



Development of construction project cost budget application using rapid application development method

Denny Jean Cross Sihombing

Dept. Information System, Faculty of Engineering, Atma Jaya Catholic University of Indonesia, Jakarta, Indonesia

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ABSTRACT

This research aims to develop a Construction Project Cost Budget Plan application using the Rapid Application Development (RAD) approach. Through prototype evaluation, the app was tested by 150 critical stakeholders in the construction industry, including project managers, estimators, and additional stakeholders. The evaluation results show that the app integrates critical features such as budget calculation, real-time monitoring, customizable reporting, resource management, project planning, team collaboration, cloud integration, and budget data analysis. This research encourages further development and broader stakeholder participation in the next stage of development. This research contributes to developing innovative applications that can help the construction industry face the challenges of complexity, improve the efficiency of project budget management, and provide relevant and sustainable solutions. In addition, this research provides an opportunity to explore the potential use of artificial intelligence (AI)-based technology and blockchain technology in construction project management.

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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

The construction industry is one of the foundations of the development of modern civilization, shaping our physical environment through the construction of buildings, infrastructure, and facilities. The industry plays a crucial role in boosting economic growth, improving quality of life, and meeting the ever-changing needs of people worldwide. Construction projects, ranging from residential buildings to large infrastructure projects, profoundly impact various sectors, including housing, transportation, energy, and trade. As a result, the industry has a significant economic footprint, creating employment opportunities and driving innovation (Almashhadani et al., 2023; Cao, 2023).

However, the complexity of construction projects must be addressed. It involves intricate planning, precise execution, and tight budget control. Achieving these goals requires high coordination between various related parties, including architects, engineers, contractors, suppliers, and project managers. In addition, projects often face challenges such as design changes, permitting, unexpected weather conditions, and changes in building regulations and codes (Sampaio, 2021; Zhang et al., 2022). Managing resources such as materials, labor, and equipment is also crucial in ensuring the project's smooth running. All this makes managing construction projects complex, requiring careful planning, effective communication, and strong management skills to achieve project success.

Cost budget plays a crucial role in project management. It is a tool to effectively plan, control, and manage project expenses. Besides being a financial guide, the budget also plays a role in decision-making, project performance monitoring, and schedule monitoring. During project execution, the budget helps keep the project within the set budget limits while allowing the project manager to identify and address potential issues that may affect costs (Bahamid et al., 2022; Gao, 2022). In addition, the budget serves as an essential communication tool between project stakeholders, ensuring that all parties involved have a common understanding of the financial aspects of the project. Thus, a cost budget is one of the critical elements in successful project management that helps optimize resources, reduce risks, and achieve project goals efficiently.

Despite its importance, budget planning in construction remains a challenging task. It involves handling uncertainties such as fluctuations in material costs, unexpected project delays, and changes in scope. As a result, there is a growing need for innovative approaches and technology-based solutions to improve the efficiency and accuracy of budget planning in the construction industry. Issues in developing and using cost budget plans in construction projects must be faced wisely. One of the main issues is cost uncertainty, which fluctuating material prices, changes in scope, or other unforeseen factors can cause. Changes in project scope are also often problematic, resulting in necessary budget adjustments. Limited resources, such as funds and human resources, can make it challenging to develop a realistic budget. Lack of historical data or sufficient reference information is often the case with unique projects (Divya Sankar & Selvam, 2020; Ingle & Mahesh, 2022).

Meanwhile, changes in regulations and building codes can affect costs. Inefficient controls during project execution and discrepancies between estimated costs and actual expenditures are also issues that must be carefully addressed. Appropriate project management technology and tools can help address most of these issues. However, a solid understanding of budget planning and adaptability to change remain critical to effectively managing project budgets (Boateng et al., 2022; Fredriksson & Hüge-Brodin, 2022; Jato-Espino et al., 2014).

Technology has played a central role in transforming how the construction industry plans and manages project cost budgets. For example, project management software has enabled managers to plan and track projects more efficiently. With tools like Microsoft Project and Primavera, they can develop schedules that are integrated with budgets, ensuring that all tasks and activities are linked. Increasingly sophisticated estimating software allows for more accurate cost estimates by integrating the latest material and labor price data (Sihombing, 2023; Sihombing et al., 2016).

A software development method is a systematic approach to designing, developing, and managing software (Huikkola et al., 2022; Persson et al., 2022; Theunissen et al., 2022). The method includes requirements analysis, designing, implementing, testing, and maintaining the software. A software development method serves as a guide that helps the development team organize work, manage resources, and ensure the software's quality and sustainability (Hinderks et al., 2022; Trzeciak et al., 2022). Some well-known methods include Waterfall, Agile, Scrum, and DevOps methods, each of which has a different

approach to integrating the software development process with business and stakeholder needs. Choosing a method that suits the project and business goals is critical to success in software development (Theunissen et al., 2022).

The use of Rapid Application Development (RAD) in the development of cost budget plan applications is highly relevant in the world of modern construction projects. Construction projects are often complex and fraught with challenges, including unexpected changes in scope, fluctuations in material costs, and uncertainties in schedule. In situations like these, the RAD approach brings significant benefits. RAD offers much-needed flexibility in coping with changes. In budget plan application development, changes must be accommodated quickly and efficiently. With RAD, developers can easily adapt the application to changes in scope or requirements that arise during the project (Daraghmi & Daraghmi, 2022; Gananjaya et al., 2022; Rabuske, 2020).

In addition, RAD encourages active involvement from stakeholders, such as project managers, estimators, and project owners. They can be involved in the development of the application from the very beginning, providing valuable input on the real needs and requirements that must be met. This helps ensure that the final application truly matches the needs of the field. Rapid prototype development is also a hallmark of RAD. In the context of a cost budget plan application, this allows users to immediately view and test early versions of the application. This facilitates immediate feedback and quick fixes to ensure the application achieves the expected level of accuracy and functionality (Schneider & Gärtner, 2022; Wahyuningrum et al., 2021a, 2021b).

RAD encourages intensive testing during application development. In complex budget planning, sound testing is essential to ensure the accuracy of budget calculations and avoid errors that could significantly impact the project. Finally, RAD enables streamlining of the development process, which reduces development costs and speeds up the time to market applications. This is a precious aspect in a construction industry with tight deadlines. Overall, using RAD in developing cost budget plan applications brings many benefits, including flexibility, stakeholder involvement, coping with change, and rapid development. These can help improve efficiency and accuracy in construction project budget planning, result in more effective budget management, and reduce the risk of cost uncertainty (Chen et al., 2020; Montalbán-Domingo et al., 2023; Santos et al., 2023).

This research aims to develop a cost budget plan application for construction projects using the Rapid Application Development (RAD) methodology. The application to be developed is expected to ease the budget planning process, increase flexibility in the face of scope changes, and enable more effective budget monitoring and control during project execution. In addition, this research aims to facilitate better collaboration between various project stakeholders and reduce the risk of cost uncertainty often associated with construction projects. Thus, the main objective of this research is to make a meaningful contribution to the construction industry by improving more efficient and accurate project budget management.

This research is expected to encourage the application of technology in construction project management by demonstrating the benefits of using the Rapid Application Development (RAD) methodology in application development. This research will highlight the importance of simplifying the application development process in a construction environment, encouraging companies to look for more efficient ways of developing technology-based solutions. By providing a more effective tool for project budget management, this research can also assist construction companies in controlling costs and minimizing the risk of cost uncertainty. As such, this research has great potential to positively impact technology development in the construction sector, improving efficiency, accuracy, and collaboration in construction project management and resulting in positive changes in the industry.

2. RESEARCH METHOD

The research consisted of eight main stages, as shown in Figure 1.

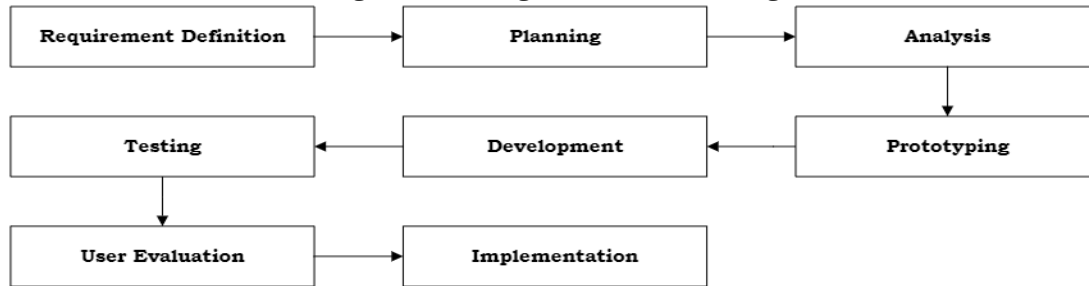


Figure 1. Research Stages

Requirement Definition

Identify the needs and requirements of construction project cost budget plan applications. Communicate with stakeholders, such as project managers and estimators, to understand their requirements.

Planning

Plan the overall development process, including resource allocation and work schedule. Determine the initial scope of the project and critical features of the application.

Analysis

Conduct an in-depth analysis of user requirements and identify how the application will fulfill those needs—identify critical elements to be implemented in the app, such as budget calculation, real-time budget monitoring, and reporting.

Prototyping

Build an initial prototype of the app that includes critical features. Engage stakeholders in prototype testing to get early feedback and refine the design.

Development

Initiate application development based on the approved prototype. Code, integrate features and implement the planned design.

Testing

Conduct thorough application testing to ensure correct functionality and accuracy of budget calculations. Involve stakeholders in piloting to verify that the application meets the requirements.

User Evaluation

Conduct end-user evaluations to identify issues or improvements needed. Incorporate user feedback to improve the user experience of the application.

Implementation

Implement the construction project cost budget plan application in a production environment. Provide training to end users who will use the application.

3. RESULTS AND DISCUSSIONS

Results of Requirement Definition

During the requirements definition stage, the results shown in Table 1 became a foundational step in the development process, providing clear guidance and insight into

the functions, features, and user expectations that needed to be accommodated in the later stages of application development.

Table 1. The Results of requirement

Identification of Needs and Requirements	Stakeholder Communication
A comprehensive analysis was conducted to identify the specific needs and requirements for the construction project budget planning application. This involved a thorough examination of the functionalities and features essential for effective budget management within the construction project context.	Extensive communication with stakeholders, including project managers and estimators, was carried out to gain a deep understanding of their unique requirements and expectations from the application. Their valuable insights and inputs were collected to ensure that the application aligns closely with their workflow and objectives.

Table 2. Results of Planning and Analysis

Resource	Quantity/Allocation
Development Team	6 team members (1 lead developer, 1 UI/UX designer, 2 back-end developers, 2 software testers)
Hardware	High-capacity server with adequate specifications
Software	Oracle Application Development
Cloud Infrastructure	Oracle Cloud Infrastructure

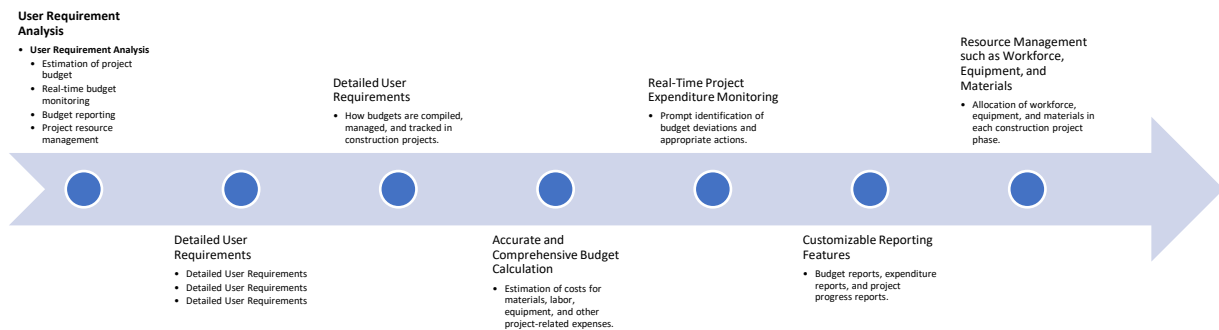


Figure 2. Result Analysis

In the analysis stage, as shown in Figure 2, users' key needs were identified, and an in-depth understanding of their workflow was obtained. Key elements of the application, such as accurate budget calculation, real-time expense monitoring, customizable reporting, and resource management, were identified as key to success. Real-time monitoring and reporting capabilities and the importance of data-driven decision-making in project budget management came into focus. The application is expected to significantly improve the efficiency and effectiveness of construction project budget management in the future.

Prototyping

In this stage, an initial prototype of the construction project cost budget plan application was built. This prototype included the key features identified in the previous analysis stage. It is important to note that the development of this prototype actively involved project stakeholders, including project managers and estimators, in testing the

prototype to obtain initial feedback. Stakeholder involvement in prototype testing enables early identification of potential design problems or flaws, allowing for quick and appropriate improvements. Thus, this prototyping stage aims to ensure that the design and functionality of the application can better meet the expectations and needs of the users before proceeding to a more advanced stage of development.

Development

The initial prototype of the construction project cost budget plan application has been successfully built at this stage. This prototype includes the key features identified in the previous analysis stage. The development process actively involves project stakeholders, such as project managers and estimators, in testing the prototype to get initial feedback. Stakeholder involvement in prototype testing is crucial as it allows the identification of potential problems or flaws in the design that can be corrected early on. Thus, this stage of development aims to ensure that the application's design and functionality can meet users' expectations and needs before proceeding to further implementation and testing stages.

Testing

Concrete test steps should be designed to generate accurate data, and prototype testing should be conducted according to a predefined testing methodology. After testing, the collected data will provide insight into the extent to which the prototype meets user expectations and needs. These results will form the basis for further improvements and adjustments before proceeding to the next stage of development and implementation.

Table 3. Results of Testing

No.	Tested Features	Test Description	Hasil Pengujian	Catatan
1	Budget Calculation	Input material, labor, equipment, and other costs into the application for budget calculation.	This feature works well and provides accurate calculation results.	There are no additional notes.
2	Real-Time Monitoring	Monitor project expenditure in real-time. Enter expenditures and compare them to the established budget.	This feature works well and provides notifications when there is a deviation from the budget.	Real-time monitoring provides good visibility into pengeluaran.
3	Budget Reporting	Produce initial budget, expense, and project progress reports according to user requirements.	This feature provides reports that can be customized to the desired format.	Reports can be edited and customized before they are generated.
4	Resource Management	Allocate labor, equipment, and materials in each stage of the project.	This feature helps in allocating resources efficiently and prevents wastage.	Resource usage can be viewed in graphs and reports.
5	Project Planning	Plan the overall project with resource allocation and work schedule.	This feature provides an integrated view of the project and enables better planning.	Work schedules can be changed and updated as needed.

6	Team Collaboration	The collaboration feature allows project teams to share real-time information and updates.	Team collaboration is smooth, facilitating communication and collaboration between team members.	Access to projects can be organized based on roles and responsibilities.
7	Cloud Integration	The app provides data storage in the cloud for easy access and better collaboration.	Data is available online and offline, making it easy to access anytime and anywhere.	Data security in the cloud is guaranteed.
8	Analysis Support	The analytical tools provided assist users in making decisions based on budget data.	Analysis of budget data provides valuable insights for decision-making.	Users can make projections based on historical data.

User Evaluation

The User Evaluation of the Construction Project Cost Budget Plan Application Prototype results, which involved 150 key stakeholders, including project managers, estimators, and additional stakeholders, revealed that the user-driven approach in the application design has been successful. Stakeholders responded positively to the ease of use and functionality implemented in the prototype. Budget calculation, real-time monitoring, customizable reporting, and resource management were judged to have clear benefits. In taking feedback from a diverse set of 150 users, including core users, secondary users, and additional stakeholders, it was found that the application could accommodate a wide range of needs and experience levels. The evaluation also helped plan for further development by adding resource allocation optimization features and developing a budget data analysis prediction model. Repeating the evaluation with multiple stakeholders helped identify issues that may have been apparent to the core users. While the results of this evaluation provide a positive view of the prototype application, it should be noted that the number of users involved in this evaluation reflects the diversity in user backgrounds and roles, which can be considered representative in the early development stage but more users need to be involved in the later development stages to ensure the application's suitability to different construction project contexts and improve its reliability and competitiveness in the dynamic construction project management market.

Table 3. Results of User Evaluation

No.	Evaluated Features	Evaluation Description	Stakeholder Feedback	Corrective Action
1	Budget Calculation	Users were tested in performing budget calculations for simulation projects.	Users provided positive feedback regarding the ease of use of this feature.	No corrective action is required at this time.
2	Real-Time Monitoring	Users are required to monitor project expenses and enter expenses in real-time.	Stakeholders appreciated the real-time monitoring and notification capabilities when deviations occur.	Minor improvements to enhance the visualization of the expense chart are being implemented.

3	Budget Reporting	Users are required to generate budget reports and edit them as needed.	Users found the report easy to customize and recorded the findings well.	The addition of report filter options is being planned.
4	Resource Management	Users allocate labor, equipment, and materials in the simulation project.	Stakeholders found this feature helpful in the efficient allocation of resources.	Additional resource allocation optimization features are under development.
5	Project Planning	Users plan the overall project, including resource allocation and work schedule.	Stakeholders see value in this integrated project planning.	Improved integration of project calendars into planning is in the works.
6	Team Collaboration	Users try to collaborate on project budget management with the project team.	Project teams value real-time information sharing and role organization.	The addition of collaboration notifications and user interface improvements are underway.
7	Cloud Integration	Users access data from the cloud and test it in offline mode.	Stakeholders are happy with flexible access to data in the cloud.	The improvement of data synchronization speed when switching modes is being improved.

Implementation

In the Implementation phase, the initial prototype of the Construction Project Cost Budget Plan application was successfully built with the involvement of key stakeholders. This process focused on developing key features identified in the previous phase. Some of the features developed, such as user management, are shown in Figure 3.

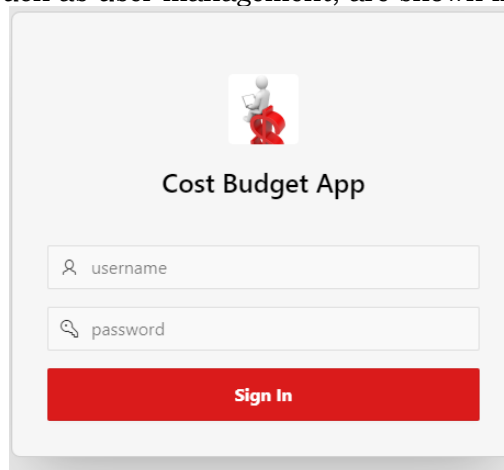


Figure 3. Sign In Page

In addition, dashboard features were also developed, as shown in Figure 4. The Construction Project Cost Budget Plan app dashboard serves as a real-time monitoring tool that provides visualization of budget data in the form of easy-to-understand graphs and reports. It enables stakeholders, including project managers and estimators, to identify budget changes, generate customized reports, monitor resource allocation, receive alert notifications, and collaborate efficiently. With extensive data integration, the dashboard

becomes an information hub that enables quick and effective decision-making, improving the efficiency of construction project budget management.

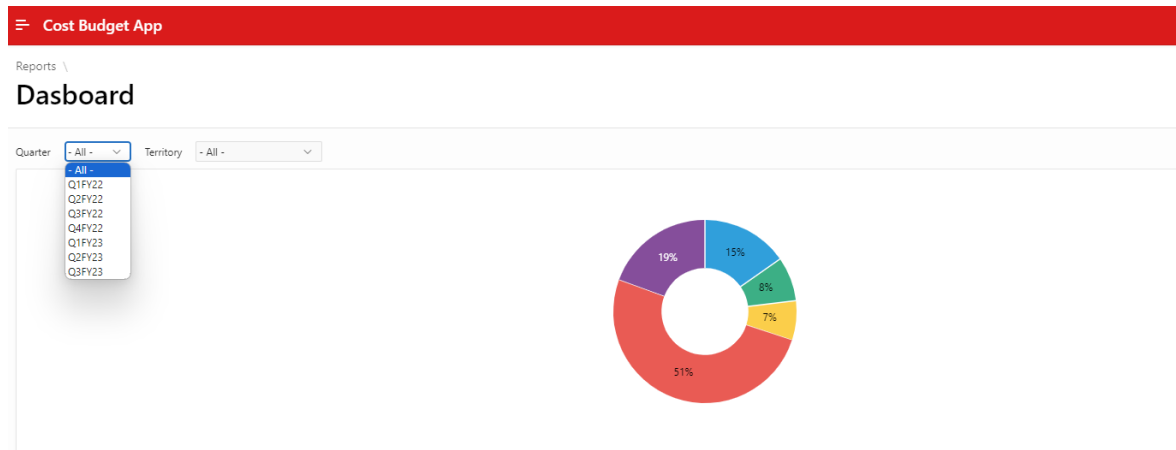


Figure 4. Dashboard

Competitor Analysis is a significant feature of this application, which is used for budget analysis of construction projects. The application display is shown in Figure 5. Competitor Analysis in this app plays a vital role in helping users understand and monitor the activities and performance of competitors in their industry. This feature presents relevant data and information about competitors, including analysis of market trends, assessment of competitors' strengths and weaknesses, and comparison of their performance with the user's business. With this information, users can identify market opportunities, develop better competitive strategies, and take appropriate business management steps. In addition, this feature also allows users to monitor changes in competitors' strategies and respond to them quickly, thus improving their competitiveness and overall business success.

Competitor	Quarter	Status	Accounts	Opportunity Count	Total Amount	Weighted Amount
Competitor D	Q4FY23	Open	1	1	\$212,890	\$21,289
Competitor A	Q4FY23	Open	2	2	\$112,887	\$11,289
Competitor B	Q4FY23	Open	1	1	\$65,432	\$6,543
Competitor E	Q3FY23	Won	1	1	\$6,145	\$6,145
					\$397,354	\$45,266

Figure 5. Competitor Analysis

Discussion

This research aims to develop a Construction Project Cost Budget Plan application using the Rapid Application Development (RAD) method. The results of the User Evaluation of this Application Prototype provide a positive picture of the progress and acceptance of this application by critical stakeholders involved in the management of construction projects. The evaluation results showed that the user-driven approach to application design had been successful, with users appreciating the ease of use and functionality

implemented in the prototype. Budget calculation, real-time monitoring, customizable reporting, and resource management were judged to have clear benefits. In taking feedback from a diverse set of 150 users, including core users, secondary users, and additional stakeholders, it was found that the app can accommodate a wide range of needs and experience levels.

An implementation process involving a development team with clearly defined roles and adequate resource allocation has resulted in a robust prototype. High-capacity servers and cloud infrastructure ensure that the application has the responsiveness and ability to integrate data from multiple sources. Despite the positive evaluation results, several corrective actions are in the works, including improved visualization of expense charts, addition of report filter options, optimization of resource allocation, and improved integration of project calendars into planning. Furthermore, developing predictive models in budget data analysis will provide deeper insights into project decision-making.

In addition, it should be noted that the use of prototypes in this evaluation reflects users' various backgrounds and roles. However, it is recommended to involve more users and stakeholders in the next stage of development to ensure the app's suitability to different construction project contexts and improve its competitiveness in the dynamic construction project management market. Overall, this research provides a positive outlook on developing a Construction Project Cost Budget Plan application using the RAD method, with the potential to be a valuable tool in assisting project managers and estimators in managing construction project budgets more efficiently and effectively.

4. CONCLUSION

This research makes significant progress in this field by providing a practical and innovative solution for more efficient and accurate construction project budget management. The integration of key features, such as real-time budget calculation, customizable reports, resource management, project planning, team collaboration, cloud integration, and budget data analysis, demonstrates the relevance and applicability of the RAD approach in this context. The application has potential for further development in future research, such as integrating artificial intelligence for more precise budget forecasting, applying blockchain technology for better data security, and adaptation for large-scale and sustainable construction projects. This corresponds to the ever-changing needs in the construction industry and emphasizes the importance of continuous research and innovation in the development of project budget management. Future experiments and continued development will contribute to further progress in this field, addressing complex challenges and opportunities in construction project management.

REFERENCES

- 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. <https://doi.org/10.35629/8028-1206284290>
- Bahamid, R. A., Doh, S. I., Khoiry, M. A., Kassem, M. A., & Al-Sharafi, M. A. (2022). The Current Risk Management Practices and Knowledge in the Construction Industry. *Buildings*, 12(7). <https://doi.org/10.3390/buildings12071016>
- 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. <https://doi.org/10.1080/15623599.2020.1842962>
- Cao, T. (2023). *Research and implementation of budget management integration system based on data resource fusion*. 6. <https://doi.org/10.1117/12.2688654>
- 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. <https://doi.org/10.17775/CSEEJPES.2019.00100>

- Daraghmi, Y.-A., & Daraghmi, E.-Y. (2022). RAPD: Rapid and Participatory Application Development of Usable Systems During COVID19 Crisis. *IEEE Access*, 10, 93601–93614. <https://doi.org/10.1109/ACCESS.2022.3203582>
- Divya Sankar, S., & Selvam, J. (2020). Risk Management in Construction Industry. *International Research Journal of Engineering and Technology*. www.irjet.net
- Fredriksson, A., & Hüge-Brodin, M. (2022). Green construction logistics – a multi-actor challenge. *Research in Transportation Business and Management*, 45(PA), 100830. <https://doi.org/10.1016/j.rtbm.2022.100830>
- Gananjaya, I., Chandra, J. O. T., Christanto, J. F. A., Widiyanto, M. H., & Audrey, J. (2022). “A Lone Burglar” Stealth Game Development Using Rapid Application Development. *2022 4th International Conference on Cybernetics and Intelligent System (ICORIS)*, 1–5. <https://doi.org/10.1109/ICORIS56080.2022.10031499>
- Gao, J. (2022). Research on Financial Informatization Construction of Business and Finance Integration. *International Journal of Science and Research (IJSR)*, 11(7), 354–358. <https://doi.org/10.21275/sr22704192347>
- Hinderks, A., Domínguez Mayo, F. J., Thomaschewski, J., & Escalona, M. J. (2022). Approaches to manage the user experience process in Agile software development: A systematic literature review. *Information and Software Technology*, 150. <https://doi.org/10.1016/j.infsof.2022.106957>
- Huikkola, T., Kohtamäki, M., Rabetino, R., Makkonen, H., & Holtkamp, P. (2022). Overcoming the challenges of smart solution development: Co-alignment of processes, routines, and practices to manage product, service, and software integration. *Technovation*, 118. <https://doi.org/10.1016/j.technovation.2021.102382>
- Ingle, P. V., & Mahesh, G. (2022). Construction project performance areas for Indian construction projects. *International Journal of Construction Management*, 22(8), 1443–1454. <https://doi.org/10.1080/15623599.2020.1721177>
- Jato-Espino, D., Castillo-Lopez, E., Rodriguez-Hernandez, J., & Canteras-Jordana, J. C. (2014). A review of application of multi-criteria decision making methods in construction. In *Automation in Construction* (Vol. 45, pp. 151–162). Elsevier B.V. <https://doi.org/10.1016/j.autcon.2014.05.013>
- Montalbán-Domingo, L., Casas-Rico, J., Alarcón, L. F., & Pellicer, E. (2023). Influence of the experience of the project manager and the foreman on project management's success in the context of LPS implementation. *Ain Shams Engineering Journal*, 102324. <https://doi.org/10.1016/j.asej.2023.102324>
- Persson, J. S., Bruun, A., Lárusdóttir, M. K., & Nielsen, P. A. (2022). Agile software development and UX design: A case study of integration by mutual adjustment. *Information and Software Technology*, 152. <https://doi.org/10.1016/j.infsof.2022.107059>
- Rabuske, T. (2020). Polymath: A Platform for Rapid Application Development of Modular EDA Tools. *2020 IEEE International Symposium on Circuits and Systems (ISCAS)*, 1–5. <https://doi.org/10.1109/ISCAS45731.2020.9180601>
- Sampaio, A. Z. (2021). Project management in office: BIM implementation. *Procedia Computer Science*, 196, 840–847. <https://doi.org/10.1016/j.procs.2021.12.083>
- Santos, J. I., Pereda, M., Ahedo, V., & Galán, J. M. (2023). Explainable machine learning for project management control. *Computers and Industrial Engineering*, 180. <https://doi.org/10.1016/j.cie.2023.109261>
- Schneider, L., & Gärtner, H. (2022). Additive manufacturing for lab applications in environmental sciences: Pushing the boundaries of rapid prototyping. *Dendrochronologia*, 76(June). <https://doi.org/10.1016/j.dendro.2022.126015>
- 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.
- Sihombing, D. J. C., Santoso, A. J., & Rahayu, S. (2016). Model Perangkingan Proyek Kontruksi Pada Asosiasi Kontraktor Menggunakan Fuzzy AHP. *Scientific Journal of Informatics*. <https://doi.org/10.15294/sji.v2i1.4531>
- Theunissen, T., van Heesch, U., & Avgeriou, P. (2022). A mapping study on documentation in Continuous Software Development. *Information and Software Technology*, 142. <https://doi.org/10.1016/j.infsof.2021.106733>

- Trzeciak, M., Sienkiewicz, Ł. D., & Bukłaha, E. (2022). Enablers of Open Innovation in Software Development Micro-Organization. *Journal of Open Innovation: Technology, Market, and Complexity*, 8(4). <https://doi.org/10.3390/joitmc8040174>
- Wahyuningrum, T., Fitriana, G. F., Wardhana, A. C., Sidiq, M. A., & Wahyuningsih, D. (2021a). Developing Suicide Risk Idea Identification for Teenager (SERIINA) Mobile Apps Prototype using Extended Rapid Application Development. *2021 9th International Conference on Information and Communication Technology (ICoICT)*, 92–97. <https://doi.org/10.1109/ICoICT52021.2021.9527508>
- Wahyuningrum, T., Fitriana, G. F., Wardhana, A. C., Sidiq, M. A., & Wahyuningsih, D. (2021b). Developing Suicide Risk Idea Identification for Teenager (SERIINA) Mobile Apps Prototype using Extended Rapid Application Development. *2021 9th International Conference on Information and Communication Technology (ICoICT)*, 92–97. <https://doi.org/10.1109/ICoICT52021.2021.9527508>
- 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). [https://doi.org/10.1061/\(asce\)me.1943-5479.0000948](https://doi.org/10.1061/(asce)me.1943-5479.0000948)