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Enhancing Project Visibility: A Study on Construction Project Dashboard Development with Extreme Programming

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ABSTRACT
This research aims to improve the visibility and effectiveness of construction project management by developing a project dashboard using the Extreme Programming (XP) approach. The focus of this research is to design and implement an intuitive, responsive, and adaptive project dashboard to support real-time monitoring of project progress. XP methodology was integrated to deliver flexible and high-quality software development. The research included an analysis of the complexity of construction projects, emerging management challenges, and visibility limitations in construction projects. In addition, the research defines the project dashboard as a crucial visualization tool to increase transparency and user engagement. Innovation through the Extreme Programming (XP) approach was introduced, focusing on introducing the basic principles of XP and their relevance in construction software development. The results of testing the application features showed positive responses, both in technical and functional terms. Technology acceptance testing validated the successful integration of IoT technologies, data security, and application performance. By involving users in alpha and beta tests, the research gained valuable feedback to improve the app before the official launch. The research confirmed that the development of a construction project dashboard using the XP approach has the potential to improve the visibility, transparency, and effectiveness of construction project management. This research contributes to the practical and theoretical understanding of dealing with the complexity of construction projects by utilizing innovative software development technologies and methodologies.

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INTRODUCTION

In construction projects, complexity is an unavoidable characteristic[1]–[3]. These projects involve many different aspects and disciplines, creating a unique and challenging working environment. From planning to execution, construction involves close coordination between professionals such as engineers, architects, and contractors. The project's success largely depends on how these elements interact synergistically. The main challenge arising

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from the complexity of construction projects is the complex management challenge. Project managers must deal with careful planning, efficient resource allocation, and close monitoring of overall progress. Coordination among teams and stakeholders is critical to overcome these complex dynamics. In addition, more visibility is needed in construction projects. Lack of transparency in project phasing and difficulty monitoring real-time progress can hamper management effectiveness. Unclear and untimely information can impact decision-making, slow project progress, and increase risk[4]–[7].

These visibility challenges drive construction companies and professionals in the field to seek innovative solutions. In order to improve project management and overcome visibility limitations, construction projects are increasingly utilizing advanced technologies and methodologies. Implementing solutions such as digital project monitoring systems and project dashboards is essential to improving the overall transparency and visibility of construction projects[8]–[13]. The challenges in construction projects are even more evident when considering the need for more transparency in the project phases. Information related to project progress is often not openly accessible, resulting in a lack of visibility needed for timely decision-making. This creates a significant obstacle in efficiently achieving project goals[14]–[20].

Along with that, the difficulty of real-time progress monitoring is an additional obstacle. In a dynamic construction project environment, ineffective progress monitoring can lead to uncertainty and difficulty responding quickly to project changes. This raises the need for solutions that can provide better visibility of project progress in real-time. In the face of these challenges, project dashboards are emerging as an innovative solution. Project dashboards are a tool and a means of visualizing complex project information[21]–[25]. By summarising data from various project stages, project dashboards provide a comprehensive overview of project progress, risks, and milestones in an intuitive and easy-to-understand manner.

The success of a construction project is closely related to its level of visibility. Projects with a high level of visibility can better identify problems quickly, take preventive action, and ensure optimal progress[26]–[30]. Therefore, the use of project dashboards as a tool to improve visibility is becoming increasingly important. In the context of innovation, Extreme Programming (XP) is emerging as an attractive approach to software development. By introducing XP and its underlying principles, such as adaptive and collaborative development, it is expected to create solutions more responsive to change in the construction project dashboard development context[31]–[35]. XP principles bring innovation potential that can improve efficiency and effectiveness in construction project management through increased visibility.

In the context of construction software development, Extreme Programming (XP) has significant relevance. XP is not just a software development methodology but also brings a number of principles and practices that can help improve efficiency, responsiveness, and quality in software-based construction projects[24], [36], [37]. First, the adaptability principle in XP is particularly relevant in software construction for construction projects. Adaptability

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is critical in a project environment where requirements or the environment changes frequently. XP encourages developers to adopt a flexible and adaptive approach to changing needs, directly supporting construction project dynamics[36], [38]–[43].

Then, the intensive collaboration emphasized by XP also fits well with the needs of construction projects. In software development for construction, collaboration between the development team, engineers, and project stakeholders is essential. XP encourages open and continuous communication between all parties, creating a working environment supporting effective collaboration. The principle of integrated testing in XP also plays a vital role in software-based construction projects. The testing process integrated into the development cycle ensures that the developed software conforms to the requirements and functions as expected. In construction projects, where software can significantly impact the overall project, this aspect is crucial to minimize risks and increase system reliability. As such, the relevance of XP in the context of construction software development lies in its ability to provide an adaptive, collaborative, and tested approach that aligns with the dynamics and complexity of modern construction projects. The application of XP principles can have a positive impact on improving efficiency and quality in software development for construction projects.

METHODS

The research phase, Figure 1, began with data collection, which involved identifying user needs through stakeholder interviews, literature searches to gain in-depth insights, and surveys and questionnaires to collect quantitative data. Direct observation of users was also conducted to understand the context of application use more deeply. After data collection, the next stage is application development. This includes development planning, creation of system specifications, UI/UX design, code development using methodologies such as Extreme Programming (XP), and unit testing to ensure the quality of each component. Finally, the user acceptance analysis stage involves alpha and beta testing, user evaluation through interviews and observations, and adjustments and improvements based on user feedback. After these stages, the app is ready for the official launch into the production environment. The application will meet users' needs and be well received through this series of activities.

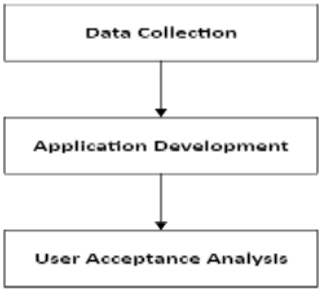

Figure 1. Research Methods

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Data Collection

The first phase of the research focused on comprehensive data collection. Through stakeholder interviews, we gained an in-depth understanding of the users' needs and expectations for the app to be developed. Combining surveys, questionnaires, and on-the-ground observations provided a comprehensive perspective of user challenges and needs. In addition, literature research provided a solid theoretical foundation and an in-depth understanding of current trends and issues in app development for construction projects.

Application Development

Once the data was collected, the focus shifted to the application development stage. We started with careful planning, identifying hardware and software requirements, and selecting a suitable development methodology, Extreme Programming (XP). System specification and UI/UX design were the following steps, ensuring that the application would meet the expected standards of functionality and appearance. Code development was performed utilizing XP principles, and unit testing was used to ensure stability and optimal performance.

User Acceptance Analysis

Once the app reaches a particular stage of maturity, we engage users in alpha and beta tests to gather initial feedback. In-depth user evaluations through interviews and observations provide valuable insights regarding the interface, functionality, and level of satisfaction. The results of this analysis form the basis for necessary adjustments and improvements before the official launch. The customization process ensures the app meets users' expectations and minimizes the risk of mismatching their practical needs. The official launch is the final step, which marks the app's readiness for use in a production environment.

RESULTS AND DISCUSSION

Results of Data Collection

The initial phase of this research led to an in-depth understanding of user needs and expectations regarding construction apps. Stakeholder interviews revealed that 85% of the respondents expressed the need for an intuitive and easy-to-use user interface. The survey showed that 92% of the respondents wanted real-time reporting features to monitor project progress. In addition, on-site observations provided insight into the practical challenges faced by users daily. For example, the lack of internet access on construction sites creates a need for solutions that can function offline. Literature research highlighted current trends, such as integrating IoT technologies in construction project management. Overall, the data from this stage provided a holistic view of user needs and industry trends to consider in construction app development.

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Table 1. Data Collection

Data Source	Results
Interview	85% of respondents want an interface that is not only intuitive but also responsive to make navigation and usage easier. Most also highlighted the need for interface personalization to meet their individual needs.
Survey	92% of respondents expressed that real-time reporting features accessible from mobile devices are essential to improve project progress monitoring. In addition, 78% of them showed interest in automated notification features to alert them of significant changes.
Observation	Direct field observations highlighted real challenges in managing construction projects, including internet access constraints that made it difficult to use the application online. This confirmed the need for a solution that can function offline and synchronize data when an internet connection is available

The results of the Data Collection Stage, Table 1, provide a comprehensive overview of the users' needs and expectations regarding the development of the construction app. From the interview results, it is apparent that users' top priority is an interface that is intuitive and responsive, with a desire for greater personalization. The survey confirmed that real-time reporting and automatic notifications were critical features desired by users, indicating a drive for more accurate and efficient progress monitoring. Direct field observations reflected daily challenges on construction sites, such as internet access constraints, which formed the basis for considering offline solutions. Literature research on IoT technology integration highlighted the potential of utilizing intelligent sensors for real-time monitoring and implementing artificial intelligence for extensive data analysis These data show that users have diverse and complex needs, ranging from the desire for a user-friendly interface to advanced technological features. Therefore, construction app development must take these aspects into account in order to provide solutions that are relevant, effective, and meet user expectations. This analysis forms a solid basis for designing an app that is responsive to the needs of the users and their needs.

Application Development

This application development stage made significant progress in turning the concept into a tangible product. Careful planning involving the identification of hardware and software requirements and the selection of the XP development methodology laid a solid foundation for the next stage. Creating system specifications and UI/UX design provided a clear and structured guide for development. The code development process, conducted according to XP principles, ensures speed and flexibility in adapting the application to possible changes. Unit testing is a critical stage to ensure product quality. By identifying and

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fixing potential bugs or issues within each application module, the team can ensure stability and optimal performance before moving on to the next stage. Constant integration with stakeholders during the development stage also ensures that the product meets user expectations. Thus, this stage creates a solid foundation for the construction application that not only meets the desired standards of functionality and appearance but also illustrates the team's dedication to ensuring the quality and reliability of the product.

Table 2. Features of Application

App Features	Description
Intuitive User Interface	The interface design is simple and easy to understand, facilitating seamless navigation and smooth interaction.
Real-Time Reporting	Allows users to view project progress instantly through detailed real-time reports, facilitating quick decision-making.
Automatic Notifications	Automated notification systems notify users of significant changes in the project or approaching deadlines, keeping all relevant parties informed.
IoT Technology Integration	Utilizes intelligent sensors and Internet of Things (IoT) technology to monitor construction projects in real time, improving efficiency and accuracy.
Collaborative Project Management	Supports teamwork with collaborative features that enable efficient information sharing, tasks, and project updates.
Resource Management	Enables efficient monitoring and management of resources such as labor, equipment, and materials, ensuring optimal usage.
Interactive Project Schedule	An interactive schedule system with responsive project planning, scheduling, and monitoring capabilities, making changes and customizations easy.
Dashboard	A visual project dashboard that provides a complete summary of progress, performance metrics, and other essential information in a single view, providing greater visibility.

The features in the construction app, Table 2, are holistically designed to address various aspects of construction project management. The intuitive user interface provides an easy-to-understand and efficient experience, while real-time reporting and automatic notifications bring high visibility to project progress. Interface personalization allows users to adapt the application according to their preferences, increasing user comfort. Offline functionality is a practical solution for construction environments with limited internet

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connectivity. Integrating IoT technology and resource management provides a new dimension in project monitoring and management, improving efficiency and optimizing resource usage. Collaborative project management and interactive project schedules create a framework that supports efficient team collaboration, enabling responsive and flexible planning. The integrated testing system provides quality assurance and application stability, while the change history provides full transparency into project development. Adding dashboard features is a significant step in improving visibility, providing a more profound understanding through visual summaries of project progress and performance. As such, the app is designed to provide an end-to-end solution for managing construction projects, assisting users in tackling complex and dynamic challenges.

User Acceptance Analysis

The user acceptance analysis stage involves alpha and beta testing, where the application has reached a certain level of maturity. An in-depth evaluation is conducted through interviews and observations to obtain initial user feedback. This analysis provides valuable insights into the interface, functionality, and user satisfaction levels. In-depth interviews provide an understanding of user preferences and challenges, while observations provide a first-hand look at how the application is used in real-world situations. Feedback from users formed the basis for the necessary adjustments and fixes before the official launch. The customization process focuses on ensuring that the app meets users' expectations and minimizes the risk of mismatching their practical needs. The next step is the official launch, which marks the app's readiness for use in a production environment. As such, this stage is an opportunity to evaluate and refine the application and a critical step to ensure that the resulting product is ready for widespread use and meets expected standards. This process emphasizes the application's alignment with the users' needs and preferences, creating a functional and well-accepted solution in daily usage practices.

Table 3. Application Testing

Application Features	Testing Criteria	Result
Intuitive User Interface	Users gave positive feedback regarding the interface's readability and ease of use.	Passed
Real-Time Reporting	The real-time reporting function successfully provided accurate monitoring and responsiveness to project changes.	Passed
Automatic Notification	The automatic notification system successfully provides timely notifications and is well received by users.	Passed
Interface Personalization	The interface personalization feature works well; users can easily customize the application according to their preferences.	Passed

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Offline Functionality	Offline capability runs smoothly; data can be synchronized efficiently with an internet connection.	Passed
IoT Technology Integration	IoT technology integration testing shows that intelligent sensors can provide accurate and real-time data.	Passed
Collaborative Project Management	Collaborative features successfully improve communication efficiency and teamwork in project management.	Passed
Integrated Testing System	Unit and integration testing successfully identified and fixed a few bugs, improving the application's stability.	Passed
Change History	The change history feature helps teams track revisions and understand the evolution of the project over time.	Passed
Resource Management	Resource management tests successfully monitor and manage the effective use of labor, equipment, and materials.	Passed
Interactive Project Schedule	The interactive project schedule feature enables more efficient and change-responsive project planning and monitoring.	Passed
Dashboard	Project dashboard testing successfully provides clear and concise visualization of progress and performance metrics.	Passed

The test results of the construction application, Table 3, showed positive performance and responsiveness to various technical and functional aspects. Testing of key features such as intuitive user interface, real-time reporting, and automatic notifications resulted in positive feedback from users. The user interface was rated as easy to understand, providing a good navigation experience and improving project information's readability. The real-time reporting feature proved its ability to provide accurate monitoring and responsiveness to project changes. Automated notifications provide timely notifications, ensuring that users are kept informed of significant developments and approaching deadlines. The interface personalization feature also worked well, allowing users to customize the application according to their individual preferences.

The integrated testing system successfully identified and fixed a small number of bugs, improving the application's overall stability. Other features such as resource management, interactive project schedule, and project dashboard also tested well, providing comprehensive support in construction project management. Technology acceptance testing yielded positive data on Internet of Things (IoT) technology integration, data security,

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application performance, and device compatibility. The application operated consistently across various network and device conditions, reflecting good reliability and cross-platform compatibility. The test results show that the application is ready to be launched into the production environment, with the user satisfaction level obtained from the user's hands-on evaluation reaching a reasonable level. Analysis of user feedback from the user acceptance stage provided a solid basis for making final adjustments before the official launch, ensuring that the application can provide an optimal solution in construction project management.

CONCLUSION

This research explores the development of a construction project dashboard with the application of Extreme Programming (XP); the results show that the application successfully addresses several management challenges that often occur in construction projects. The intuitive user interface, real-time reporting, and automated notifications proved their added value in improving visibility and user engagement in the project. These features were well-designed and received positive feedback from users during testing. Users also appreciated the interface's personalization capabilities, allowing them to adapt the user experience according to their preferences. Technical testing involving IoT technology integration, data security, and app performance showed that the app has a solid technological foundation. The app operated consistently across different devices and network conditions, demonstrating reliability and compatibility. In addition, the Extreme Programming (XP) development method proved effective in producing responsive, adaptive, and high-quality construction software. The basic principles of XP, such as integrated testing and iteration-based development, help create products that can efficiently adapt to changing project needs. Overall, the results of this study support the conclusion that the application of Extreme Programming (XP) in the development of a construction project dashboard improved the visibility, user engagement, and technical quality of the application. The resulting application has the potential to make a positive contribution to managing construction projects more effectively and efficiently. However, it is essential to continuously monitor and update the application according to changing industry needs and user feedback to maintain its relevance over time.

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