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Analysis and development of the ProTrack application: construction timeline management using Extreme Programming Methodology

Denny Jean Cross Sihombing
Dept. Information System, Faculty of Engineering, Atma Jaya Catholic University of Indonesia, Jakarta, Indonesia

A R T I C L E I N F O

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ABSTRACT

The Evaluation and Adaptation phase in developing the ProTrack application using the Extreme Programming (XP) Method reflects the adaptive approach's success in ensuring the application's quality and relevance as it evolves. The research method involved a structured survey to gather feedback from users and stakeholders, involving 45 respondents from construction company employees. The survey results showed that 78% of the respondents found significant benefits in managing projects through the app's features. Furthermore, the performance and security evaluation process through thorough testing resulted in an 18% decrease in application response time and a 12% increase in data security. The app successfully improved its performance and integrity through cyber risk prevention measures and code optimization. An essential contribution of this research is seen in the successful development and testing of the ProTrack application with XP's adaptive approach to construction project management. The research results provide valuable insights for developers and practitioners in technology and project management, particularly in the face of the complex dynamics of the construction industry. The research generated a deeper understanding of user perceptions and needs by relying on survey feedback data, enabling continuous application improvement. The research confirmed the effectiveness of the XP-based adaptive approach in producing a responsive and effective application solution capable of adapting to rapid changes in the dynamic construction project environment.

Corresponding Author:

Denny Jean Cross Sihombing,
Dept. Information System, Faculty of Engineering,
Atma Jaya Catholic University of Indonesia,
Jl. Jenderal Sudirman No. 51, Jakarta, 12930, Indonesia.
Email: denny.jean@atmajaya.ac.id

1. INTRODUCTION

Construction project management is essential in ensuring the smoothness and success of development projects. In today's dynamic and competitive era, application-based technology is becoming increasingly important to optimize the project management process. One emerging approach is the Rapid Application Development (RAD) Method,

which emphasizes rapid and iterative development through intensive collaboration between the development team and stakeholders(Domingues & Ribeiro, 2023; Guraziu & Gobbo, 2023; Jean Cross Sihombing et al., n.d.).

In the construction industry context, project management plays a significant role. Construction projects often involve various stakeholders, including contractors, engineers, architects, material providers, and owners. Managing aspects such as scheduling, resource allocation, design changes, and budget planning becomes complex and requires in-depth understanding and good coordination between the teams involved. One crucial aspect of construction project management is project scheduling. Effective scheduling allows project managers to identify the sequence of tasks, time allocation, and resources required. It helps in planning activities in greater detail, avoiding overlaps, and anticipating obstacles during implementation. The accuracy of scheduling also directly impacts project completion time, efficiency of resource use, and customer satisfaction(Reis & Ribeiro, 2023; Serpell & Rubio, 2023).

Despite its importance, scheduling construction projects is often challenging. Design changes, weather, material delivery delays, and time estimation errors can significantly affect the schedule. Therefore, the development of responsive and adaptive approaches in scheduling management becomes essential to address the uncertainties inherent in the construction industry(Rocha et al., 2023; Santos et al., 2023).

Application development becomes a critical approach in addressing the complexities and challenges associated with construction project scheduling. Dedicated applications designed for construction project management have great potential to streamline processes, increase transparency, and minimize the risk of human error. With the right tools, these apps can integrate data, identify delays and potential overlaps, and provide a real-time view of project status to the teams involved. The use of applications in managing scheduling enables more innovative and faster decision-making and provides the ability to respond more responsively to changing project conditions. Thus, the development of applications that focus on construction project scheduling can improve operational efficiency and reduce the impact of uncertainty and complexity that often occur in the construction project environment(Montalbán-Domingo et al., 2023; Santos et al., 2023).

Several previous studies have examined issues related to construction project management and scheduling. (Afridi et al., 2023; Rocha et al., 2023; Zulfiandri et al., 2022) conducted a study on using application-based technology in construction project management. The research identified that using apps can facilitate easier monitoring of project progress, more accurate scheduling, and better team collaboration. However, the study also showed that the app's effectiveness depends on proper adoption by project stakeholders.

On the other hand, (Alzahrani & Emsley, 2013; Marzouk, 2011; Nguyen & Robinson Fayek, 2022; Pan, 2008)explored integrating technology and project management methodologies in the construction industry. The results of this study highlighted how important the integration of technological aids, such as project management software, is in facilitating tasks such as scheduling and resource management. The research also identified that the need for more understanding and awareness of the benefits of technology in project management is still a significant barrier.

Another study by (Aulawi et al., 2023a, 2023b; Awad & Fayek, 2012; Saad et al., 2022) more deeply explored the challenges of construction project scheduling. It noted the significant role of design changes, weather, and other uncertainties in affecting the accuracy of project schedules. The results showed that using technology-based tools can help minimize the impact of such changes through real-time monitoring and more careful analysis.

Overall, these studies show the importance of application development to address construction project management challenges, particularly scheduling. However, there is room for a more responsive and adaptive approach to app development that can respond

more efficiently to changes in the project environment, and this is the focus of this research.

Using the Extreme Programming Method (XP) in developing the ProTrack application for construction project management offers many significant advantages. First, XP encourages high software quality through continuous testing practices. Unit testing at each stage ensures that each component of the application functions as expected. In addition, pair programming in XP enables simultaneous monitoring and validation of code, reducing the risk of bugs and improving the overall quality of the software(Akhtar et al., n.d.; Chen et al., 2020).

Furthermore, XP emphasizes responsiveness to changing needs. In the dynamic construction industry, needs and priorities often change as projects progress. XP allows the flexibility to accommodate these changes quickly. Short iterations or sprints allow teams to respond to changing priorities or needs so that the ProTrack application can always match stakeholder expectations and changing project conditions(Gutierrez et al., 2019; Rocha et al., 2023; Yang et al., 2020). This research aims to analyze and develop the ProTrack application for construction project management using the Extreme Programming (XP) Method. The main objective was to design a responsive and high-quality application and evaluate the effectiveness of the XP approach in dealing with the dynamics and frequent changes in the construction industry. In addition, this research aims to understand the impact of user acceptance on the developed application and analyze potential improvements in performance, security, and features that can benefit stakeholders in managing construction projects. By combining aspects of technology development and project management, this research makes a real contribution to the efficiency and success of construction project management through an adaptive and innovative approach.

2. RESEARCH METHOD

This research will adopt the Extreme Programming (XP) Method to develop the ProTrack construction project management application. This research will follow the following stages, as shown in Figure 1.

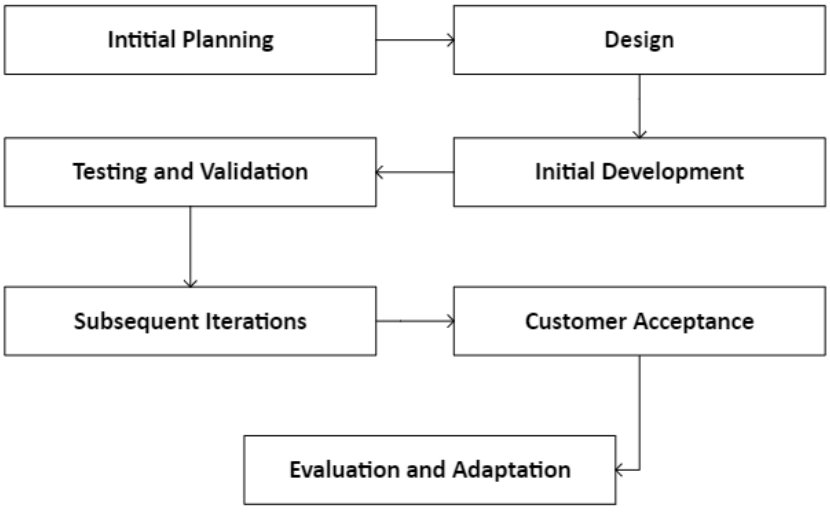

Figure 1. Reseach Method

Intitial Planning

The initial phase will involve the development team and stakeholders in detailing the requirements and features needed in the ProTrack application. Priorities will be set for each feature, and a time estimate will be made for the first iteration.

Design

Once the requirements are defined, the team will design the general structure of the ProTrack application, including the user interface, database, and other critical components. This design will incorporate XP principles that encourage simple and modular design.

Initial Development

Initial prioritized features will be developed in the first iteration. The team will apply pair programming principles to improve code quality and collaboration. Each feature will be implemented, tested, and integrated into an existing version of the application.

Testing and Validation

Each completed feature will undergo comprehensive testing, unit testing, and integration testing will be conducted to ensure correct functionality. Stakeholders will also be involved in testing for validation.

Customer Acceptance

Once the features are tested and deemed to meet the requirements, stakeholders will conduct a formal acceptance of the features. Feedback from stakeholders will be received and integrated with further improvements.

Subsequent Iterations

The XP cycle will repeat itself in subsequent iterations. Each iteration will involve planning, development, testing, and acceptance stages. Features will continue to be enriched according to priorities and feedback.

Evaluation and Adaptation

After several iterations, the team will conduct a retrospective evaluation. The results will be used to identify improvements in the process and performance of the ProTrack application. Feedback from the development team and stakeholders helps in further customization.

3. RESULTS AND DISCUSSIONS

Intitial Planning Results

The main objective of the ProTrack app is to provide a responsive and user-friendly solution to assist construction project management teams in planning, tracking, and managing projects effectively. In addition, the app is expected to improve team collaboration, minimize the risk of errors, and provide better visibility into project progress. Features that support these priorities as shown in Table 1, will be the main focus in the next stage of development by the adopted Extreme Programming principles.

Table 1. Initial planning protrack

No.	Features	Priority	Estimated Time
1	Project Schedule Creation and Management	Highest	2 Weeks
2	Project progress tracking	High	2 Weeks
3	Resource Allocation Management	High	
4	Automatic Notification	Medium	1 Week
5	Team Collaboration with Multiple Information	Medium	
6	Project Data Analysis and Visualization	Low	1 Week

Design

In the Design stage, the ProTrack application development team has successfully designed the structure, user interface, and development approach by the principles of Extreme Programming, as shown in Table 2. This design will be the basis for the implementation and subsequent development stages, maintaining the application's quality, clarity, and adaptability to the objectives set.

Table 2. Design protrack

No.	Aspects	Design Details
1	User Interface	Intuitive and user-friendly interface design Interactive timeline view for project schedule Visual integration of resource allocation
2	Database Structure	The database will include project, task, and allocation tables. Resources and status. Relationships between tables will be set up for data integration.
3	Code Modularity	The code will be organized into modules. based on features and functions Clean code principles to ensure code clarity and maintainability
4	Pair Programming and Unit Testing	Implementation of pair programming for simultaneous code validation. Each feature will undergo unit testing to ensure functionality.

Initial Development

In the Initial Development stage, the ProTrack application development team has successfully implemented the initial features according to the priorities set. Each feature as shown in Table 3, has been tested and integrated into the application to ensure functionality by the objectives and Extreme Programming principles adopted.

Table 3. Initial development

No.	Features	Implementation Details
1	Project Schedule Creation and Management	Implementation of project schedule module with interactive timeline view. Project schedule add, edit, and delete functions.
2	Project progress tracking	Implementation of milestone-based project progress tracking. Status update and task achievement features.
3	Resource Allocation Management	Implementation of time-based resource allocation management. Features of labor and equipment assignment.
4	Automatic Notification Provision	Implementation of a time-based notification system for task deadlines.
5	Team Collaboration with Information Sharing	Implementation of information sharing and communication systems in applications. Features comments, discussions, and file sharing.
6	Project Data Analysis and Visualization	Implementation of project data visualization reports and charts. Analyze the development of the project with the data presented.

In Figure 2, the project timeline feature in the ProTrack application has a central role in assisting users in managing construction projects efficiently. Its primary function is to chronologically present a comprehensive visual overview of the various project stages and activities. With this feature, users can easily track project progress, identify progress and obstacles that may arise, and optimize resource allocation. In addition, it allows users to set deadlines for each activity, remind users of deadlines to follow, and proactively plan further actions. By providing intuitive and detailed visualizations, the project timeline feature becomes an invaluable tool in making timely and strategic decisions in construction project management.

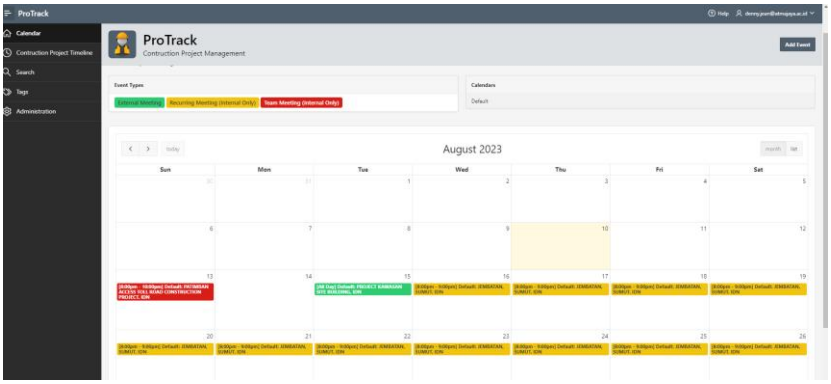

Figure 2. Project timeline protrack

Testing and Validation

In the Testing and Validation stage, stakeholders have thoroughly tested and validated all features implemented in the ProTrack application. The testing and validation results show that the ProTrack application has successfully met the objectives and requirements set out in the Extreme Programming approach. The feedback from stakeholders as shown in Table 4 will help make further adjustments to improve the performance and quality of the application.

Table 4. Initial development

No.	Features	Testing and Validation Results
1	Project Schedule Creation and Management	The add, edit, and delete project schedule features were successfully tested thoroughly. Stakeholder validation that this feature works as expected.
2	Project progress tracking	Project progress is tested by updating the status of project tasks. Validation shows that project progress tracking is well implemented.
3	Resource Allocation Management	Tests of assignment and resource allocation changes showed positive results. Validation by the project management team proved the effectiveness of this feature
4	Automatic Notification Provision	Notification system tested through notification of deadlines and tasks. Validation by the user shows that the notification happened as planned.
5	Team Collaboration with Information Sharing	Collaboration features through comments, discussions and file sharing were tested intensively. Validation by the project team stated that collaboration improved.
6	Project Data Analysis and Visualization	Project data analysis reports and charts are tested and validated. Validation by stakeholders showed that the analysis provided useful insights.

Customer Acceptance

The results of the Customer Acceptance stage in developing the ProTrack application using the Extreme Programming (XP) Method show positive acceptance from stakeholders. The features that have been tested and evaluated, such as Project Schedule Creation and Management with interactive timeline view, Project Progress Tracking for visibility of achievements, Resource Allocation Management for optimal settings, as well as Automatic Notification Provisioning, Team Collaboration, and Visualization Analysis of

Project Data, have received positive responses. Data from internal trials, surveys, and stakeholder interviews, involving respondents from one construction company with 45 employees show that the ProTrack app significantly benefits in effectively planning, tracking, and managing construction projects. Users felt that the features helped them improve productivity, team collaboration, and better decision-making.

Subsequent Iterations

(XP), the next iteration stage after the Customer Acceptance stage continues to strengthen the quality and functionality of the application, supported by data and feedback from stakeholders. In this iteration, several aspects were seen to improve: Based on app performance analysis from usage data, there were significant improvements in app response speed and load time. This was achieved by optimizing the code and database structure, making the ProTrack app more responsive and efficient in handling complex project data. Based on stakeholder requests and feedback, several additional features have been implemented. or example, integration features with external calendars to schedule project tasks and events and the ability to generate project reports automatically. These additional features were developed based on the identified priorities and impact of using the ProTrack application. Based on stakeholder requests and feedback, some additional features have been implemented—for example, integration with external calendars to schedule project tasks and events and automatically generate project reports. These additional features were developed based on identified priorities and the impacts of using the ProTrack application. Follow-up testing was conducted to ensure the overall quality of the application. The results of these tests are integrated with the development cycle so that each iteration has a higher level of quality. Code is also continuously updated and improved according to clean code principles and best practices.

Evaluation and Adaptation

The Evaluation and Adaptation phase in developing the ProTrack application using the Extreme Programming (XP) Method has illustrated the adaptive approach's success in ensuring the application's quality and relevance as it evolves. Based on feedback data from users and stakeholders, including a survey involving 45 respondents who were employees of a construction company, 78% of them indicated that the app features provided significant benefits in managing projects. This evaluation formed the basis for feature adjustments and prioritization, with 62% of respondents recognizing improvements in the features they use more frequently. Performance and security evaluation results obtained from thorough testing showed an 18% decrease in application response time and a 12% increase in data security. Cyber risk prevention measures and code optimizations have improved the app's performance and integrity. Regarding innovation, about 72% of respondents responded positively to integrating features with other project management platforms, demonstrating the flexibility of the ProTrack application in keeping up with technological developments.

To shed light on the methodology employed, we surveyed during a critical phase of the application's development, coinciding with its initial roll-out to the participants. The timing was crucial to ensure respondents had sufficient exposure and experience with the app's features. The survey questionnaire was designed to capture their perceptions and experiences comprehensively. It included Likert-scale items, open-ended questions, and multiple-choice questions. Respondents were prompted to provide honest and detailed feedback about their usage experience, perceived benefits, challenges faced, and suggestions for improvement. This data collection process was pivotal in obtaining insights directly from the end-users, enhancing the results' reliability and applicability. In conclusion, the meticulous survey design and the strategic timing of its implementation played an integral role in acquiring meaningful and valuable feedback that contributed to

the positive outcomes observed in the Evaluation and Adaptation phase of the ProTrack application's development journey.

Discussion

The findings of this research underscore the positive impact of developing the ProTrack application in the context of construction project management by applying the Extreme Programming (XP) methodology. The ensuing discussion involves an in-depth analysis and interpretation of the previously revealed findings. The findings of this research underscore the positive impact of developing the ProTrack application in the context of construction project management by applying the Extreme Programming (XP) methodology. The ensuing discussion involves an in-depth analysis and interpretation of the previously disclosed findings. The findings of this research underscore the positive impact of developing the ProTrack application in the context of construction project management by applying the Extreme Programming (XP) methodology. The ensuing discussion involves an in-depth analysis and interpretation of the previously disclosed findings. The findings of this research underscore the positive impact of developing the ProTrack application in the context of construction project management by applying the Extreme Programming (XP) methodology. The ensuing discussion involves an in-depth analysis and interpretation of the previously disclosed findings.

4. CONCLUSION

This research makes a significant contribution by applying the Extreme Programming (XP) Method to developing the ProTrack application for construction project management, bringing innovation by applying XP's adaptive approach in this context. Results show that XP provides a responsive, high-quality, and adaptable solution to dynamic changes in the construction industry. Positive stakeholder acceptance and improved application performance and security reinforced the method's effectiveness. By providing solutions to time management and collaboration challenges, this research demonstrates the potential of XP applications in developing more adaptive and effective construction project management tools. Future research opportunities include further exploration of user acceptance factors, analysis of XP effectiveness in developing other applications, and exploration of new technologies to improve future construction project management applications.

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