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Application of Agile Approach in Transportation Management System Development to Improve Construction Company Performance

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ABSTRACT
This research aims to explore the application of an Agile approach in developing a transport management system to improve the performance of construction companies. Problems encountered in construction transport management, including inflexibility, non-adaptability, and lack of communication, prompt a more dynamic and responsive approach. This research method involves stages of system development, from requirements definition to testing, by applying Agile principles such as Scrum or Kanban. Through thorough testing, the system is confirmed to have met the set quality standards before being widely implemented. The results show that applying Agile approaches can provide the flexibility, adaptability, and responsiveness needed to deal with the complexities in construction transport management. The contribution of this research is that it provides valuable insights for practitioners and academics in understanding the potential of Agile approaches in improving efficiency, transparency, and risk management in construction projects, as well as offering a foundation for developing more effective transport management systems in the future.

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INTRODUCTION

The construction industry is one of the vital sectors in developing a country's infrastructure and economy. With its crucial role, the industry is responsible for constructing buildings and infrastructures and is also a driver of economic growth through job creation and improved connectivity. In the context of infrastructure development, the construction industry is the backbone for significant projects such as the construction of roads, bridges, airports, and other transport facilities that support the mobility of people and the transport of goods(Alzahrani & Emsley, 2013; Divya Sankar & Selvam, 2020; Ingle & Mahesh, 2022; Marzouk, 2011; Pan, 2008).

Transport management plays an essential role in the smooth execution of construction projects. In this context, transportation management is not only concerned with managing the movement of goods and personnel but also involves efficient coordination in organizing material distribution and logistics flow and optimizing the supply chain. The smooth running of a construction project relies heavily on the transportation system's efficiency, as timely delivery of materials, coordination of personnel, and effective logistics

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management are crucial to success in maintaining schedules and minimizing delays. Good transport management also reduces costs and risks associated with shipping and distribution and increases work productivity by ensuring the timely availability of necessary materials and equipment. In practice, aspects such as fleet management, delivery routing, inventory monitoring, and coordination between the parties involved are the main focus in developing an efficient transport system for construction projects(Boateng et al., 2022; Choi & Ha, 2022; Fredriksson & Huge-Brodin, 2022; Guo et al., 2023; Jato-Espino et al., 2014; Nieto-Morote & Ruz-Vila, 2012). Therefore, an in-depth understanding of the importance of transport management in the construction context is necessary to improve the effectiveness and efficiency of project execution and better achieve project objectives.

Traditional approaches to the development of transport management systems often face several disadvantages that can limit their effectiveness in meeting the dynamic demands of the construction industry. Firstly, traditional approaches are rigid and need more flexibility in the face of change. Rigidly defined systems are complex to adapt to changing needs or unforeseen situations, which can hamper responsiveness in managing transport for construction projects. In addition, traditional approaches also tend to be slow and unadaptive in responding to changes that occur. Lengthy and multi-layered decision-making processes often result in delays in implementing changes, which can negatively impact the smooth running of the project. Furthermore, traditional approaches are difficult to adapt to changes in the project environment, such as changes in weather, traffic conditions, or project-specific requirements. The lack of flexibility in traditional systems often leads to an inability to adjust transport operations quickly and meet project deadlines or needs. Finally, traditional approaches often need more communication and collaboration between the various parties involved in transport management. Lack of transparency and clear communication channels can hinder coordination between teams, contractors, and suppliers, reducing the overall efficiency and effectiveness of managing construction project transport. Therefore, understanding the weaknesses of the traditional approach is essential in designing strategies to develop a more responsive and adaptive transport management system to support construction project success(Bahamid et al., 2022; Pham et al., 2023; Rajabi et al., 2022; Serpell & Rubio, 2023; Sihombing, 2023; Tessema et al., 2022; Xu et al., 2022).

The potential of Agile approaches offers a promising solution in overcoming the drawbacks commonly associated with traditional transport management system development approaches(Al-Saqqa et al., 2020; Bomström et al., 2023; Dingsoeyr et al., 2019; Dingsøyr et al., 2012; Santos et al., n.d.; Serrador & Pinto, 2015; Shrivastava & Rathod, 2014). With a more adaptive and responsive approach, Agile allows developers to quickly adjust system strategies and features to changes in the project environment. The flexibility of this approach allows the system to adapt to dynamics, such as changing business needs or project conditions. In addition, the Agile approach promotes better communication and collaboration between the various parties involved, including the development team, stakeholders, and end users. This can increase transparency, facilitate more effective information exchange, and improve decisions. In addition, agile approaches are recognized for delivering results quickly and iteratively, thus enabling direct user feedback to improve

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product quality and overall user satisfaction(Akhtar et al., n.d.; Alami et al., 2022, 2023; Almeida et al., 2022; Estrada-Esponda et al., 2024; Hasan et al., 2013). Thus, the potential of Agile approaches not only helps to overcome the drawbacks associated with traditional approaches but also brings additional benefits in flexibility, responsiveness, communication, and product quality for developing more efficient and effective transport management systems in the construction industry.

While there is an increasing interest and application of Agile approaches in various industries, significant research gaps still exist regarding the application of these approaches in developing transport management systems, particularly in the construction industry. While there is ample evidence of the success of Agile approaches in software development, the use of these approaches in construction transport management still needs to be explored. Some of the unanswered research questions include the extent to which the Agile approach can improve the efficiency and responsiveness of transport management systems in construction projects, how the Agile approach integrates with existing construction management principles, and what impact the implementation of the Agile approach has on the overall performance of construction companies. In addition, there needs to be more understanding of the challenges and barriers faced in adopting Agile approaches in the construction transport context and how to overcome these obstacles. Therefore, further research that deepens the understanding of the application of Agile approaches in the development of transport management systems in the construction industry is needed to fill the existing research gaps and develop a more comprehensive understanding of the potential and challenges of these approaches in this unique context.

This research is expected to significantly contribute to knowledge and practice in the construction management field, particularly in developing transport management systems. By delving deeper into applying the Agile approach in construction transport management, this research will provide a more in-depth understanding of the potential and constraints associated with this approach in the construction industry. The findings of this research will provide practical guidance for construction companies in implementing Agile approaches in developing their transport management systems, thereby helping to improve their operational performance and efficiency. Using a more adaptive and responsive approach, construction companies can overcome challenges such as project delays, cost overruns, and the need for more efficiency in transport management. Furthermore, this research can also help improve collaboration and communication between the various parties involved in a construction project, improving productivity, quality, and end-user satisfaction. Thus, it is hoped that this research will advance construction management practices and help construction companies achieve their goals more effectively and efficiently.

METHODS

The development phase of a transport management system in the context of an Agile approach starts with the requirements definition phase, where the needs and objectives of the system are identified and prioritized. Then, at the planning stage, a detailed work plan is

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developed with the creation of a sprint backlog and time estimates for each task. The development stage is done by incrementally developing the system in short sprints using Agile methodologies, such as Scrum or Kanban. Finally, the testing phase is conducted periodically to ensure the system functions appropriately and fulfills user needs by involving users in the testing process to ensure quality and end-user satisfaction.

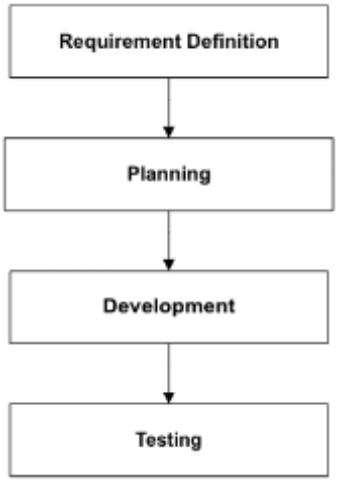

Figure 1. Research Stages

Definition of Need

At this stage, the needs and objectives of the system to be developed were identified. An in-depth analysis was conducted to understand the challenges and needs of construction transport management. The needs are then prioritized based on their urgency and impact on the construction company's performance. This needs identification process is very important to ensure that the system development can meet the actual needs of users and organizations.

Planning

A detailed work plan for system development was developed in the planning stage. Firstly, a sprint backlog lists the tasks in each iteration. After that, the time required to complete each task in the sprint backlog is estimated. This planning aims to organize and manage the project more efficiently and ensure optimal use of resources.

Development

In the development phase, the system is developed incrementally in short sprints, typically 2-4 weeks per sprint. Agile methodologies such as Scrum or Kanban are used in this development to organize and track system development progress. With this approach, changes and adjustments can be made more flexibly according to the needs during the development process.

Testing

The testing phase is carried out periodically to ensure the system functions properly and meets user needs. Tests are conducted on various aspects of the system, including functionality, performance, and security. Users are also involved in the testing process to provide direct feedback on system performance and ensure the system can be used effi-

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ciently and effectively. This testing phase aims to ensure the quality and reliability of the system before it is widely implemented in the production environment.

RESULTS AND DISCUSSION

Definition of Needs

The requirements definition includes several key points, as shown in Table 1. Firstly, the activities in this stage involve in-depth identification and analysis of the needs and objectives of the system to be developed in construction transport management. It is essential to understand in detail the challenges faced and the needs that must be met for the system to be developed as expected. Furthermore, the objective of this stage is to ensure that the system requirements are identified and prioritized based on their urgency and impact on the construction company's performance. This process is critical because it will affect further system development. Then, the benefit of the Needs Definition stage is to ensure that the system developed can meet the actual needs of users and organizations to contribute to the positive effectiveness and efficiency of construction transportation management. This process is carried out at the beginning of the system development stage to ensure a strong foundation is laid before further development stages. The analysis method used includes data collection through interviews, observations, document analysis, and literature studies to ensure that all aspects of system requirements are well documented. The output of this stage is a document containing a list of identified system requirements, system objectives, and requirements prioritization based on urgency and impact. The discussion of the Requirements Definition stage provided a deep understanding of the importance of accurate requirements identification and prioritization in developing a construction transport management system.

Table 1. Results of Needs Definition

Stage	Definition of Need
Activity	Identification of system needs and objectives
Objective	In-depth analysis of challenges and needs in construction transport management Understand in detail the system requirements Prioritising requirements based on urgency and impact
Benefits	Ensure system development can meet user and organisational needs
Time	Performed at the beginning of the system development stage
Analysis Method	Data collection through interviews, observation, document analysis, and literature study
Output	A document that lists identified system requirements, system objectives, and requirements prioritization based on urgency and impact.

Planning

Planning indicates that this stage is an essential step in system development. Activities such as developing detailed work plans, creating sprint backlogs, and estimating task

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completion times all aim to organize and manage the project efficiently. This ensures that the available resources are optimally utilized in the system development. The objective of this stage is to ensure that the project goes according to plan and needs and minimize the risks that may arise. Benefits include increased efficiency in system development and assurance of optimal use of resources.

The timing of this phase was prior to the start of the system development phase, demonstrating the importance of careful planning before entering the execution phase. The analysis methods used included time estimation based on previous experience, needs analysis, and references from literature studies, showing a comprehensive approach to planning system development. The output of this stage is a detailed work plan and a well-organized sprint backlog, providing clear guidance for the subsequent stages of system development. Overall, the Planning stage is crucial in ensuring success and efficiency in system development.

Table 2 lists the tasks to be performed in the Planning stage, a brief description of each task, and the estimated time needed to complete each task. This table provides a complete guide to organizing and managing the project more efficiently.

Table 2. Planning

Planning Stage	Task Description	Estimated Time (days)
System Requirements Identification	Analyse system requirements with the project team	3
Sprint Backlog Compilation	Create a sprint backlog containing the tasks to be done in each iteration	2
Task Time Estimation	Determine the estimated completion time for each task in the sprint backlog	1
Discussion and Approval	Discussion with project team on work plan and scheduling	2
Prioritisation	Set task priorities in the sprint backlog	1
Communication Plan Preparation	Develop internal and external communication plans	2
Documentation Preparation	Prepare documents required for the development phase	3

Development

The result of the Development stage is the incremental development of the system in short sprints with a typical duration of 2-4 weeks per sprint. Agile methodologies such as Scrum or Kanban are used to organize and track progress in system development. With this approach, changes and adjustments can be made more flexibly according to the needs during the development process. This stage aims to ensure that the system continues to be

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developed iteratively and is responsive to changes, achieving the desired quality and meeting user needs better.

As shown in Table 3, Sprints has a list of tasks that must be completed during one sprint with a duration of 2 weeks. Each task has a brief description and a status indicating its completion stage. This table helps the development team track the work's progress and ensure that each task is completed according to the set schedule.

Table 3. Sprint

Task Description	Status
System requirements analysis for the project management module	Finish
Database design for project information storage	Finish
Implementation of new project creation feature	In Process
Integration testing between project management module and task module	Hasn't Started
Maintenance of technical documentation	In Process

Table 4 presents a series of features carefully designed to support the effective management of construction projects. Firstly, the Project Monitoring Dashboard feature allows project managers and relevant parties to access up-to-date information on project progress, including schedule, budget, and project team performance. This feature provides a deeper understanding of the project status and facilitates quick and informed decision-making. Next is Transport Route Mapping and Monitoring, which enables efficient planning of delivery routes for construction materials and equipment based on considerations such as distance, travel time, and traffic conditions. Then, the Inventory Management feature provides the ability to track and manage a detailed inventory of construction materials and equipment, ensuring adequate availability throughout the project. Finally, Risk and Issue Monitoring enables identifying, monitoring, and mitigating risks and issues that may arise during the project. By providing tools to record and manage potential risks, this feature helps minimize negative impacts on project progress. Overall, this application is designed to improve efficiency, transparency, and risk management in developing a transport management system with an Agile approach. With the implementation of these features, construction companies are expected to improve their project performance and achieve goals more effectively.

Table 4. Application Features

Features	Function
Project Monitoring Dashboard	Provides a visual display of the status and progress of construction projects in real time. Enables monitoring of project schedule, budget, progress, and project team performance.
Transport Route Mapping and Moni-	Enables mapping of transport routes for delivery of construction materials and equipment. Provides information on the best route based on

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Features	Function
toring	distance, traveling time, traffic conditions, and project needs.
Inventory Management	Facilitate monitoring and inventory management of construction materials and equipment. Track inventory quantity, location, status, and usage. Provide inventory updates and re-procurement arrangements of materials and equipment as per project needs.
Risk and Issue Monitoring	Enables identification, monitoring, and mitigation of risks and issues in construction projects. Provides tools to record, manage, and track potential risks and issues that arise during the project. Provides the ability to establish corrective actions and reduce their impact on the project.

Testing

The outcome of the testing phase is to ensure that the system has been thoroughly tested to ensure its quality and reliability before it is widely implemented in a production environment. Tests are conducted periodically on various aspects of the system, including functionality, performance, and security. Users are also involved in the testing process to provide direct feedback on system performance and ensure that the system can be used efficiently and effectively according to their needs. The outcome of this testing phase is to ensure that the system has met the set quality standards and is ready to be implemented in the production environment without experiencing significant disruptions.

Table 5. Testing Results

Testing Aspects	Examination Status	Description
Functionality	Done	All major features have been tested and work as expected.
Performance	Completed	Performance testing has been conducted to ensure the system's responsivenesssystem's responsiveness to different workload situations.
Security	Ongoing	Security testing is being conducted to identify potential vulnerabilities and implement protective measures.
User	Completed	Users have been involved in testing to provide direct feedback on the user experience.

In Table 5, the test results of the transport management system are recorded in detail. Each aspect of testing, including functionality, performance, security, and user experience, has a test status assigned, either "Completed" for tests that have been completed or "In Progress" for still in progress. The captions provide additional details about each aspect of the test, including specific results found during testing. As such, these results provide a

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complete picture of the progress of testing and the overall status of the system prior to widespread implementation.

CONCLUSION

The application of the Agile approach in the development of transport management systems has great potential to improve the performance of construction companies. Through stages such as requirements definition, planning, development, and testing, the Agile approach can provide the flexibility, adaptability, and responsiveness needed to deal with the complex challenges of construction transport management. The features integrated into the application, such as project monitoring dashboards, transport route mapping and monitoring, inventory management, and risk and issue monitoring, provide strong support for efficient and effective project management processes. The test results show that the system has been thoroughly tested to ensure its quality and reliability before being implemented in a production environment. Users are also involved in the testing process to provide direct feedback on system performance, thus ensuring that the system can be used efficiently and effectively according to their needs. Thus, this research concludes that applying the Agile approach in developing transport management systems can assist construction companies in improving efficiency, transparency, and risk management in their construction projects. It is hoped that this research will make a meaningful contribution to knowledge and practice in the field of construction management and help construction companies achieve their goals more effectively.

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