded. The discovery phase is an important stage in the software development process, during which the goals, objectives, and requirements of the project are identified and defined (Khalimonchuk, 2022). All the necessary software requirements for each project phase, from initiation to closing were considered, and TVD and the traditional construction approach were integrated into the user interface designs. Thus, this necessitate the need to measure the degree of effectiveness and acceptance of the software designs.

Research Gaps

Despite the growing interest in adopting digital technologies in the construction industry, there is still a lack of large-scale applications or better adaptation of current technological developments. Additionally, while many usability evaluations are conducted at the later stage of the software development process, some researchers have suggested that issues surrounding the ease of use of software should be addressed as early as possible, because such issues are considerably cheaper to rectify early in the development cycle (Hornbæk et al. 2007). However, identifying such issues early is difficult in today's software development practice since usability testing is typically segregated from core software development operations. Lárusdóttir (2011) argued that usability evaluation is essential for ensuring that software applications are effective and easy to use for their intended users and that it should be an integral part of the software development process. Finally, although there is various project management software available currently, many are limited in the area of covering the complete lifecycle of a typical construction project.

Aim and Objectives

The paper aims to evaluate the usability of the LeanBuild software application after the design stage of development.

a) To review the literature on current project management software
b) To identify the most common usability problems experienced by users of project management software after the design stage of development.
c) To determine the ease of use and effectiveness of the LeanBuild software application for its intended users after the design stage of development
d) To determine the comprehensiveness of the LeanBuild software design flow

LITERATURE REVIEW

Lean Construction to Lean Construction 4.0

LC is a concept that originated in the manufacturing industry and has been adopted and adapted for use in the construction industry (Koskela, 2000; Musa, 2019; and Daniel, 2017). LC aims to optimize resources, reduce waste, and improve the overall efficiency of construction projects (Musa 2019; Daniel 2017). As an adaptation of Lean production, LC is the application of Lean thinking to the design and production (or delivery, in general) of capital projects (or projects, in general) (Musa 2019).

In construction, the Lean approach has been applied to a wide range of processes, including project design and planning, construction management, and commissioning. Studies have shown that the implementation of LC can lead to significant improvements in the efficiency and quality of construction projects. The development of new digital technologies and the widespread use of the Internet of Things (IoT) has led to the transition from LC to LC 4.0 (Hamzeh et al., 2021). LC 4.0 aims to increase the efficiency and productivity of construction projects while reducing waste and improving quality by leveraging the power of digital technologies. This is achieved by leveraging the data and connectivity provided by digital technologies to better manage the construction process, from design to construction to commissioning and maintenance (Hamzeh et al., 2021).

Some of the major differences between LC and LC 4.0 are the emphasis on data-driven decision-making and the use of digital technologies. LC 4.0 also emphasizes the use of virtual and augmented reality technologies to improve the design and planning processes. This allows for better visualization of the construction process and helps identify potential problems before construction begins.

Project Management and Project Management Software

Project management is the process of planning, organizing, and managing the resources, tasks, and schedules of a project to achieve a specific goal or objective (Project Management Institute, 2017). It involves several activities, including defining the scope and objectives of the project, creating a project plan, identifying and allocating resources, tracking progress and performance, and communicating with stakeholders (Project Management Institute, 2017, Harold, 2017). The goal of project management is to deliver a successful project within the agreed-upon time, budget, and quality constraints (Philpotts, 1996). Effective project management requires the ability to identify and manage risks, as well as the ability to adapt to changing circumstances and requirements (Project Management Institute, 2017). Project management can be aided by the use of tools and software, such as project management software and project management methodologies, such as Agile or Waterfall (Project Management Institute, 2017, Harold, 2017).

Project management software is a digital tool that helps organizations initiate, plan, execute, monitor/control and close projects effectively (Project Management Institute, 2017). There has been a significant increase in the use of project management software in recent years, as it provides numerous benefits over traditional methods of project management. The most common features of current project management software include task management, time tracking, resource allocation, collaboration, project planning, and project reporting (Hoban, 2023). These features help project managers to break down complex projects into manageable tasks, allocate resources and time, communicate effectively with project stakeholders, and track project progress.

However, the current project management software market is highly competitive, and there are a large number of options available, each with different strengths and weaknesses. Choosing the right project management software can be a challenge, and it is important for organizations to carefully consider their specific needs and requirements. As project management software continues to evolve, it will likely become an increasingly essential tool for organizations looking to improve project outcomes. Several challenges have been identified with current project management software, including complexity, limited scope, limited customization, lack of integration, limited access, and concerns about data security and privacy (Goncalves, 2018). The LeanBuild software, which is currently under development, seeking to address these challenges. Despite the availability and implementation of various new and innovative construction technologies, including software, over the past four decades, the construction industry has made slow progress in improving efficiency, due to limited adoption of new technologies among other reasons (Li et al., 2012, McKinsey & Company, 2020).

Usability Testing

Software usability evaluation is the process of evaluating the ease of use and effectiveness of a software application by testing it with a representative sample of users (Lárusdóttir 2011, Dillon 2015, Bruun and Stage 2015). It is an important aspect of software development because it helps ensure that the software is effective and easy to use for its intended users. There are a variety of tools and techniques that can be used to evaluate software functionality and identify opportunities for improvement. These include:

a. Usability testing: This is a method in which users are observed as they complete tasks with the software and data is collected on their performance. This can help identify problems or issues that users encounter when using the software and provide insights into ways to improve the efficiency of the software (Moran, 2019).
b. Heuristic evaluation: This method involves having a small group of experts review the software and identify any issues based on established principles of usability. This can provide valuable insights into the functionality of the software but may be limited in its

ability to capture the perspectives and experiences of a representative sample of users (Ssemugabi & Villiers, 2010).

c. Expert review: This method involves having a single expert review the software and identify usability issues. This can be a useful technique for identifying specific usability issues, but may not provide a comprehensive view of the usability of the software (Harley, 2018).
d. User experience (UX) evaluation: this is a more comprehensive approach to evaluating software usability that takes into account the overall user experience of the software, including factors such as user satisfaction, functionality, and effectiveness (Kaisa and Virpi, 2008).

Studies have shown that early usability testing is a key factor in determining whether a software will be designed with users in mind or not (Lárusdóttir 2011). Users are more likely to adopt and continue using software that is easy to use and effective for their needs. User interface design, plays a crucial role in determining the efficiency of the software. A well-designed user interface can make the software easier to use and more intuitive, while a poorly designed user interface can make the software confusing and frustrating to use. All these are dependent on early usability testing.

METHODOLOGY

The research methodology adopted for this study is a combination of qualitative and quantitative methods. Integrating the two methodologies will not only give various viewpoints on the study's research aim and objectives, but it will also improve the quality and depth of the entire research process and findings (Bouma 2000).

The usability testing was carried out in the United Kingdom and Nigeria and the process included focus groups discussion, questionnaires and interviews. It has been argued that the focus group approach is a quick and inexpensive way to get information from experts and users. It can give content-rich, qualitative data and highlight findings that would be difficult or expensive to get using other approaches (Kontio, et al., 2004).

Focus group discussions: Three sets of focus group discussions (one face-to-face and two online/virtual focus group discussions) were held with a total of 33 participants to gather qualitative data about the usability of the software application. The focus group discussions were used to obtain the participants' opinions, preferences, and experiences with the software design. The focus groups aimed to understand how users interact with the software, identify areas for improvement, and gather suggestions for enhancements. By having a group of participants, the focus group discussions allowed for a more interactive and dynamic discussion, encouraging the exchange of ideas and opinions. Holding both face-to-face and online/virtual focus groups allowed the researchers to reach a wider range of participants, and gather data from both in-person and remote users.

Questionnaire survey: The questionnaire survey was used to gather data in a structured and standardized format. The questionnaire survey consisted of a set of questions aimed at gathering feedback and opinions on various aspects of the software's usability, such as ease of use, functionality, and overall satisfaction. The questionnaire survey was conducted using SurveyMonkey, a widely used online survey tool. 29 out of 33 professionals (97%) who participated in the focus group filled out the online questionnaire survey.

Interviews: The interviews were conducted to gather more in-depth and personalized feedback from the participants. Interviews were conducted with about 16 out of the 33 participants in the focus groups. The interviews were recorded with the consent of the interviewees and then transcribed for analysis.

The literature review reveals that previous research has explored various methods to conduct usability testing, including focus groups, interviews, and questionnaires. For instance, Kontio's (2001) study on software engineering risk management utilized interviews to gather information on risk management practices. Similarly, Lehtola, et al., (2004) study on requirements prioritization challenges utilized a questionnaire to collect data from software professionals. Furthermore, Sunikka's (2004) study on the usability evaluation of the Helsinki School of Economics website used a combination of usability tests, interviews, and questionnaires to gather data from users. Therefore, in line with these previous studies, the current study adopts a mixed-methods approach to conduct usability testing. The use of these methods enables a comprehensive understanding of the usability of the software, from both user and expert perspectives, and can inform possible reviews of the user interface (UI) before commencing the development of the software.

The participants in the study included industry practitioners, academics, and software/Information Technology (IT) professionals, providing a diverse range of perspectives and feedback. By combining these different methods, the researchers aim to gather a comprehensive understanding of the usability of the LeanBuild software application and to identify opportunities for improvement.

The responses obtained from the participants (both the focus group, questionnaire and interview) were analysed using descriptive analysis. Inferential statistics were not conducted because the sample size is very small and the purpose of the survey was not for generalisation, but basically to rate the respondents' opinions on the factors of the software.

RESULTS AND DISCUSSION

The section presents the analysis and discussion of the results obtained from this study.

ANALYSIS OF RESPONDENTS

The questionnaire results provide some useful information about the background and experience of the respondents, as well as their familiarity with the internet and software tools, particularly project management software.

The respondents' professional backgrounds and years of experience are presented in table 1.

Table 1: Participants' Professional backgrounds and years of experience

Professional background	% of Respondent	Years of Experience	% of Respondent
Industry Practitioners	72%	Not more than 5 years	21%
Academics	14%	5 to 10 years	17%
Software/IT Professional	14%	10 to 15 years	38%
		More than 15 years	24%

The respondents include industry practitioners, academics and software/IT professionals. In terms of experience, the results indicate that the respondents are fairly evenly distributed across different levels of experience. This suggests that the views and insights of the respondents may be representative of a diverse range of career stages and backgrounds.

The results also indicate that all the respondents have an appreciable knowledge of the internet and the use of software, which is an important factor in conducting online surveys and using software tools for project management. However, it's notable that only 41% of the respondents have used project management software before, which suggests that some

respondents may be less familiar with this type of tool and may need additional guidance or training in its use.

Common Usability Problems Experienced by Users of Project Management Software

Based on the survey and interview results, it is clear that data privacy and security are major concerns for end users. Approximately 83% of the participants recommended that data must be controlled by subscribing organizations to ensure data privacy and security. This indicates that data privacy and security should be a top priority when developing software. To address this concern, the development team would focus on incorporating top-notch security features into the software to ensure the end-users data is secure and protected.

According to the feedback received from the questionnaire, participants suggested that the software should include a budget approval process and a disbursement process. This would enable project managers to track and manage project costs more effectively. This will ensure that budget limits are not exceeded. Another issue raised was that the software should be more colourful and visually appealing. Some respondent noted that the software's current interface is more academic than practical, which could lead to less user engagement. This concern highlights the need for the software to be designed with the end-users in mind, making the interface more visually appealing, and enhancing user experience (Lárusdóttir, 2011).

Additionally, the survey and interview results indicated that there is a need for the software to offer more features and functionalities. Participants noted that the current design of the software has a limited scope and function, which can limit its usability. To address this concern, the development team would consider adding more features and functionalities to the software to provide more value to the end users.

The Comprehensiveness of the LeanBuild Software Design Flow

The questionnaire results suggest that a large majority of the respondents (86%) agree that the documents listed on the project initiation homepage are comprehensive enough to initiate a project, while 14% neither agree nor disagree. This indicates that most of the respondents perceive the listed documents as sufficient for initiating a project. To ensure the comprehensiveness of the documents listed, the researchers compared the listed documents against established best practices and standards for project initiation to determine their adequacy and completeness.

The questionnaire results show that a significant majority of the respondents (83%) agree that the documents listed on the project planning page are all the documents needed for the scope management planning of a project. However, 17% of the respondents neither agree nor disagree, which suggests that they may have some uncertainty or lack of clarity about the completeness of the listed documents. One possible explanation for the disagreement or uncertainty among the respondents could be that they have different levels of experience or expertise in project management or scope management, which may influence their perception of what documents are needed for effective planning. A respondent suggested the addition of an accounting interface and project responsibility flow to the software.

In the case of the cost planning sheet, the majority of the respondents (79%) agree that it represents the standard bill of quantities for a typical construction project. However, a notable percentage (14%) disagreed with this statement, while a smaller percentage (7%) were undecided. Respondents suggested providing a feature for budget approvals, cash flow, and disbursement to manage and control costs. Regarding the TVD user interface, the results indicate that a significant majority of the respondents (86%) agreed that it captures the detailed working principles of TVD. However, a smaller percentage (14%) were undecided. The majority of the respondents (69%) agreed that the TVD "set targets" interface covers all the typical project constraints, while a significant percentage (28%) were undecided. This suggests

that some respondents may not have a clear understanding of TVD principles and its associated constraints, or may need more information to fully evaluate the "set targets" interface. Further clarification and explanation may be needed to ensure that all respondents have a common understanding of TVD and its associated constraints.

In regards to the execution page user interface, a large majority of the respondents (89%) agreed that it captures all the necessary activities for the execution stage of a typical project, while a smaller percentage (11%) were undecided. This suggests that the majority of respondents perceive the interface as comprehensive enough for the execution stage of a typical project. The respondents suggested the addition of task flow and project report interface.

Similarly, for the control schedule page user interface, a significant majority of the respondents (86%) agreed that it captures all the necessary elements for controlling the schedule of a typical project, while a smaller percentage (11%) were undecided, and a very small percentage (3%) disagreed. This indicates that the majority of respondents perceive the interface as sufficient for controlling the schedule of a typical project, but some may have reservations or uncertainty about the completeness of the interface.

Results also show that all respondents agreed that the construction project data model is well represented in the user interface (UI). This is a positive finding that indicates that the UI is effective in presenting the data model to the users (Hornbæk, et al., 2007).

The Ease of Use and Effectiveness of the Leanbuild Software

The questionnaire results indicate that the majority of respondents find the user interface of various project management software clear, easy to understand and implement. Specifically, 93% agreed that the layout of the project initiation homepage and the project planning user interface is clear and easy to understand. Furthermore, 96% agreed that the labels and instructions for using these pages are clear and concise. Regarding the appropriateness of the visual elements used in the user interface, most respondents agreed with the project initiation homepage (75%) and the project planning user interface (81%). However, some respondents (17%) were undecided about the appropriateness of the visual elements used in the initiation homepage UI. This means there is still room for improvement (Dillon, 2014).

Similarly, the cost planning sheet user interface, Set Target user interface, and the execution stage user interface are also clear and easy to understand, with over 90% agreement. Some respondents were undecided about some aspects of the UI, such as the visual elements used in the project planning UI (15%) and the labels and instructions for using the software (15%).

However, when it comes to the design of the UI, the results were somewhat mixed (Bruun, and Stage, 2015). While most respondents found the colours, fonts, and other visual elements used in the project initiation homepage UI to be appropriate, only 75% agreed that they were appropriate for the project planning UI.

This survey result shows that the majority of participants (77%) gave a score of 8 or higher on the recommendation scale, indicating that they are likely to recommend the software to a friend or colleague. 42% of participants gave the highest score of 10, indicating that they are extremely likely to recommend the software. 8% gave a score of 9, which is still a high score. 35% of participants gave a score of 8, which is a somewhat likely score. Finally, 15% of participants gave a score of 7, which is a neutral score indicating that they might recommend the software but with some hesitation.

Overall, the results suggest that the UI is effective in presenting the construction project data model, and the labels and instructions are clear and concise (Bruun, and Stage, 2015). However, some improvements may be necessary for the design of the UI to ensure that it is visually appealing and appropriate for all users.

FINDINGS AND RECOMMENDATIONS FROM INTERVIEWS

The interview results provide valuable feedback and suggestions for improving the LeanBuild software. The figure 1 shows the various suggestions and number of interviewee that made the recommendation.

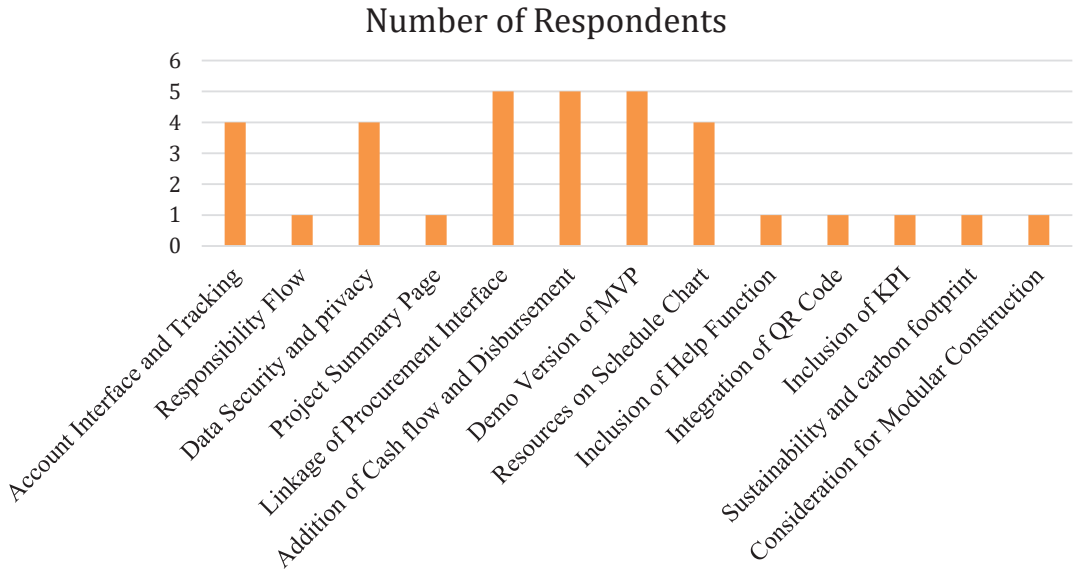

Figure 1: Suggestions and Number of Respondents that Made the Recommendation

Figure 1 shows the recommendations for improving the LeanBuild software. Some of the key suggestions include adding an account interface and tracking feature, defining responsibility flow and linking line management to activities, capturing variation of material and material diversion, providing budget approvals, cash flow, and disbursement, and offering a demonstration version of the software. The respondents also suggested the addition of resources to the schedule tracking chart to show the volume of resources required, and making the Gantt chart flexible enough to accommodate changes. Also the software should include a help function and screen guide; and integrate Building Information Modeling (BIM), Microsoft Project files, QR Codes for inventory management, Key Performance Indicators (KPIs), Artificial Intelligence (AI), sustainability and carbon footprints measurement (Sawhney and Odeh, 2020). The respondents also recommended that a provision should be made to capture the variation of material, and linkage of activities on the procurement interface. Finally, they suggested incorporating the features that support emerging trends in off-site and modular construction. The interview feedback has helped to validate the findings of the focus group and questionnaire survey. It also provides valuable insights into improving the LeanBuild software, and incorporating the suggestions provided would enhance the software's overall effectiveness and user experience.

CONCLUSIONS

The study evaluated the usability of the LeanBuild software application after the design stage of software development. Literature on current project management software was reviewed and the most common usability problems were identified. Attempt was made to determine the comprehensiveness of the design flow, the ease of use and effectiveness of the LeanBuild software application.

The research adopted a hybrid of qualitative and quantitative methodologies which include focus groups, questionnaires, and interviews. Integrating the two techniques not only provided different perspectives on the study's research aim and objectives, it also increased the overall quality and depth of the research process and findings. The study participants/respondents include industry practitioners, academics and software/IT professionals – as such views and insights of the respondents represents diverse range of career stages and backgrounds.

The results show that data privacy and security are important to end-users, and that the software should include a budget approval and a disbursement process. There were also suggestions for additional features, such as an accounting interface and project responsibility flow. The majority of respondents perceive the designed user interface to be sufficient and comprehensive for initiating, planning, executing, monitoring & controlling, and closing a typical project. Overall, respondents find the user interface of the project management software clear, easy to understand, and implement. The majority of participants have a positive view of the LeanBuild software and are likely to recommend it to others, which is a good sign for the software's success.

The implication of this research for researchers and software developers is that the paper has established that it is possible and better to identify usability issues early by conducting early usability test after the design stage. The limitation of the study includes small sample size and limited generalizability. Finally, the paper presented a digital technology that construction experts have been advocating for. This digital technology is a project management software that covers the complete lifecycle of a typical construction project. And also incorporated TVD and traditional construction methodology. The paper has also demonstrated that it is advantageous to conduct early usability test after the design stage of the software development cycle.

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