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Development of Financial Management Applications in Construction Companies Using the Extreme Programming Method

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Abstract

Cost control is a critical element of the financial management of the construction industry. Every expenditure must be monitored closely to keep the project within the budget. In this industry, daily costs, labor costs, material costs, and other components must be carefully managed to avoid overspending. There is an urgent need to plan financially well. This includes correctly calculating project costs, finding suitable sources of funds, and anticipating financial risks that may arise during construction. This research aims to develop a financial management application for construction companies using the Extreme Programming (XP) Method. The construction industry often faces complexities in managing project finances, including cost tracking, cash control, and accurate financial reporting. The XP method was chosen as the primary approach due to its unique features, such as automated testing, close team collaboration, and flexibility in the face of change. The stages of application development, such as planning, design, coding, testing, integration, and launch, have been explained in detail. Continuous integration was used to ensure that any code changes were automatically tested and integrated into the main version of the application. The research results created a reliable and efficient financial management application that helps construction companies better manage projects, improve efficiency, and reduce financial risks. The main contribution of this research lies in applying the XP Method in developing a specialized financial application for the construction industry, providing a significant solution in addressing the complexity of financial management. In addition, this research provides valuable insights into the potential application of XP in various business contexts, making significant contributions to software developers and stakeholders in the construction industry.

Keywords: Financial Management Application, Construction Finance, Extreme Programming

1. Introduction

The construction industry is central to developing a country's physical infrastructure. However, various issues need to be addressed along with the massive potential for economic growth. One of the critical challenges in the financial management of construction companies is the volatile cash and capital cycle. Construction projects often require significant capital investment, and when funds are tied up in such projects, companies can face severe liquidity pressures. Improper management of the cash and capital cycle can threaten project viability and impact the company's financial health(Boateng et al., 2022; Choi & Ha, 2022).

Costs in the construction industry can be challenging to predict. Factors such as changes in technical requirements, fluctuations in construction material prices, and changes in environmental regulations can destabilize project costs. As a result, projects often exceed the initial budget set, making it difficult for companies to achieve expected profitability(Cao, 2023).

The complexity of construction projects is also one of the main challenges. Resource management, team coordination, and careful planning are required to keep the project on track. The inability to manage these complexities can disrupt the project and result in significant cost increases. On the other hand, human resources also play an essential role in the financial management

of construction companies. Poor management of the workforce can result in instability in productivity and work quality, which can affect the project as a whole. Process control is also crucial. Construction companies must be able to control projects well, meet tight deadlines, and maintain quality. Difficulties in this control can significantly impact the company's financial results(Ingle & Mahesh, 2022; Khodabakhshian & Re Cecconi, 2022).

On the other hand, construction companies also have to deal with uncertainties in the external environment. Changes in government policies, fluctuations in construction material prices, and changes in market demand can all significantly impact a company's financial management. Developing efficient and integrated financial management applications is essential to address these challenges. Such applications can help construction companies manage resources, better oversee projects, and optimize their financial performance(Sampaio, 2021; Xu et al., 2022). Financial management is central to ensuring construction projects run smoothly and sustainably. The construction industry has a unique dynamic that requires companies to face complex financial challenges.

There is an urgent need to plan financially well. This includes correctly calculating project costs, finding suitable sources of funds, and anticipating financial risks that may arise during construction. Poor planning can lead to financial failure. Furthermore, cost control is a critical element of the financial management of the construction industry. Every expenditure must be monitored closely to keep the project within the budget. In this industry, daily costs, labor costs, material costs, and other components must be carefully managed to avoid overspending(Almashhadani et al., 2023; Sampaio, 2021; Zhang et al., 2022).

Accurate and timely financial reports are essential in communicating with relevant parties such as shareholders, investors, or regulatory authorities. It helps in understanding the company's financial performance and making timely decisions. Poor financial reporting can lead to distrust of shareholders and potential investors. Financial risk management is another essential aspect of the construction industry. Technical, legal, and environmental risks must be appropriately identified, evaluated, and managed. Managing financial risks can minimize their negative impact on the company's finances. Cash management is another challenge in the construction industry. A company's cash cycle must be managed wisely to ensure sufficient funds are available when needed. Lack of good cash management can result in serious liquidity issues(Alzahrani & Emsley, 2013; Divya Sankar & Selvam, 2020; Ingle & Mahesh, 2022; Pan, 2008).

Information technology and applications have changed how financial management is done in the construction industry. Financial management apps bring several significant advantages; they enable the automation of routine tasks such as invoice processing, cost tracking, and financial report generation. This saves time and reduces the risk of human error. Applications provide real-time monitoring capabilities of financial data. Financial managers can quickly identify issues and take corrective action early. Financial information can be accessed from anywhere, allowing managers to make better decisions faster, regardless of physical location. The application provides powerful data analysis tools. This enables construction companies to analyze financial trends, identify opportunities for savings, and formulate more brilliant financial strategies. Financial apps generally have high security and compliance features that ensure that financial data is protected and compliant with applicable regulations(Aulawi et al., 2023; Awad & Fayek, 2012).

The use of apps in the financial management of the construction industry can help overcome some of the challenges faced in managing complex and frequently changing finances. By integrating this technology into their financial strategy, construction companies can improve efficiency, reduce risk, and achieve better financial performance. In this ever-evolving world, the development of financial management applications in the construction industry is becoming essential to meet increasingly complex needs. One development method that has emerged as a practical solution is "Extreme Programming," or XP(Sihombing, 2023).

One of the critical advantages of XP in the context of financial management applications is its ability to provide rapid delivery. XP encourages iteration-based development, which means applications can be broken down into smaller

pieces that can be used immediately. Construction companies can immediately leverage applications to improve efficiency and optimize financial management(Akhtar et al., n.d.; Chen et al., 2020; Sihombing, 2023).

In addition, XP is designed to handle change with great flexibility. In the frequently changing construction industry, the ability to quickly adapt applications to changing business needs is an asset. XP makes identifying and integrating changes more quickly than other development methods possible.

Integrated testing is another crucial feature of XP. In financial management, applications can be tested thoroughly and more accurately. This helps reduce the risk of possible errors in financial management, which can significantly impact a construction company. Close collaboration is a fundamental principle of XP. In the context of financial management, it leads to the strong involvement of all stakeholders, including end users. By involving active users in development, applications can better meet the actual needs of the users, ultimately providing more incredible value(Dingsøyr et al., 2012; Santos et al., n.d.; Serrador & Pinto, 2015).

XP also encourages the practice of pair programming, where two developers work together to produce higher quality and more maintainable code. In financial management applications, this means that the code produced is more thorough and more reliable. XP encourages the active involvement of stakeholders in the development process. In the context of financial management, this ensures that the application meets the expectations of the business and provides a solution that fits the actual needs(Beecham et al., 2021; Gutierrez et al., 2019; Pérez-Piqueras et al., 2023; Wiechmann et al., 2022).

With these advantages, Extreme Programming is an attractive option for developing financial management applications in the construction industry. In a changing world, the ability to deal with change, provide quick solutions, and optimize financial management is more critical than ever, and XP can be a powerful tool to achieve these goals. Therefore, this research will focus on using Extreme Programming methods to develop applications that can help address these specific financial management challenges in the construction industry.

2. Methods

This research consists of five main stages, as shown in Figure 1.

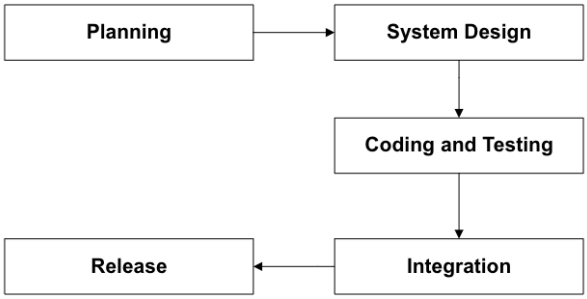

Figure 1. Research Stages

Planning

Identification of customer requirements and feature prioritization. Creation of User Stories that describe the behavior and functionality of the application. Estimation of development time and cost for each User Story. Scheduling of development iterations based on priorities and estimates.

Sytem Design

Design of application architecture and structure. Identification of critical components and relationships between components. Design of database and database schema if required. Creation of test plan.

Coding and Testing

The development team works in pairs (pair programming) to implement the User Stories. Developers write automated tests for each feature they work on (Test-Driven Development or TDD). Code should be integrated into a shared repository at regular intervals. Continuous integrated testing ensures that new features do not break existing ones. The end-user team performs acceptance testing. Bugs found are immediately fixed and retested.

Integration

Continuous integration is used to incorporate changes from each developer and run automated tests at regular intervals. Changes that have been tested and passed are integrated into the main version of the application.

Release

Launching the product to end users with completed and well-tested features. Monitoring application performance and responding to issues that may arise.

3. Results

Planning

The Planning stage forms a solid financial management application development project foundation. The outcomes of this stage are shown in Table 1. This stage ensures that the client's needs are well understood, priorities are set, and a clear plan with time and cost estimates is created. These outcomes will guide the later stages of the project towards the development of a successful application tailored to the financial management requirements of the construction company.

Table 1. Results of the Research Phase

Planning Results	**Description**
Customer Needs Identification	Construction companies' needs in financial management have been carefully identified through close collaboration with clients. This included understanding their specific requirements regarding project cost tracking, cash flow control, and financial reporting. Engagement with the client ensured that the application development matched the business objectives.
Feature Prioritization	The identified features have been prioritized based on their significance and impact on the financial management process. Key features such as project budget management, material cost monitoring, and financial analysis were identified as high priority due to their critical role in the construction industry.
User Stories Creation	User Stories have been designed to explain the behavior and functionality of the application from the end user's point of view. These User Stories clearly understand how the application will function, ensuring that the development team and stakeholders have a common understanding of the project.
Time and Cost Estimation	Each User Story is evaluated in terms of the time and cost required for its development. This estimation process helps allocate resources efficiently and ensures the project stays within the specified budget and schedule.
Development Iteration Scheduling	Based on priorities and estimates, development iterations have been scheduled. The iterative approach enables a flexible and adaptive development process, allowing adjustments as needed during the project cycle.

System Design

The results of the System Design stage, as shown in Table 2, form a solid framework for developing construction company financial management applications. These results will guide the subsequent development process and ensure that the application is well constructed by the business needs and predefined design interface design, as shown in Figure 2.

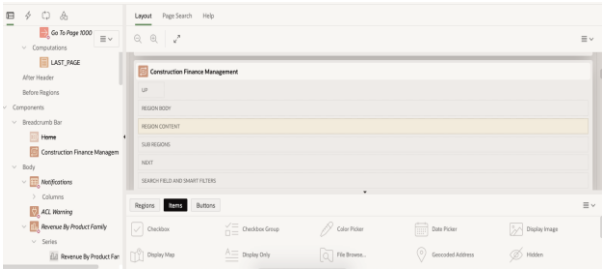

Figure 2. System Design

Tabel 2. Analisis System Design

System Design Results	**Description**
Design of Application Architecture and Structure	- The application architecture will utilize a microservices-based architecture to allow for better scale and modularity of features. The application structure will consist of a project cost tracking module, a cash control module, and a financial reporting module that interacts through clearly defined interfaces. - Data will flow from the project cost tracking module to the cash control module to ensure consistency of financial data.
Identification of Main Components and Relationship between Components	- The main components have been identified as follows: a. Project Cost Tracking Module b. Cash Control Module c. Financial Reporting Module - The relationship between these components is as follows: - Project Cost Tracking Module sends project cost data to the Cash Control Module for cash analysis. -The Cash Control Module provides current cash data to the Financial Reporting Module for report generation.
Database Design and Database Schema (if needed)	- The database will use a relational database management system (RDBMS) to store project and financial data. The database schema includes Project, Financial Transaction, and Project Budget tables. -Relationships between tables have been identified to manage data efficiently. For example, foreign keys connect the Project table to the Financial Transaction table.
Test Plan Creation	-The test plan includes: - Unit testing for each application module separately. -Integration testing to check the interaction between modules. -Functional testing to ensure features conform to specifications. -Performance testing to measure application performance under high-load situations. -Test scenarios included simulated users creating financial reports and managing project budgets. -Test passing criteria included data accuracy and adequate performance.

Coding and Testing

The Coding and Testing Stage results include sample data showing how the application development was done with the Pair Programming method, TDD implementation, code integration, integrated testing, acceptance testing, and bug handling and retesting, as show in Table 3.

Table 3. Coding and Testing Results

Coding and Testing Stage Results	**Description**
Pair Programming	- The development team works in pairs to implement the defined User Stories. Example of a pair: a. Developer A: Create a project cost-tracking module. b. Developer B: Monitors data integrity between the cost tracking and cash control modules. - Here is an example of developer pair performance: - Developers A and B work on the User Story: "Enable real-time tracking of project material costs."
Test-Driven Development	- For example, for the feature "Project Material Cost Tracking," the developer wrote an automated test that verifies that each cost entry is correctly stored in the database. - The automated test would input dummy data and verify the results with correct expectations.
Periodic Integration of Code into a Shared Repository	- The code generated by the development team is regularly integrated into the shared repository. Here is an example of an integration log: - Date: 2023-07-15 - Description: Integration of Developer A's "Daily Cash Control" feature and "Monthly Financial Report" by Developer B. - Result: Integration was successful, no conflicts occurred. - Continuous Integration (CI) practices ensure that changes are automatically tested and integrated into the main source code.
Continuous Integrated Testing	- Continuous Integration Testing is done every time there is a code change. Example of integrated testing results: - Date: 2023-07-18 - Description: Automated testing of the "Daily Cash Control" feature after integration. - Result: All tests went well, with no failures. - Integrated testing ensures that code changes do not break functions already in the application.
Acceptance Testing by End User Team	- The end-user team is involved in acceptance testing to examine the application from the end-user perspective. Example of a test scenario: - Scenario: "Manage Project Budget" - End User: Project Manager - Result: Project Managers could easily manage project budgets using the application and reported that this feature met their needs. - The acceptance testing results provided valuable feedback and ensured the application met the end users' business needs.
Found Bug Fixes and Retesting	- Some bugs were found during acceptance testing and integrated testing. Examples of bugs: - Bug: "The Monthly Financial Report does not generate the total project costs correctly." - The responsible developer fixed this bug immediately. - After the fix, a retest was performed to ensure that the bug was properly fixed and that there were no other negative impacts.

Integration

In the Integration Stage, the concept of continuous integration is critical. This means that any changes the developers make are immediately integrated into the application's main code. The results of this stage are:

- Incorporation of Changes: Whenever there are code changes by the developers, the changes are integrated into the application's main code automatically. This allows the developers to work collaboratively and ensure all changes go smoothly.
- Automated Testing: Every change integrated into the main code instantly activates automated testing. This is an essential part of this development approach, where every new feature or change is automatically tested to ensure no side effects break existing features.
- Log and Results Storage: The results of the integration and its logs are actively monitored. This helps the development team identify and address issues as quickly as possible. If any errors or conflicts arise, they can be resolved quickly.
- Successful Integration: Only changes that have been tested and passed testing are integrated into the main version of the app. Thus, the main version of the app remains stable and reliable.

Release

After a successful integration phase, the financial management app is ready for launch.

- Stable Version Launch: The application's version to be launched contains only completed and well-tested features. This version is considered stable and reliable, as shown in figure 3-5.

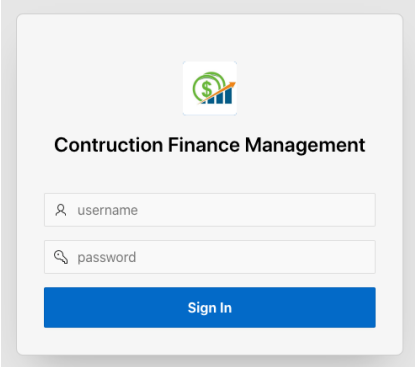

Figure 2. Sign In Page

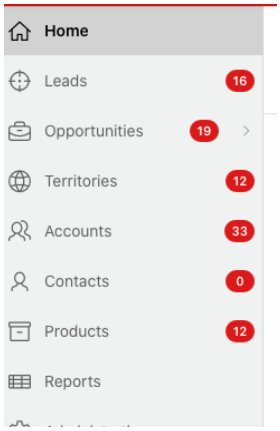

Figure 3 Main Menu

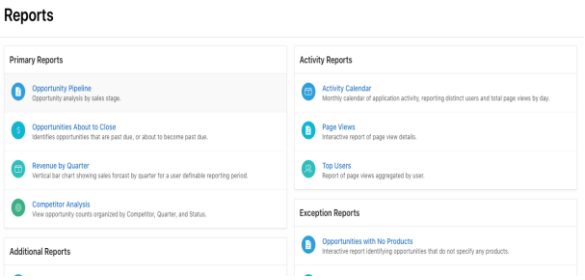

Figure 3 Report Page

- Performance Monitoring: After launch, the application will continue to be actively monitored. Performance data such as response time and resource usage will be continuously monitored. This helps ensure that the app remains high-performing and responsive.
- Response to Issues: Despite thorough testing, issues or bugs can still arise after launch. The development team is prepared to respond quickly should this occur. Fixes and updates will be applied as needed.
- End Users: This powerful financial management application can finally be presented to end users. This includes project managers and finance staff who will utilize it in managing their construction project finances more efficiently.
- With a successful integration phase and stable rollout, the construction company has a reliable and efficient financial management tool. Monitoring and responding to issues will ensure the application remains high-performing and in line with their business needs. Thus, the development of this application has reached an important milestone in supporting their business operations.

4. Conclusion

This research focuses on developing a financial management application for construction companies using the Extreme Programming (XP) Method. The results of this study show that XP is a suitable approach to address challenges in the financial management of construction companies, such as project complexity and changing customer demands. XP provides flexibility, close collaboration between developers and stakeholders, and robust automated testing. The app can help construction companies with project cost tracking, cash control, and financial reporting, which can improve efficiency and reduce financial risk. Overall, the app has the potential to be a valuable asset for construction companies in better managing their projects. With further development and testing in a natural environment, this application can positively contribute to improving the construction industry's performance.

References

Akhtar, A., Bakhtawar, B., & Akhtar, S. (N.D.). Extreme Programming Vs Scrum: A Comparison Of Agile Models. *International Journal Of Technology, Innovation And Management (IJTIM)*, *2*, 2022.

Almashhadani, M., Almashhadani, H., & Almashhadani, H. A. (2023). The Impact Of Education On Construction Management: A Comprehensive Review. *International Journal Of Business And Management Invention (IJBMI) ISSN*, *12*, 284–290.

Alzahrani, J. I., & Emsley, M. W. (2013). The Impact Of Contractors ' Attributes On Construction Project

Success : A Post Construction Evaluation. *JPMA*, *31*(2), 313–322.

Aulawi, H., Nuraeni, F., Setiawan, R., Rianto, W. F., Surya Pratama, A., & Maulana, H. (2023). Simple Additive Weighting In The Development Of A Decision Support System For The Selection Of House Construction Project Teams. *2023 International Conference On Computer Science, Information Technology And Engineering (Iccosite)*, 517–522.

Awad, A., & Fayek, A. R. (2012). A Decision Support System For Contractor Prequalification For Surety Bonding. In *Automation In Construction* (Vol. 21, Issue 1, Pp. 89–98). Elsevier B.V. Https://Doi.Org/10.1016/J.Autcon.2011.05.017

Beecham, S., Clear, T., Lal, R., & Noll, J. (2021). Do Scaling Agile Frameworks Address Global Software Development Risks? An Empirical Study. *Journal Of Systems And Software*, *171*.

Boateng, A., Ameyaw, C., & Mensah, S. (2022). Assessment Of Systematic Risk Management Practices On Building Construction Projects In Ghana. *International Journal Of Construction Management*, *22*(16), 3128–3136.

Cao, T. (2023). *Research And Implementation Of Budget Management Integration System Based On Data Resource Fusion*. 6.

Chen, J., Yu, T., Yin, L., Tang, J., & Wang, H. (2020). A Unified Time Scale Intelligent Control Algorithm For Microgrid Based On Extreme Dynamic Programming. *CSEE Journal Of Power And Energy Systems*, *6*(3), 583–590.

Choi, J., & Ha, M. (2022). Validation Of Project Management Information Systems For Industrial Construction Projects. *Journal Of Asian Architecture And Building Engineering*, *21*(5), 2046–2057.

Dingsøyr, T., Nerur, S., Balijepally, V., & Moe, N. B. (2012). A Decade Of Agile Methodologies: Towards Explaining Agile Software Development. In *Journal Of Systems And Software* (Vol. 85, Issue 6).

Divya Sankar, S., & Selvam, J. (2020). Risk Management In Construction Industry. *International Research Journal Of Engineering And Technology*. Www.Irjet.Net

Gutierrez, G., Garzas, J., De Lena, M. T. G., & Moguerza, J. M. (2019). Self-Managing: An Empirical Study Of The Practice In Agile Teams. *IEEE Software*, *36*(1), 23–27.

Ingle, P. V., & Mahesh, G. (2022). Construction Project Performance Areas For Indian Construction Projects. *International Journal Of Construction Management*, *22*(8), 1443–1454.

Khodabakhshian, A., & Re Cecconi, F. (2022). Data-Driven Process Mining Framework For Risk Management In Construction Projects. *IOP Conference Series: Earth And Environmental Science*, *1101*(3).

Pan, N. (2008). Fuzzy AHP Approach For Selecting The Suitable Bridge Construction Method. *Automation In Construction*, *17*(8), 958–965.

Pérez-Piqueras, V., Bermejo, P., & Gámez, J. A. (2023). *Projection: A Computational Intelligence-Based Tool For Decision Support In Agile Software Development Projects*.

Sampaio, A. Z. (2021). Project Management In Office: BIM Implementation. *Procedia Computer Science*, *196*, 840–847.

Santos, R., Cunha, F., Rique, T., Perkusich, M., Almeida, H., Perkusich, A., & Icaro Costa, ´. (N.D.). *A Comparative Analysis Of Agile Teamwork Quality Instruments In Agile Software Development: A Qualitative Approach*.

Serrador, P., & Pinto, J. K. (2015). Does Agile Work? - A Quantitative Analysis Of Agile Project Success. *International Journal Of Project Management*, *33*(5). Https://Doi.Org/10.1016/J.Ijproman.2015.01.006

Sihombing, D. J. C. (2023). Analysis And Development Of The Protrack Application: Construction Timeline Management Using Extreme Programming Methodology. In *Jurnal Mantik* (Vol. 7, Issue 2). Online.

Wiechmann, D. M., Reichstein, C., Haerting, R. C., Bueechl, J., & Pressl, M. (2022). Agile Management To Secure Competitiveness In Times Of Digital Transformation In Medium-Sized Businesses. *Procedia Computer Science*, *207*, 2353–2363. Https://Doi.Org/10.1016/J.Procs.2022.09.294

Xu, H., Chang, R., Pan, M., Li, H., Liu, S., Webber, R. J., Zuo, J., & Dong, N. (2022). Application Of Artificial Neural Networks In Construction Management: A Scientometric Review. In *Buildings* (Vol. 12, Issue 7). MDPI.

Zhang, J., Cheng, J. C. P., Chen, W., & Chen, K. (2022). Digital Twins For Construction Sites: Concepts, Lod Definition, And Applications. *Journal Of Management In Engineering*, *38*(2).