


Enhancing workforce efficiency in construction: a technological intervention for skill matching and resource optimization using extreme programming

Denny Jean Cross Sihombing

Faculty of Engineering, Atma Jaya Catholic University of Indonesia

| Article Info | ABSTRACT |
|--|---|
| <p>Keywords: Workforce Efficiency, Freelance Workers, Extreme Programming, Construction Projects.</p> | <p>This research addresses a crucial issue related to labor deployment and management in construction project management. In the context of the complexity of skill needs and dynamic changes in construction projects, this research proposes an innovative solution by developing a Human Resource Management application. The research method was structured in three main stages. The first stage involved data collection to identify skills needs, team dynamics, and project demands. The second stage involved developing the application using the Extreme Programming (XP) method, focusing on critical features such as skills matching, team performance monitoring, and labor risk analysis. The final stage was user acceptance analysis, where a user acceptance measurement model was applied to a representative group of users. The results showed that the application received high user ratings, with the Interactive Project Schedule feature being the most favored. Team Performance Monitoring and Centralised Team Communication also received high ratings. While Labour Risk Analysis scored positively, there were notes for improvement. The app provides an integrated solution for effective human resource management in construction projects. The main contribution of this research lies in developing an application that is responsive and adaptive to changing project needs, utilizing XP principles.</p> |
| <p>This is an open access article under the CC BY-NC license</p>  | <p>Corresponding Author: Denny Jean Cross Sihombing Atma Jaya Catholic University of Indonesia Jakarta, Indonesia denny.jean@atmajaya.ac.id</p> |

INTRODUCTION

In the reality of construction project management, the placement and management of labor is a crucial aspect. Construction projects, which often involve many workers with diverse skills, require effective coordination and intelligent human resource management strategies. It is essential to identify the skills required carefully, place the workforce appropriately, and maintain efficient communication among team members (Alzahrani & Emsley, 2013; Ingle & Mahesh, 2022; Jato-Espino et al., 2014). The success of a construction project largely depends on the involvement of a skilled, coordinated, and motivated workforce. In this perspective, human resource management becomes a central

element that determines the project's outcome. By ensuring the availability of the appropriate skills at the right time, avoiding labor vacancies or backlogs, and executing team dynamics well, effective human resource management enables projects to achieve operational efficiency and overall success(Almashhadani et al., 2023; Bahamid et al., 2022; Rajabi et al., 2022; Xu et al., 2022; Zhang et al., 2022).

The challenge in managing the workforce on construction projects often lies in the complexity of skill and expertise requirements. With various specialists and backgrounds, team members' coordination can be complicated. External factors such as weather changes, regulations, and project needs can complicate workforce planning and management. Understanding these challenges is critical to developing innovative solutions for human resource management in construction projects. As such, an innovative and adaptive approach is required to address the unique dynamics of the construction environment(Altaf et al., 2022; Brodskiy, 2022; Pham et al., 2023; Sihombing, 2023; Taylan et al., 2014; Tushar et al., 2022). Matching the right skills with specific tasks and optimizing human resources are critical challenges in dynamic construction. Construction projects involving various skill levels require efficient coordination to ensure each team member makes maximum contribution according to their respective roles and responsibilities. The difficulty of identifying and managing labor skills, which creates barriers to achieving efficiency, is a significant obstacle. This leads to the need for a structured solution to address discrepancies and ensure project success(Aulawi et al., 2023; Awad & Fayek, 2012; Shirai & Kiritani, 2021).

A mismatch in skill deployment can severely impact the timeframe and cost of a construction project. If the skills do not match the actual placement, the project may experience delays and increased operational costs. Mismatches can also create team instability, affect morale, and hinder collaboration. Therefore, there is a need for an in-depth understanding of how these mismatches affect the project and the search for practical solutions to improve the precision of labor placement. The importance of optimizing the use of human resources in construction projects is not only limited to matching skills with tasks but also to ensuring the work efficiency of each individual. In the construction environment, which is dominated by tight time and resource constraints, careful planning, efficient coordination, and adaptive management to the changing dynamics of the project are required. Thus, construction projects can achieve optimal efficiency in the use of resources, support timely completion, and avoid unnecessary cost wastage(Choi & Ha, 2022; Guo et al., 2023; Serpell & Rubio, 2023; Tessema et al., 2022).

In construction project management, technological developments have played a central role in changing how we approach and execute projects. Utilizing project management software, intelligent sensors, and IoT-based technologies has created a more connected, efficient, and responsive project environment. Online collaboration and cloud computing have overcome communication and coordination obstacles, while information technology has introduced intelligent data analysis tools. However, amidst these advancements, significant gaps in applying technology in human resource management

exist. Workforce monitoring and placement still rely on manual methods, and innovations to automate administrative tasks and analyze employee skills data are opportunities that have yet to be fully utilized. This research aims to bridge this gap, designing the latest technological solutions to improve the efficiency of human resource management in construction projects, ensuring that technological sophistication also pervades this critical aspect of project management(Boateng et al., 2022; Fredriksson & Hüge-Brodin, 2022; Nguyen & Robinson Fayek, 2022; Trask & Linderoth, 2023).

This research aims to outline the urgency of innovation in application development in the context of construction projects. The background of the research shows that the need for responsive and adaptive solutions to changing project needs is increasingly important. Therefore, this research addresses the relevance of using Extreme Programming (XP) in application development, focusing on human resource management in construction projects(Akhtar et al., n.d.; Fojtik, 2011; Leong et al., 2023; Sarhadi et al., 2022; Senabre Hidalgo, n.d.; Udvaros et al., 2023; Wiechmann et al., 2022; Wood et al., 2013). The center of attention of this research is to provide an in-depth understanding of the advantages of XP in addressing the complexities of human resource management. XP principles, such as intensive communication and feature-based development, are analyzed in detail to show how the application of XP can increase responsiveness and flexibility in application development for human resource management. This research will provide valuable insights to practitioners and academics in this field. This research aims to contribute to the literature and pave the way for further research by exploring the relationship between XP characteristics and specific needs in human resource management application development. Thus, the ultimate goal is positively impacting human resource management practices in construction projects.

METHODS

The research was structured in three key stages. The initial stage involved data collection, where data requirements were identified, and data collection methods were designed to support the development of a human resource management application for construction projects. Then, the focus moved to the application development stage using the Extreme Programming (XP) method. A development team was formed, and the development process was iterative, emphasizing critical features and iterative testing. Finally, the user acceptance analysis stage focused on designing and implementing a user acceptance measurement model. User responses to the application are evaluated through this model to evaluate success and identify areas of improvement. Overall, this approach provides a comprehensive methodological framework for investigating, developing, and evaluating human resource management applications with a holistic approach.



Figure 1. Research Stages

Data Collection

This research was designed in three main stages. The first stage, data collection, began with identifying relevant data needs for developing a human resource management application in construction projects. Next, data collection methods were designed, including surveys, interviews, and document analysis. Once the design was finalized, careful data collection was implemented to ensure the reliability and accuracy of the information collected.

Application Development

The second stage involved developing the application using the Extreme Programming (XP) method. First of all, the application's functional requirements were identified based on the data collection results. Forming a development team skilled in XP was the next step, with emphasis on the roles of each member and training as needed. The development process was iterative, focusing on critical features, and iterative testing was conducted to ensure the app's quality.

User Acceptance Analysis

The last stage is user acceptance analysis. In this stage, a user acceptance measurement model is designed to measure user response to the developed application. This process involves implementing the model on a representative group of users. The data from the measurements are then analyzed and interpreted to evaluate the application's success and identify areas of improvement based on user feedback. With this series of stages, this research aims to investigate, develop, and evaluate the app with a holistic and methodological approach.

RESULTS AND DISCUSSION

Data Collection

The results of the Data Collection stage show the achievement of essential steps to support the development of human resource management applications on construction projects. Identifying data needs was done by determining the critical data types required, such as workforce skills, team dynamics, and project demands. In this context, workforce skills data includes information on employees' level of expertise and experience. In the design of data collection methods, methods such as online surveys to collect workforce skills data, interviews to gain an in-depth understanding of team dynamics, and project document analysis to provide information related to project demands were used. The design carried out the data collection implementation process, with the results obtained from online surveys, interviews, and document analysis providing an initial dataset that can be used as the basis for the next stage of application development.

Table 1. identify data needs

| Data Type | Desc. |
|------------------|---|
| Workforce Skills | Information on employee skills in construction projects. Data: Skill level (construction techniques, equipment use), Work experience, Certification |

| Data Type | Desc. |
|-----------------|--|
| Team Dynamics | Information on team member dynamics and interactions. Data: Communication effectiveness, Level of collaboration, Team trust, Adaptability |
| Project Demands | Information on project-specific characteristics and demands. Data: Project type (high-rise, highway), Project schedule, Project budget, Technical specifications |

Table 1 covers the critical data types required for developing human resource management applications on construction projects. In the context of labor skills, information on technical expertise and work experience is critical to ensuring effective placement in the project. Team dynamics include communication and trust, vital to improving team performance. Meanwhile, information on project demands, such as project type, schedule, budget, and technical specifications, provide a deep understanding of the context of construction projects. This analysis highlights the need for diverse data to support holistic and practical human resource management applications.

Application Development

The results of the Application Development Stage using the Extreme Programming (XP) Method include achieving several essential steps. First of all, the application's functional requirements were identified based on the data collection results. This involved an in-depth understanding of the critical aspects required by a human resource management application in a construction project. Next, a development team skilled in XP was formed. This team formation process involved defining the roles of each team member, with an emphasis on appropriate skill sets and responsibilities. Training was provided to ensure each team member understood and could implement XP principles effectively.

The application development process was carried out in an iterative manner, where focus was given to the development of critical features. The selection of these features is based on previously identified functional requirements. Iterative development allows for quick adaptation to changes during the development process. In addition, iterative testing is implemented to ensure the quality and reliability of the application. Testing includes validating critical features, testing the application's overall functionality, and identifying and fixing any bugs that may appear. The result of this stage is an application that has undergone thorough development, meets the identified functional requirements and has been carefully tested to ensure its quality.

Table 2. Application Features

| Features | Function |
|------------------------------|---|
| Skill Matching | Allows project managers to match employee skills with specific tasks or projects, ensuring efficient placement based on individual expertise. |
| Interactive Project Schedule | Provides an interactive calendar visualizing the project schedule, enabling teams to view deadlines, tasks, and progress in real- |

Enhancing workforce efficiency in construction: a technological intervention for skill matching and resource optimization using extreme programming –

Denny Jean Cross Sihombing

| Features | Function |
|--|---|
| | time. |
| Team Performance Monitoring | Enables managers to monitor team members' performance, including productivity levels, time spent on specific tasks, and individual contributions to project goals. |
| Centralized Team Communication | Provides a centralized communication platform for team members, including real-time chat, discussion forums, and project notifications, enhancing collaboration and information exchange. |
| Workforce Risk Analysis | Analyzes potential risks associated with the workforce, such as absenteeism, decreased productivity, or skill shortages, aiding project managers in preventive actions. |
| Workforce Change and Rotation Management | Facilitates changes in roles or workforce rotations, allowing managers to adjust team structures based on evolving project needs. |
| Employee Performance Evaluation | Provides tools for regular employee performance evaluations, offering constructive feedback and identifying areas for development. |
| Human Resource Budget Monitoring | Tracks budgets related to human resources, assisting project managers in cost management and efficient resource allocation. |
| Analytics Dashboard | Displays a dashboard with comprehensive data analysis, offering insights into team performance, skill matching, and other key factors influencing human resource management. |
| Integration with External Systems | Enables integration with external systems such as employee attendance systems or other project management tools to achieve better data connectivity. |

The Human Resource Management on Construction Projects application has several key features, Table 2, that can significantly improve the efficiency and effectiveness of project management. The Skill Matching feature allows managers to optimally place labor based on individual skills, ensuring maximum contribution from each team member. Interactive Project Schedule provides real-time visibility into the project schedule, enabling teams to quickly identify and address potential delays. Team Performance Monitoring provides an in-depth understanding of each member's contribution, improving overall team productivity and performance. In addition, Centralized Team Communication facilitates efficient collaboration through an integrated communication platform. Labor Risk Analysis enables managers to anticipate and mitigate the impact of risks to the project. Change Management and Workforce Rotation provide flexibility in adjusting the team structure according to project dynamics. Regular Employee Performance Evaluations help identify employee development potential, creating a work environment that supports professional growth.

Human Resources Budget Monitoring provides visibility into labor-related costs, supporting managers in efficient budget management. Analytics Dashboards provide a holistic view of team performance and skill matching, providing a foundation for real-time data-driven decision-making. Finally, Integration with External Systems enables efficient data exchange, minimizing double work and ensuring data consistency across platforms. Overall, the app provides an integrated solution for effective human resource management in the context of construction projects.

User Acceptance Analysis

The outcome of the last stage of the research involved a user acceptance analysis to evaluate the response to the developed application. At this stage, a user acceptance measurement model was designed, and the model implementation process was carried out on a representative group of users. The data collected from this measurement is then carefully analyzed and interpreted to assess the application's success and identify areas of improvement based on user feedback. The first step involved designing a user acceptance measurement model that included critical variables such as usability, user satisfaction, and user intention to adopt the app. The model was designed to provide an in-depth understanding of users' perceptions of the app and analyze the level of acceptance. Next, the model is implemented on a representative group of users, which may include diverse stakeholders involved in the construction project. The data collected is then analyzed quantitatively and qualitatively. Quantitative analysis involves statistical measurement of user acceptance scores, while qualitative analysis involves a more in-depth evaluation of user feedback and views.

This analysis aims to provide deep insight into how users receive the app, the extent to which it meets their expectations and needs, and which areas require improvement. With this holistic and methodological approach, this research aims not only to develop an app that suits the needs of construction projects but also to ensure maximum acceptance and adoption by end users.

Table 3. Application Feature Testing

| Features | Scenario | Results |
|------------------------------|---|--------------|
| Skill Matching | The project manager needs to assign a worker with high skills in managing specialized equipment for a high-rise construction project. Test this feature by matching the worker's skills with tasks that require such expertise. | successfully |
| Interactive Project Schedule | The project team encounters a sudden change in the schedule requiring quick adjustments. Test the application's response to real-time scheduling changes and its ability to adapt promptly | |
| Team Performance Monitoring | A manager wants to monitor individual performance within the team during a critical project phase. Test this feature by tracking the | successfully |

Enhancing workforce efficiency in construction: a technological intervention for skill matching and resource optimization using extreme programming –

Denny Jean Cross Sihombing

| Features | Scenario | Results |
|--|--|--------------|
| Centralized Team Communication | productivity and contributions of each team member individually. The construction team faces an issue that requires immediate communication. Test the application's ability to provide a centralized communication platform through direct chat for efficient issue resolution. | successfully |
| Workforce Risk Analysis | The project manager wants to analyze potential risks related to the absence of key workers. Test the application's ability to provide risk analysis and recommendations for preventive measures. | successfully |
| Workforce Change and Rotation Management | Faced with a change in the team structure, a manager wants to use the application to manage workforce role changes. Test the change management feature for smooth process execution. | successfully |
| Employee Performance Evaluation | Conducting periodic performance evaluations for an employee. Test the application in organizing and implementing the performance evaluation process, including feedback provision and development planning. | successfully |
| Human Resource Budget Monitoring | The financial manager wants to see how the human resource budget evolves during the project. Test the application's ability to track and report the budget in real-time. | |
| Analytics Dashboard | The project manager wants quick insights into team performance and skill matching. Test the analytics dashboard's ability to provide information for instant decision-making. | successfully |
| Integration with External Systems | Employee attendance data is integrated with the human resource management application. Test data connectivity with external systems to ensure data integrity and consistency across platforms. | successfully |

Testing of the application features, Table 3, resulted in positive evaluations of their Performance and functionality. The Skill Matching feature successfully optimized workforce deployment by matching workers' skills with appropriate tasks, supporting efficiency in human resource management. The Interactive Project Schedule responded quickly to sudden schedule changes, allowing teams to adjust efficiently. Team Performance Monitoring successfully tracks team members' individual contributions, providing valuable

insights for performance management. The Centralized Team Communication feature effectively addressed urgent issues through a live chat platform, facilitating efficient communication. Workforce Risk Analysis provided a proactive solution by analyzing potential risks related to crucial worker absenteeism. Workforce Change and Rotation Management runs smoothly, supporting adaptation to changes in team structure.

The Employee Performance Evaluation process proved efficient, providing constructive feedback and development plans. Human Resource Budget Monitoring successfully provided good visibility of budget developments during the project. Dashboard Analytics provided deep insights, facilitating instant decision-making based on real-time data. Integration with External Systems was successful, ensuring data consistency across platforms. The test results showed that the application met expectations well, providing an integrated solution for effective human resource management in construction projects.

Involving 50 respondents actively involved in construction projects, a satisfaction rating scale from 1 to 100 was applied to measure user response to the app. The test results showed that the critical features of the app received high ratings. Skills Matching achieved an average satisfaction score of 84, reflecting the app's success in making it easier for users to manage labor skills. The Interactive Project Schedule feature received the highest average satisfaction score of 90, indicating a positive response to the app's ability to quickly and efficiently respond to schedule changes.

Team Performance Monitoring and Centralized Team Communication also received ratings of 87 and 88, respectively. This reflects the effectiveness of the application in providing visibility into individual Performance and facilitating centralized communication to address project issues. While the Labor Risk Analysis feature was positively rated with a score of 81, there were notes for improvement to ensure the risk analysis becomes more comprehensive. With an overall average satisfaction score of 86, users positively assessed the app. An in-depth evaluation of user responses shows that the app has successfully met expectations in human resource management on construction projects. Nonetheless, continuing to conduct regular evaluations and continuous improvement will be vital to maintaining high satisfaction and ensuring the app remains relevant to user needs.

CONCLUSION

This research highlights the crucial role of workforce management in the success of construction projects. In the face of complex skill requirements, team dynamics, and changing project demands, developing a Human Resource Management application using an Extreme Programming (XP) approach proved to be a holistic and adaptive solution. User acceptance evaluations positively responded to the application, with the Interactive Project Schedule feature being a bright spot. Although the Labor Risk Analysis received positive ratings, further improvements are needed to enhance its comprehensiveness. The app effectively addresses challenges in skill matching, team performance monitoring, centralized communication, and risk analysis, making significant contributions to improving the efficiency of human resource management in construction projects. The contribution of

this research goes beyond practical implementation, paving the way for a deeper understanding of the application of XP methodology in human resource management. Overall, this research provides valuable insights for practitioners and academics alike, calling for the continued optimization of construction project management strategies through an adaptive and responsive approach to dynamic changes in the construction environment. As such, this research encapsulates a step forward in human resource management innovation, positively contributing to the effectiveness of construction project management.

REFERENCE

- 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. <https://doi.org/10.54489/ijtim.V2i1.77>
- 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 (Ijbmj) Issn*, 12, 284–290. <https://doi.org/10.35629/8028-1206284290>
- Altaf, M., Alalaoul, W. S., Musarat, M. A., Hussain, A., Saad, S., Rabbani, M. B. A., & Ammad, S. (2022). Evaluating The Awareness And Implementation Level Of Lcca In The Construction Industry Of Malaysia. *Ain Shams Engineering Journal*, 13(5). <https://doi.org/10.1016/j.asej.2021.101686>
- 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. <https://doi.org/10.1016/j.jproman.2012.06.006>
- 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. <https://doi.org/10.1109/iccosite57641.2023.10127813>
- 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>
- 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>

- Brodskiy, V. (2022). Improving Transport And Technological Process To Supply Material Resources For House Construction. *Transportation Research Procedia*, 63, 639–647. <https://doi.org/10.1016/j.trpro.2022.06.057>
- 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. <https://doi.org/10.1080/13467581.2021.1941999>
- Fojtik, R. (2011). Extreme Programming In Development Of Specific Software. *Procedia Computer Science*, 3, 1464–1468. <https://doi.org/10.1016/j.procs.2011.01.032>
- 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>
- Guo, F., Wang, K., & Cao, E. (2023). A Digital Twin (Dt) Framework At Design And Construction Phases. <https://www.researchgate.net/publication/371416031>
- 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>
- Leong, J., May Yee, K., Baitsegi, O., Palanisamy, L., & Ramasamy, R. K. (2023). Hybrid Project Management Between Traditional Software Development Lifecycle And Agile Based Product Development For Future Sustainability. *Sustainability*, 15(2), 1121. <https://doi.org/10.3390/su15021121>
- Nguyen, P. H. D., & Robinson Fayek, A. (2022). Applications Of Fuzzy Hybrid Techniques In Construction Engineering And Management Research. *Automation In Construction*, 134, 104064. <https://doi.org/10.1016/j.autcon.2021.104064>
- Pham, T. T., Lingard, H., & Zhang, R. P. (2023). Factors Influencing Construction Workers' Intention To Transfer Occupational Health And Safety Training. *Safety Science*, 167. <https://doi.org/10.1016/j.ssci.2023.106288>
- Rajabi, S., El-Sayegh, S., & Romdhane, L. (2022). Identification And Assessment Of Sustainability Performance Indicators For Construction Projects. *Environmental And Sustainability Indicators*, 15(June), 100193. <https://doi.org/10.1016/j.indic.2022.100193>
- Sarhadi, P., Naeem, W., Fraser, K., & Wilson, D. (2022). On The Application Of Agile Project Management Techniques, V-Model And Recent Software Tools In Postgraduate Theses Supervision. *Ifac-Papersonline*, 55(17), 109–114. <https://doi.org/10.1016/j.ifacol.2022.09.233>
- Senabre Hidalgo, E. (N.D.). *Adapting The Scrum Framework For Agile Project Management In Science: Case Study Of A Distributed Research Initiative*. <https://doi.org/10.1016/j.heliyon.2019>

- Serpell, A., & Rubio, H. (2023). Evaluating Project Management (Pm) Readiness In Construction Companies: Cases From Chile. *Procedia Computer Science*, 219, 1642–1649. <https://doi.org/10.1016/j.procs.2023.01.457>
- Shirai, T., & Kiritani, K. (2021). A Study On The Problem Of Business It System Utilization In Japanese Companies Construction Of Non-Utilization Model According To Business Characteristics Of Japanese Companies-. *Procedia Computer Science*, 181, 285–293. <https://doi.org/10.1016/j.procs.2021.01.148>
- Sihombing, D. (2023). Development Of Construction Project Cost Budget Application Using Rapid Application Development Method. In *Jurnal Mantik* (Vol. 7, Issue 3). Online.
- Taylan, O., Bafail, A. O., Abdulaal, R. M. S., & Kabli, M. R. (2014). Construction Projects Selection And Risk Assessment By Fuzzy Ahp And Fuzzy Topsis Methodologies. *Applied Soft Computing Journal*, 17, 105–116. <https://doi.org/10.1016/j.asoc.2014.01.003>
- Tessema, A. T., Alene, G. A., & Wolelaw, N. M. (2022). Assessment Of Risk Factors On Construction Projects In Gondar City, Ethiopia. *Heliyon*, 8(11), E11726. <https://doi.org/10.1016/j.heliyon.2022.E11726>
- Trask, C., & Linderoth, H. C. (2023). Digital Technologies In Construction: A Systematic Mapping Review Of Evidence For Improved Occupational Health And Safety. In *Journal Of Building Engineering* (Vol. 80). Elsevier Ltd. <https://doi.org/10.1016/j.jobe.2023.108082>
- Tushar, Z. N., Bari, A. B. M. M., & Khan, M. A. (2022). Circular Supplier Selection In The Construction Industry: A Sustainability Perspective For The Emerging Economies. *Sustainable Manufacturing And Service Economics*, 1(September), 100005. <https://doi.org/10.1016/j.smse.2022.100005>
- Udvaros, J., Forman, N., & Avornicului, S. M. (2023). Agile Storyboard And Software Development Leveraging Smart Contract Technology In Order To Increase Stakeholder Confidence. *Electronics (Switzerland)*, 12(2). <https://doi.org/10.3390/electronics12020426>
- 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>
- Wood, S., Michaelides, G., & Thomson, C. (2013). Successful Extreme Programming: Fidelity To The Methodology Or Good Teamworking? *Information And Software Technology*, 55(4), 660–672. <https://doi.org/10.1016/j.infsof.2012.10.002>
- 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. <https://doi.org/10.3390/buildings12070952>
- 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)