

EXPLORING USER EXPERIENCE AND EFFECTIVENESS OF AN INNOVATIVE LEANBUILD UK PROJECT MANAGEMENT SOFTWARE: USABILITY STUDY POST DEVELOPMENT STAGE

Muktari M. Musa¹, Emmanuel I. Daniel², Namadi S. Ahmed³, Ifeatu C. Enedah⁴, Momoh Job⁵ and Samuel I. Haa⁶

ABSTRACT

This paper explores the usability and efficiency of the LeanBuild project management software; an innovative solution rooted in Lean Construction 4.0 principles. Through collaboration with the University of Wolverhampton UK, Kingston University UK, and London South Bank University UK, the LeanBuild Limited project presents a promising innovation in the construction industry.

The integration of usability evaluations and user recommendations in software development is limited, despite the importance of usability testing. Even with limited adoption of construction project management software, Target Value Delivery principles are often overlooked. The study employs a mixed-methods approach, incorporating focus groups, questionnaires, and interviews to assess the software's usability. Recommendations gathered from industry practitioners, academics, and IT professionals emphasize the need for improvements such as financial reporting, critical path display, resource assignment features, simultaneous file uploads, BIM integration, enhanced security, and E-Tendering and Marketplace integration.

The paper concludes that despite requiring further enhancements from its minimum viable product, LeanBuild is an effective solution, endorsed by users as a viable and scalable innovation with global applicability for efficient project delivery. This study highlights the importance of post-development usability checks and positions LeanBuild as a significant breakthrough in the construction software landscape.

¹ MD/CEO, LeanBuild Limited, UK muktari@leanbuild.co.uk, macclimited@yahoo.com, orcid.org/0000-0002-9650-3125

² Senior Lecturer in Construction Management, School of Architecture and Built Environment, Faculty of Science and Engineering., University of Wolverhampton, Wolverhampton, UK, e.daniel2@wlv.ac.uk, orcid.org/0000-0002-5675-1845

³ Lecturer, School of Engineering and the Environment, Department of Civil Engineering, Surveying and Construction Management, Kingston University: London, Greater London, GB. s.ahmed@kingston.ac.uk, orcid.org/0000-0002-3815-0683

⁴ Lead Program Manager, LeanBuild Limited, UK ifeatu@leanbuild.co.uk, orcid.org/0000-0002-3101-9658

⁵ Lecturer, School of Engineering and Architecture, Department of Construction, Property, and Surveying., London South Bank University, UK momohj@lsbu.ac.uk, orcid.org/0000-0001-9103-8933

⁶ Program Manager, LeanBuild Limited, UK haasamuel@leanbuild.co.uk, samhaa19@gmail.com, orcid.org/0000-0001-7910-0714

KEYWORDS

Lean construction, Digital Innovation, Project management, Software Usability test, Target Value Delivery

INTRODUCTION

Lean construction (LC) researchers actively advocate the integration of both old and modern technologies within the framework of Lean Construction 4.0 (LC 4.0) (Musa et. al., 2023). In light of the revolutionary changes occurring in the construction sector due to creative digitalization, automation, and artificial intelligence, Lean Construction (LC) has embraced digitalization by utilising both conventional and innovative technology through the use of Lean Construction 4.0 principles.

Recognizing the potential for significant service and delivery benefits, Architecture, Engineering, and Construction (AEC) firms are increasingly embracing emerging construction technologies (McCoy & Yeganeh 2021a). This trend stands in contrast to the historical perception within the AEC sector that innovation disrupts established workflows and leads to inefficiencies (Love et al. 2014). Studies now show that strategic implementation of technologies can enhance collaboration, improve project predictability, and ultimately reduce costs (Azhar et al. 2017). However, challenges remain. McCoy and Yeganeh (2021b) highlight the need for upskilling the workforce and ensuring interoperability between different technologies for successful innovation uptake.. Therefore, there is a strong push for advocating the adoption of these technologies to maximise their potential in the construction industry (Momoh et. al., 2016, Musa et. al., 2023). The concept of LC 4.0 involves the seamless integration of digital technologies into the construction process (Hamzeh et al., 2021). As a result, the adoption of project management software becomes an essential tool to ensure the overall delivery of projects.

Currently, web app development has become a matter of paramount significance for firms as the global economy is experiencing an exponential rise in commercial digitalization. The increasing number of businesses choosing web applications as a means to address societal problems and facilitate service delivery further accentuates the significance of web applications (Agarwal & Venkatesh 2002). This has led to the development of LeanBuild project management innovation; a construction technology software in the UK that aims to optimise user experience and efficiency in the evolving demands of digitised project management. The software is efficient in managing diverse project types. It is leveraging on digitalizing an innovative framework called the Framework for Implementing Target Value Delivery (FFITVD) that aligns with the principles and values of TVD (Target Value Delivery) (Musa et. al., 2023). This is an approach for the automated management of large construction projects to secure cost savings and minimise waste. The digitalization of an innovative framework enhances technological fluidity, and user engagement, and fortifies the framework's intellectual property policies.

TVD is an innovative management approach that applies target cost, quality, and schedule to design to generate value for stakeholders by minimising waste and ensuring that every facet of the construction process aligns with the agreed-upon targets, encompassing cost, quality, standards, time, and stakeholder value (Musa, 2019, Orihuela et. al., 2015, Zimina et. al., 2012). The LeanBuild web app encompasses all essential software requirements for each phase of project management, starting from initiation to closure. It successfully integrates both TVD and the traditional construction approach into the user interface designs. The software is offered on a subscription basis to clients who will be able to manage their construction projects 'end-to-end' using an applied software package which, by its nature, is accessible on any enabled device. As a result, it becomes imperative to evaluate the effectiveness and acceptance of the software provision and properties (Musa et. al., 2023).

To develop a functional technological system for global utility, it is crucial to consider the influence of user experience (UX) within the context of technological innovation (Hassenzahl, 2001). Usability studies, a key component of UX design, aim to identify usability issues, improve the user interface (UI), and ultimately enhance the overall user experience, leading to increased user satisfaction, system adoption, and potentially, even greater innovation (Nielsen, 1993; Rogers, 2020, Desideria & Bandung 2020).

Conducting a usability check on the software has resulted in a significant enhancement by the implementation of the recommendations from participants. It underscores the importance for any developed software to undergo usability testing before launch and implement key recommendations to improve functionality and versatility. This approach ensures the software becomes a viable and scalable innovation for global utility.

RESEARCH GAPS

There is limited integration of usability evaluations of user recommendations before the official launch of the software (Shneiderman et al., 2009). Although there is widespread adoption of various construction innovations, most of the adoptions give little or no attention to the integration of Target Value Delivery (TVD) principles into the construction digitization process. Current literature indicates that the implementation of TVD remains inadequately realized in the construction space, with both organisations and project teams falling short of fully embracing its transformative potential (Musa, 2019, Musa et. al., 2023). While there is an innovative framework for implementing Target Value Delivery (FFITVD), the digitalization of the framework becomes a necessity to enhance the understanding of the framework, digital integration, user validation, and protection of the framework's intellectual property rights. The lack of digitalization of the framework is a shortfall, prompting further innovation to digitize the framework to system that facilitates seamless progression of construction activities, efficient resource allocation, timely production and delivery of project outcomes. Conclusively, there are numerous construction project management software in circulation; several of them lack full coverage of the entire lifecycle of a typical construction project.

AIM AND OBJECTIVES

This paper aims to evaluate and enhance the usability of the LeanBuild software for improved user experience.

- a) To explore the overall user experience of the LeanBuild software, including ease of use, user-friendliness, and satisfaction.
- b) To identify any usability issues that may hinder users from effectively utilising the software.
- c) To gather feedback and suggestions from users for further improvements and enhancements.

LITERATURE REVIEW

EVOLUTION OF LEANBUILD FROM LEAN CONSTRUCTION TO LEAN CONSTRUCTION 4.0

Lean Construction (LC) takes its origin from the practice of the manufacturing industry that has gained adoption in the construction industry (Koskela, 2000; Musa, 2019, Demirkesen, 2021, Daniel, 2017). The target of LC is the full optimization of resources, adequate reduction of waste, and improvement of the entire performance of construction activities (Ahmed et. al., 2018, Nikakhtar et. al., 2015, Musa 2019; Daniel 2017, Francis & Thomas 2019). The

procession in lean thinking forms the basis of LC, which harmonizes design and product delivery for both small and capital projects.

The construction industry's successful integration of Lean practices across a wide range of activities, from design and planning to execution and handover, has laid a strong foundation for further innovation (Babalola et al., 2019; Hamzeh et al., 2021). This evolution is driven by the emergence of modern digital solutions and the increasing utilization of the Internet of Things (IoT) dubbed Lean construction 4.0 (Hamzeh et al., 2021; Ramadan & Salah, 2019). LC 4.0 builds upon Lean principles by leveraging enhanced connectivity through digital technologies for improved construction management throughout the project lifecycle (Hamzeh et al., 2021; Oguntona et al., 2018; Al-Aomar, 2012). A key distinction between LC and LC 4.0 lies in its emphasis on data-driven decision-making and the utilization of advanced technological solutions. While the potential of LC 4.0 is significant, challenges such as a lack of industry-wide standards, workforce upskilling needs, and initial investment costs may hinder its widespread adoption.

PROJECT MANAGEMENT AND SOFTWARE SOLUTIONS IN CONSTRUCTION

Effective project management (PM) ensures construction projects are completed on time, within budget, and meet quality standards (Akintola & Goulding, 2006). It involves strategic planning, resource allocation, task management, and risk mitigation (Project Management Institute, 2017).

Traditional PM methods are giving way to Project Management Software (PMS) due to its advantages. PMS offers features for task & schedule tracking, resource allocation, team collaboration, project planning and progress reporting (Akintola & Goulding, 2006). However, choosing the right PMS can be challenging due to software complexity, limited scope, customization issues, integration problems, access restrictions, and security concerns (Musa et al., 2023; Goncalves, 2018)

Organizations should assess their needs before adopting new technology (Talukder, 2012). Tools like LeanBuild address challenges by offering comprehensive project management functionalities and user-friendly interfaces. Despite advancements in software development, the construction industry faces slow technology adoption (McKinsey & Company, 2020) as a result of the beliefs within the AEC sector and this have impeded the full realization of benefits offered by established and emerging technologies.

SOFTWARE USABILITY TESTING

The efficacy of any software depends on rigorous usability testing, a pivotal phase in software development. Usability evaluations assess user-friendly interactions and evaluate software's effectiveness before deployment (Sadowska & Piętak, 2015, Bandi & Heeler, 2013, Lárusdóttir, 2011, Dillon, 2015, Bruun & Stage, 2015). Thorough usability testing is an essential part of software development that determines how effective any software will be. Software usability assessments determine how user-friendly the interface is and how effective the programme is. Various methods exist for conducting usability tests, including:

- a. Usability testing: In this approach, users are tasked with completing specific assignments using the software, their actions are observed, and the outcomes of their performances are systematically collected. This method identifies the challenge of a user trying the software and suggests an improvement scheme for the enhancement of the software's efficiency. (Moran, 2019, Hasan, 2014).
- b. Heuristic evaluation: This approach involves gathering feedback from a group of experts on the software and identifying challenges through the practice of usability evaluation. The limitation of this approach lies in its inability to capture the comprehensive picture and overall user experience. (Ssemugabi & Villiers, 2010).

- c. Expert review: This method entails obtaining feedback and insights from a single subject expert who reviews and identifies issues related to the software under evaluation. This method proves most beneficial when there is a need to pinpoint a specific issue; however, it falls short of providing a comprehensive overview of the user experience with the software (Privitera, 2019, Harley, 2018).
- d. Evaluation of User Experience (UX): Among all the methods, the UX approach stands out for its holistic nature, encompassing fundamental aspects of user experience such as functionality, efficiency, effectiveness, and overall user satisfaction.(Musa et. al., 2023, Kaisa and Virpi, 2008).

Researchers have established that carrying out usability on time is a key factor in determining whether the software was developed in consideration of the intended users (Lárusdóttir 2011). User experience testing helps in revealing if the software would be adopted by the users based on their reviews, results, and recommendations. From the result of carrying out user experience testing, the user experience (UX) will undergo continuous improvement until the best of the software becomes globally utilizable.

METHODOLOGY

This section details the methodology employed to evaluate the usability of LeanBuild software, focusing on a user-centered design (UCD) approach (Morris et al., 1995). UCD prioritizes understanding user needs and incorporating their feedback throughout the design process to ensure the software aligns with established usability principles. These principles, as outlined by Krug (2000), encompass aspects like learnability (ease of initial use), efficiency (effectiveness in accomplishing tasks), memorability (recalling features after a period of non-use), error tolerance (forgiving user mistakes), and user satisfaction.

The researchers adopted a mixed-method approach, combining qualitative and quantitative data collection techniques to gain a comprehensive understanding of user experiences. This approach goes beyond surface-level data, capturing not only user behavior but also their perceptions, attitudes, and thought processes (Tashakkori & Teddlie, 2010). The study utilized a blend of established usability testing methods: focus groups, interviews, and questionnaires (Musa et al., 2023; Kontio, 2001; Lehtola et al., 2004; Sunikka, 2004).

Usability testing for this research involved participants from the UK (mainly from the University of Wolverhampton's Construction Futures Research Centre UK, the School of Architecture and Built Environment at Kingston University UK, and the School of Engineering and Architecture of London South Bank University UK) and from Nigeria, (predominantly from Brains and Hammers Limited, IBTank Limited, Canon Projects, and Design and Shelters Limited). This research included participants from the UK and Nigeria to capture diverse user perspectives and potential market variations in construction practices. However, to mitigate bias, the study acknowledges potential limitations arising from sample size, cultural differences, and pre-development evaluation involvement of some participants. Focus group discussions: Five sets of focus groups discussions (including two face-to-face sessions and three online/virtual sessions) were held with a total of 25 participants to gather both qualitative and quantitative data on software usability. This group setting allows participants to bounce ideas off each other, potentially revealing learnability issues and areas for improvement in the software's initial user experience (Kontio et al., 2004; Beyea & Nicoll, 2000).

Questionnaire survey: The questionnaire survey was used to gather feedback aspects like ease of use, functionality, and overall satisfaction in a structured and standardized format. 21 out of the 25 focus group participants filled out the online questionnaire survey. The questionnaire survey was conducted using SurveyMonkey, a widely used online survey tool.

This method incorporated elements from frameworks like the User Experience Questionnaire (UEQ) (Sauro, 2011), ensured efficient data collection and facilitated comparison across participants, contributing to an understanding of user efficiency and overall satisfaction with LeanBuild.

Interviews: Interviews were conducted with about 14 out of the 25 participants in the focus groups to gather personalized insights into their experiences with the software application and specific areas of interest raised during focus groups. Prior consent was obtained from the interviewees, and the sessions were recorded to facilitate accurate transcription

The respondents in the study were industry practitioners, academics, and software/Information Technology (IT) professionals. With the combination of these different perspectives, the researchers hope to collect a holistic view of the usability of the LeanBuild software application and initiate paths for continuous improvement of the software. Given the relatively small number of participants (25 in focus groups, 14 in interviews), a descriptive analysis approach was deemed most appropriate. Descriptive analysis focuses on summarizing and describing the collected data, providing valuable insights into user experiences without relying on complex statistical inferences (Creswell & Creswell, 2018). This approach is particularly suitable for smaller sample sizes where statistical tests might lack power or generalizability (Maxwell & Reed, 2004).

RESULTS AND DISCUSSION

This section provides an analysis and discussion of the results derived from the study.

LEANBUILD SOFTWARE PRESENTED

The LeanBuild project management software is a construction technology software that aims to optimise user experience and efficiency in the evolving demands of digitised project management. The software is efficient in managing diverse project types. It is leveraging on digitalizing an innovative framework called the Framework for Implementing Target Value Delivery (FFITVD) that aligns with the principles and values of TVD (Musa et. al., 2023).

The LeanBuild web app encompasses all essential software requirements for each phase of project management, starting from project initiation, planning and design, execution, monitoring and evaluation and to closing. It successfully integrates both TVD and the traditional construction approach into the user interface designs. The software is offered on a subscription basis to clients who will be able to manage their construction projects ‘end-to-end’. Screenshots and demo of the LeanBuild application can be found on <https://leanbuild.co.uk/>

DEMOGRAPHY OF RESPONDENTS

Relevant information was gathered from the administered questionnaire regarding respondents' background, expertise, and familiarity with the use of the Internet and other software tools, particularly project management software.

The professional backgrounds and years of experience of the respondents are detailed in Table 1.

Table 1: Respondents' Professional backgrounds and years of experience

Professional background	% of Participants	Years of Experience	% of Respondent
Industry Practitioners	71%	Not more than 5 years	5%
Academics	14%	5 to 10 years	24%
Software/IT Professional	15%	10 to 15 years	38%
Others	10%	More than 15 years	33%

The analysis shows a varied distribution of experience levels among respondents, representing diverse professional backgrounds. Results indicate 96% possess internet familiarity, and 72% have used project management software, suggesting a majority are acquainted, potentially needing minimal training.

USABILITY CHALLENGES ENCOUNTERED IN PROJECT MANAGEMENT USAGE

The results of interviews and surveys highlighted key challenges in project management software utilisation. About 33% cited restrictions on file uploads, 22% mentioned software complexity and internet dependency. The development team addressed these concerns, streamlining the user interface for ease of use and allowing multiple file uploads, enhancing the overall efficiency of the software.

The study findings highlighted an essential suggestion that, the software's limitations are primarily geared towards the construction industry, leading to one-sided consideration. Addressing this feedback, the software's research and development team, equipped with substantial expertise, skills, and market awareness in the digital construction industry, is aligning lean principles and practices to shape the innovation for a more extensive range of sectors, encompassing construction, manufacturing, and other service-intensive industries.

EFFICIENCY AND INCLUSIVENESS OF LEANBUILD SOFTWARE

The software comprehensively covers the entire project lifecycle, with 100% of respondents attesting to this. While 76% found the project initiation clear, 24% expressed concerns about its focus on construction, limited financial reporting, and lack of quick signposts for estimates. For the planning phase, 90% found it adequate, but 10% raised unspecified potential issues. Additionally, 95% were satisfied with the execution stage, acknowledging it as a representative interface for project implementation. These results indicate the participants' recognition of the software's Minimum Viable Product (MVP) comprehensiveness, incorporating best practices at the execution phase.

The procurement interface received approval from 81% of respondents, while 14% were undecided, and 5% strongly disagreed. Concerns centred around the need for an easy search tool and a notification trigger for material requests. For the schedule interface, 90% agreed it encompassed all necessary elements, with 10% undecided. Suggestions included features on the Gantt chart for resource assignment and highlighting the critical path in red for better visibility. The development team valued these recommendations, enhancing the software to include resource assignment options and highlighting essential paths.

The cost interface received recognition from 95% of respondents for its adequacy, while 5% neither agreed nor disagreed. Suggestions included enabling direct uploads of BIM-enabled drawings and files for better transparency. For the closing interface, 90% acknowledged its efficiency, but 10% strongly disagreed, emphasising the need for a snag list and defective liability period. The development team carefully considered these suggestions, integrating them into the software before its official launch.

The project feed integration is a strategic innovation to enhance project team efficiency. 95% of respondents affirmed its benefits in interactive communication, collaboration, and coordination, while 5% did not disclose sentiments. Other suggestions for improvement included generating comprehensive downloadable reports, compatibility with files from other software, and a feature for efficient resource allocation management..

USABILITY AND EFFECTIVENESS ASSESSMENT OF LEANBUILD SOFTWARE

The questionnaire results indicate that most respondents find the project management software easy to use beginning from the signup interface. The software's label, instructions, and functionality were distinct with simple applicability as 100% of the respondents admitted to the clarity of the software's navigation and functionality.

Concerning the suitability of the software interface's visual appearance, 90% of respondents concurred that the visual representations employed for all project phases are visually appealing. Additionally, 100% acknowledged the clarity and lack of ambiguity in the tooltips and instructions for utilising the software. Extensive research contributed to the current visual presentation of the software, and the development team remains committed to making continuous improvements to enhance the visual aspects of the software.

The software's project dashboard serves as a comprehensive summary of any project, with 81% of respondents affirming that it encompasses all essential features of a typical project dashboard. However, 14% remained undecided, and 5% strongly disagreed with the suitability of the project dashboard interface. Some respondents suggested the addition of TVD and traditional methods to the software project dashboard. The dissatisfied respondents expressed reservations, noting that the dashboard seemed limited to construction activities and suggested adding features for accounting, procurement, and other reporting summaries.

INNOVATIVENESS OF LEANBUILD SOFTWARE

94% acknowledged LeanBuild's groundbreaking advancement compared to traditional project management software, with 6% not expressing their views. 78% find Target Value Delivery (TVD) Path the most innovative, 11% prefer project feeds, and another 11% highlight control procurement. Overall, 100% of the respondents agreed that the innovation covered the full cycle of a project from initiation to closing. These results align with the software's integration of lean construction practices, making TVD the most perceived innovative feature. What makes this software innovative is that the norm of large construction projects in the UK for 'packaged' management has primarily been a process known as the traditional method. The inclusion of TVD in the software has substantial advantages over traditional approaches and has identified no current directly competing offerings available in the UK.

The findings highlight the effectiveness of the UX in facilitating construction project execution, aligning with (Bruun and Stage 2015). Ongoing enhancements are necessary for comprehensive software development, including aspects like the financial interface, plugins, multiple security factors, and integration of BIM, E-Tendering, and Market Place Integration. As there is a need to meet the fast-growing market for improved management of ever more complex construction projects requiring sophisticated applications to support delivery, The software is unique in its ability to cover all stages of construction projects, ranging from initiation to planning, execution, monitoring & control, through to hand over and operation.

VIABILITY AND SCALABILITY OF LEANBUILD SOFTWARE

The research and development team of LeanBuild Limited UK, working alongside the University of Wolverhampton's Construction Futures Research Centre UK, the School of Architecture and Built Environment at Kingston University UK, and the School of Engineering and Architecture of London South Bank University UK, showcases a data-driven approach to construction software development. This collaboration allows LeanBuild to

leverage the academic expertise of these institutions to conduct thorough market research and gain a profound understanding of current trends and demands within the construction software industry. The technical expertise and experience of the director of LeanBuild Limited, alongside the supporting team, have effectively validated the software's viability and strategically positioned it for continuous improvement. This iterative enhancement process ensures the software remains in alignment with lean principles. The team is dedicated to addressing user recommendations through collaboration with proficient and experienced professionals. This collective approach seeks further to augment the functionality and adaptability of the LeanBuild software, ensuring its continual evolution in consonance with industry requirements and user preferences.

The survey result shows that most participants (90%) score 7 or higher on the recommendation scale, indicating the software's readiness for widespread use. Although 10% provided a lower score, this positive majority highlights the software's scalability as an innovative tool. Additionally, the gradual adoption of Target Value Delivery (TVD) in the UK industry is acknowledged, recognizing that it takes time for new ideas to get fully integrated into any industry.

The software's structured planning is evident as a contemporary innovation that not only supports job creation but also stimulates growth in both national and international construction markets. Leveraging a broad construction client base in the UK, Nigeria, and worldwide, it advocates for the adoption of construction technology software to enhance business operations. This positions LeanBuild software solution as highly scalable.

INTERVIEWS FINDINGS AND RECOMMENDATIONS

The interview outcomes offer valuable insights and recommendations for enhancing the LeanBuild software. Figure 1 displays the diverse suggestions along with the corresponding number of interviewees who provided these recommendations.

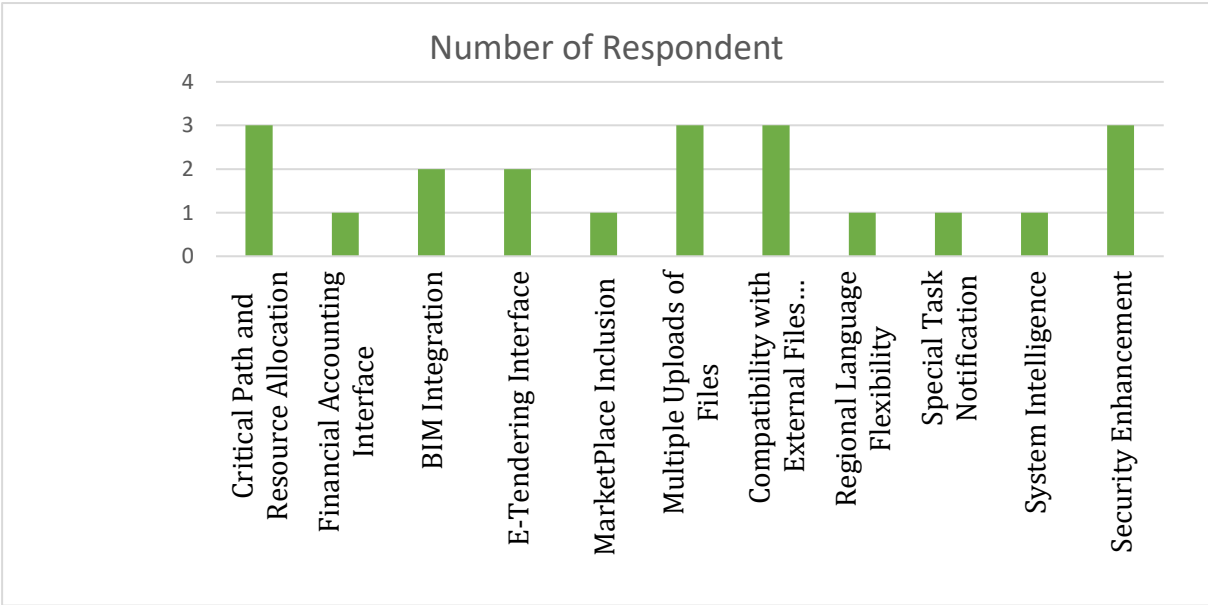


Figure 1: Suggestions and number of respondents that made the recommendation

Figure 1 outlines recommendations to enhance LeanBuild software, including a financial accounting interface and comprehensive critical path display on the Gantt chart for identifying delays. Respondents suggested features like simultaneous multiple file uploads, drag-and-drop functionality, critical paths integration for schedule monitoring, and direct resource assignment.

Stakeholders recommended an instructional guide for estimating activities or materials, BIM integration, compatibility with external files, and interfaces for snag lists and defective liability periods. Users emphasised simplicity, intelligence, multilingual support, and mobile accessibility. These suggestions align with ongoing efforts to refine LeanBuild's functionality and accessibility.

CONCLUSIONS

This study investigated the user experience and efficiency of the LeanBuild software post-development. Employing a mixed-methods approach involving focus groups, questionnaires, and interviews, the research gathered diverse perspectives from industry practitioners, academics, and IT professionals. The research and development team of LeanBuild UK collaborated with esteemed institutions in the UK.

The findings yielded key recommendations for software improvements, including financial reporting, critical path display, and resource assignment features. Stakeholder suggestions encompassed simultaneous file uploads, critical path integration, and direct resource assignment. Ongoing enhancements were proposed in financial interface, plugins, security, and integration of E-Tendering and Market Place. Users emphasised simplicity, intelligence, multilingual support, and mobile accessibility.

Despite limitations such as a small sample size and limited generalizability, the study's significance lies in highlighting the necessity of conducting usability checks after the development stage but before the software launch. The study introduces a digital innovation advocated by lean construction experts, addressing the entire project lifecycle by incorporating Target Value Delivery (TVD) and traditional construction approaches. Additionally, it underscores the benefits of conducting usability tests post-development and before the software launch, emphasizing the positive endorsement of LeanBuild as a scalable and globally applicable innovation for efficient project delivery.

This study recommends conducting user experience studies with construction professionals from other countries to understand cultural variations in software interaction and preferences.

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