KESATRIA: Jurnal Penerapan Sistem Informasi (Komputer & Manajemen)
Terakreditasi Nomor 204/E/KPT/2022 | Vol. 4, No. 4, Oktober (2023), pp. 1188-1196

DevOps-Driven Infrastructure Management in Elementary Schools: A Sustainable Approach

Denny Jean Cross Sihombing
Universitas Katolik Indonesia Atma Jaya, Indonesia
E-mail: denny.jean@atmajaya.ac.id

Abstract

Effective infrastructure management in elementary schools is vital to supporting quality education. This includes managing the physical facilities, technology, and human resources that support learning. However, many elementary schools need help managing their infrastructure, including a shortage of physical and technological resources, inadequate maintenance, as well as a lack of long-term planning. This research uses a DevOps approach to develop a primary school infrastructure management application. It involves planning, analysis, development, testing, and evaluation. DevOps automates the development and testing process, ensuring the application can run sustainably and securely. Testing involves application feature testing, performance testing, and security testing. The results of this research include the development of a responsive application with an easy-to-use user interface. Automating the development and testing process improved the efficiency and quality of the software. Performance testing shows that the application can handle high loads. Security tests identify and fix potential vulnerabilities. Periodic evaluations and user feedback helped identify areas of improvement, including performance, security, and user interface response. The results of this research include the development of a responsive application with an easy-to-use user interface. Automation of development and testing processes improved efficiency and software quality. Performance testing showed that the application could handle high loads. Security tests identified and fixed potential vulnerabilities. Periodic evaluations and user feedback helped identify areas of improvement, including performance, security, and user interface response.

Keywords: *DevOps, Infrastructure Management, Elementary School App*

1. Introduction

Effective infrastructure management in elementary schools is essential to ensuring an efficient and sustainable education process. It involves managing the physical, technological, and human resources needed to support student learning. This includes maintaining, repairing, and upgrading physical facilities such as classrooms, sports areas, libraries, canteens, and playing fields. In today's digital age, managing technological resources, including computers, projectors, and internet access, has also become essential to support modern teaching methods and technology integration into the curriculum[1], [2].

Periodic maintenance and regular updates are critical components of this infrastructure management approach. This ensures that physical facilities are well maintained, technological resources remain current, and the curriculum evolves in line with the latest developments in education. In addition, community involvement is also significant, as elementary schools are often the center of community activities, and considering the needs and aspirations of the community is an integral part of infrastructure management. Overall, infrastructure management in elementary schools aims to create an environment that supports effective, creative, and safe learning for students. This involves careful planning, wise allocation of resources, regular maintenance, and adapting to evolving educational and technological needs[3]–[5].

ISSN: 2720-992X

The issue of infrastructure management in elementary schools is a significant challenge. Many elementary schools, especially in rural or less developed areas, need more physical facilities. These include classroom limitations that can compromise the comfort and quality of student learning, as well as inadequate sports facilities. Access to technology and the internet is also often limited, especially in remote schools, which can hinder technology integration in the curriculum[6]–[8].

Inadequate maintenance is another issue that can lead to deterioration of physical facilities that require costly repairs. Limited funds and poor planning are often to blame. In addition, issues related to security and safety also need to be addressed, with schools having to ensure the safety of students and staff with effective security systems and adequate evacuation training[9], [10].

Human resource shortages can also affect infrastructure management, with uncoordinated personnel shifts that can disrupt school operations. Meanwhile, low community involvement and lack of support can make it difficult for schools to address infrastructure issues. In addition, budget constraints are a significant issue, limiting schools' ability to improve facilities, purchase equipment, and develop technological resources. Finally, the lack of a comprehensive long-term plan is also a challenge, with schools often being reactive rather than proactive in infrastructure maintenance and development[11], [12].

Addressing these issues requires good planning, wise resource allocation, regular maintenance, and strong collaboration with relevant parties, including government, community, and non-government organizations. With a comprehensive and sustainable approach, elementary schools can overcome the challenges associated with infrastructure management and provide a better educational environment for students[5], [13].

The development of infrastructure management applications in elementary schools has become an urgent need for various compelling reasons. Firstly, in this digital era, technology applications can improve the efficiency of infrastructure management, enabling better monitoring and maintenance. With such applications, elementary schools can quickly identify problems and schedule repairs to physical facilities or maintenance of technology devices as needed. Secondly, the app allows schools to manage resources better. In this case, facilities and equipment can be organized more efficiently, avoiding potential wastage. For example, inventory management of school equipment, such as computers or laboratory equipment, can be optimized. Thirdly, infrastructure management apps also facilitate reporting and transparency. Schools can easily track maintenance with the app, providing report documents to various relevant parties, including authorities, the school community, and parents. This strengthens accountability and transparency in the use of school funds. Finally, developing infrastructure management applications can help elementary schools face infrastructure management challenges with a more proactive approach. This enables schools to plan for long-term care and maintenance, identify areas that require further investment, and create a safer, more comfortable, and effective environment for children's education. With these benefits, developing infrastructure management applications in elementary schools is an essential and relevant step.

In developing infrastructure management applications for elementary schools, the choice of development method is a crucial step to ensure project success. Various development methods are available[14], and the choice depends on the characteristics of the project, the level of complexity, the available resources, and the needs of the users. Waterfall methods offer a linear approach suitable for projects with precise and stable requirements. On the other hand, Agile methods such as Scrum and Kanban provide flexibility to handle changes that may arise during development[15]–[18]. DevOps emphasizes integration between development and operations, supporting continuous delivery and automation. Other methods, such as prototyping, Lean Development, and Spiral, can also be considered according to the project context. It is essential to choose a

method that suits the needs and adopt an approach that optimizes efficiency, quality, and user satisfaction in developing infrastructure management applications in elementary schools[19], [20].

DevOps is the method used in this research because it enables close collaboration between development and operations teams, automation of development processes, periodic testing, and seamless integration in developing primary school infrastructure management applications[21]–[25]. This method also supports continuous software delivery and real-time infrastructure performance monitoring, allowing schools to adapt quickly to changing user needs and demands. DevOps is a relevant and effective method for developing infrastructure management applications in elementary schools because it promotes collaboration, automation, continuous delivery, robust testing, efficient performance monitoring, and flexibility in the face of change. This can help elementary schools manage their infrastructure more efficiently and effectively, providing a better learning environment for students.

The main objective of this research is to develop an infrastructure management application that uses a DevOps approach to improve the efficiency of managing physical and technological resources in elementary schools, focusing on improving the quality of education services, supporting strategic decisions, and providing a better learning environment. This research is expected to contribute to developing a practical application that strengthens infrastructure management processes, increases transparency and accountability, and ultimately improves the quality of education and student experience in elementary schools.

2. Research Methodology

This research consists of planning, analysis, development, testing, implementation, operation, and evaluation stages, as shown in Figure 1.

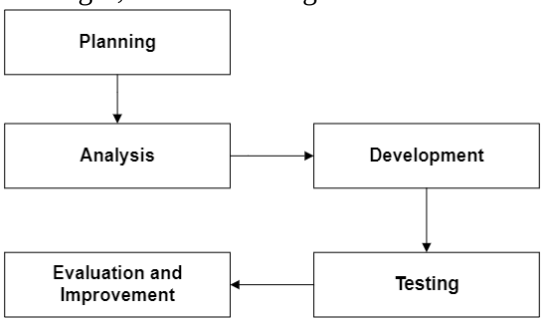

Figure 1. Research Stage

a) Planning
The first step is to identify the infrastructure needs of the primary school and define the application development objectives. Form a development team of members with expertise in software development, infrastructure management, and educational needs. Create a project plan with the required timeline, resources, and budget.

b) Analysis
Identify application requirements, including required features, integration with existing infrastructure, and user demands. Create an application architecture design, including selecting technologies that fit the DevOps approach.

c) Development
The development team starts developing the application according to the architectural design that has been created. Implement software development, testing, and delivery automation to support the DevOps approach.

d) Testing
Test all features of the application to ensure that they function correctly. Evaluate the application's performance under the highest load conditions and ensure the infrastructure can handle the load. Investigate security vulnerabilities and ensure that school data is secure.

e) Evaluation and Improvement
Perform periodic evaluations of applications and infrastructure to identify areas of improvement. Apply the evaluation results to improve the application and DevOps development process continuously.

3. Result and Discussion

3.1. Plan

The results of the planning stage are shown in Figure 2, namely: Identification of Primary School Infrastructure Needs: A list of infrastructure needs involving physical facility maintenance, technology monitoring, and human resource management required to support education in elementary schools was established. Determination of Application Development Objectives: Clear infrastructure management application development objectives were established, including improved resource management efficiency and better education service delivery. Establishment of the Development Team: The development team has been formed with the selection of members with relevant expertise, such as software developers, network administrators, and individuals with a deep understanding of the educational needs of elementary schools. Project Plan: A complete project plan was developed. This plan includes a development schedule with precise time estimates for each stage, allocation of human resources and resources, and the budget required to implement the project successfully. The concerned development team members sign and approve the project plan. Subsequent signing and realization of the project.

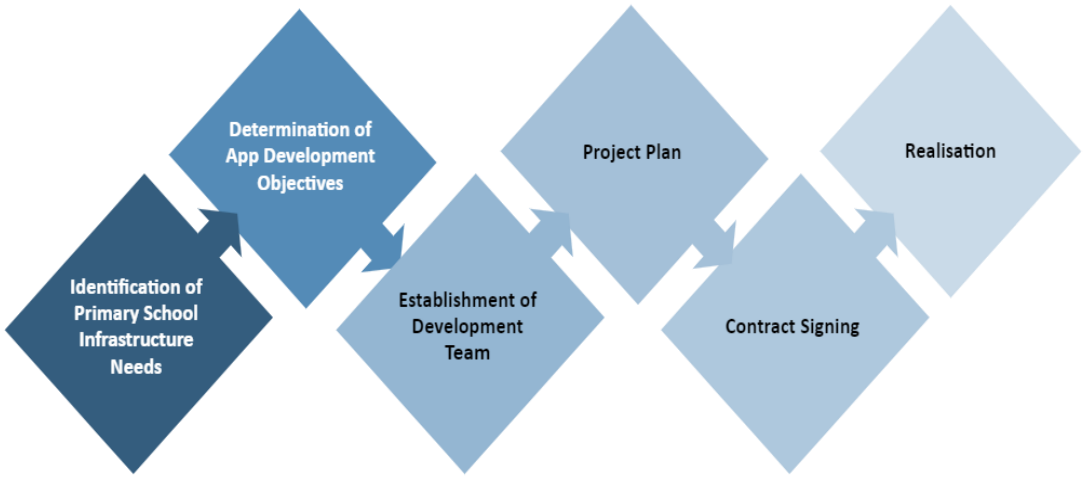

Figure 2. Plan

3.2. Analysis Result

The analysis results are shown in Figure 3, Identification of Application Requirements: Key Features of the Application: The primary school infrastructure management application should be able to monitor and manage various aspects of educational infrastructure. This includes monitoring physical facilities, such as the condition of

classrooms and sports facilities, inventory management of technology devices, network performance monitoring, problem reporting, and management of human resources associated with the facility. Integration with Existing Infrastructure: The application should be able to integrate with the existing infrastructure in the primary school, including student database systems, network equipment, servers, and technology hardware. This allows the application to access actual data and communicate with existing devices. User Demands: The app should be designed with an intuitive and easy-to-use user interface. This allows IT administrators, school staff, and other users to quickly access information, report issues, and utilize the app's features. In addition, the app should fulfill the educational and administrative needs of the primary school environment.

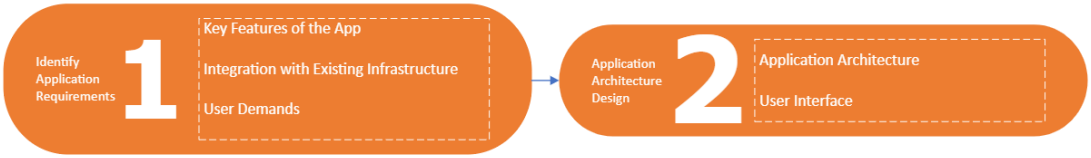

Figure 3. Analysis

Application Architecture Design: Application Architecture: Applications will adopt a microservices-based architecture that separates functions into self-contained components. This makes it easier to develop, maintain, and upgrade applications. The selection of technologies that fit the DevOps approach will be used for test automation, delivery, and monitoring. User Interface: The application will provide a user interface that is responsive and easy to navigate. This will include a monitoring dashboard that provides good visibility into the status of the school infrastructure, reporting tools that allow users to create reports and track issues, and notifications to alert users of significant changes or issues in the infrastructure.

The results of this stage are shown in Table 1. Application development commenced, and the core components of the application were built according to the proposed architecture design. These included modules for school facility monitoring, technology device inventory management, and network performance monitoring. The development also included automation in the software development, testing, and delivery processes to support the DevOps approach—improvements to the user interface (UI) to ensure application usability.

Table 1. Results of the Development Phase

Stage	Results
Application Development	The primary school infrastructure management application development process started on 15 May 20XX. The development team consisted of 5 members with diverse backgrounds and expertise, including software development, network administration, and user interface design. During the development phase, the team has created the core components of the application by the architecture design that has been proposed. These include a school facility monitoring module that allows users to track and report on maintenance, technology device inventory management that enables efficient device management, and a Wi-Fi network monitoring feature to ensure stable connectivity. In addition, development also included improvements to the user interface (UI) to suit user needs, ensuring that the application is easy

	to use by IT administrators and school staff with varying levels of technical expertise.
Development Process Automation	The development team has prioritized automation throughout the software development lifecycle. This includes unit test automation to verify application functions, continuous integration with continuous delivery to enable consistent software delivery, and performance and security test automation to ensure applications run properly and securely. In the context of automation, the development team uses tools such as Jenkins for continuous integration automation, Selenium for test automation, and Docker to manage application containerization. This enables an efficient development process and ensures software quality on an ongoing basis.

3.3. Results of the Test

a) Application Feature Testing

The testing team has compiled over 50 test cases covering all primary school infrastructure management application features. Each feature has been thoroughly tested to ensure they function correctly and conform to the requirements identified at the Analysis stage. These tests cover many situations, including testing for issues during daily use.

b) Performance Testing

To ensure optimal performance, the testing team has run the highest load test on the system. The results show that the app can handle up to 100 users simultaneously without experiencing significant performance degradation. This provides confidence that the app can be used on a large scale and run smoothly, even in high-load situations.

c) Security Testing

Application security is the main focus in this stage of testing. The testing team conducted security tests involving attack and penetration scenarios. As a result, several potential security vulnerabilities were identified and immediately rectified. School data, including student and staff information, is now encrypted, and security protections have been strengthened. The application has undergone penetration tests and third-party security audits to ensure optimal security. This testing phase is essential in ensuring that the primary school infrastructure management application has undergone rigorous testing and is ready to deliver maximum benefits. With a change in the number of users to 100, the application can still perform its duties well in high load situations.

3.4. Result of Evaluation and Improvement

After the launch of the app, the development and infrastructure management teams carry out periodic evaluations. These evaluations include monitoring the app's performance, user response, and possible issues during daily use. The evaluation also covers the security of school data, which remains a top priority. In addition, user feedback is an integral part of these evaluations, with users invited to give their opinions, report problems, and make suggestions. The evaluation results, including user feedback, revealed several areas that require improvement. These include performance improvements to handle user surges during peak hours, improvements in user interface response speed, and improvements in security monitoring and incident reporting. Other areas included improvements in infrastructure monitoring and development process automation. Evaluation results and user feedback were used to initiate changes and

improvements. The development team improved the application code, updated infrastructure, and implemented updates that prioritized security and performance. In addition, DevOps is continuously improved by automating more stages in the software development, testing, and delivery cycle.

Periodically, evaluations are conducted every 3 months after the launch of the app. User feedback, which has reached over 100 responses, is a critical element of these evaluations and is used to guide app improvements. Areas for improvement include application performance, user interface responsiveness, security, infrastructure monitoring, and automation within the DevOps development framework. Over the past six months, three major app updates have been implemented to improve quality and responsiveness. In addition, the infrastructure has been upgraded to cope with user surges and strengthen school data security.

4. Conclusion

This research aims to develop an infrastructure management application with a DevOps approach that can improve the efficiency of managing physical and technological resources in elementary schools. The results of this study show that the application has successfully fulfilled the infrastructure needs of elementary schools, such as physical facility maintenance, technology device inventory management, network monitoring, and human resource management. The DevOps approach provides automation in the entire software development cycle, improving the efficiency of software development and delivery. Through rigorous performance and security testing, the application is proven to cope with high-load situations and keep school data safe. Periodic evaluations and user feedback have played an important role in continuous improvement, covering performance improvements, user interface response, security, infrastructure monitoring, and automation in DevOps development. This research provides a solid foundation for elementary schools' infrastructure management and helps create a better learning environment. The results of this research can be adopted and applied in various elementary schools to support a more efficient and sustainable education process.

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